Translational Systems Sciences 18

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Neo-Simulation and Gaming Toward Active Learning

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In 1956, Kenneth Boulding explained the concept of General Systems Theory as a skeleton of science. He describes that it hopes to develop something like a "spectrum" of theories—a system of systems which may perform the function of a "gestalt" in theoretical construction. Such "gestalts" in special fields have been of great value in directing research towards the gaps which they reveal.

There were, at that time, other important conceptual frameworks and theories, such as cybernetics. Additional theories and applications developed later, including synergetics, cognitive science, complex adaptive systems, and many others. Some focused on principles within specific domains of knowledge and others crossed areas of knowledge and practice, along the spectrum described by Boulding.

Also in 1956, the Society for General Systems Research (now the International Society for the Systems Sciences) was founded. One of the concerns of the founders, even then, was the state of the human condition, and what science could do about it.

The present Translational Systems Sciences book series aims at cultivating a new frontier of systems sciences for contributing to the need for practical applications that benefit people.

The concept of translational research originally comes from medical science for enhancing human health and well-being. Translational medical research is often labeled as "Bench to Bedside." It places emphasis on translating the findings in basic research (at bench) more quickly and efficiently into medical practice (at bedside). At the same time, needs and demands from practice drive the development of new and innovative ideas and concepts. In this tightly coupled process it is essential to remove barriers to multi-disciplinary collaboration.

The present series attempts to bridge and integrate basic research founded in systems concepts, logic, theories and models with systems practices and methodologies, into a process of systems research. Since both bench and bedside involve diverse stakeholder groups, including researchers, practitioners and users, translational systems science works to create common platforms for language to activate the "bench to bedside" cycle.

In order to create a resilient and sustainable society in the twenty-first century, we unquestionably need open social innovation through which we create new social values, and realize them in society by connecting diverse ideas and developing new solutions. We assume three types of social values, namely: (1) values relevant to social infrastructure such as safety, security, and amenity; (2) values created by innovation in business, economics, and management practices; and, (3) values necessary for community sustainability brought about by conflict resolution and consensus building.

The series will first approach these social values from a systems science perspective by drawing on a range of disciplines in trans-disciplinary and cross-cultural ways. They may include social systems theory, sociology, business administration, management information science, organization science, computational mathematical organization theory, economics, evolutionary economics, international political science, jurisprudence, policy science, socioinformation studies, cognitive science, artificial intelligence, complex adaptive systems theory, philosophy of science, and other related disciplines. In addition, this series will promote translational systems science as a means of scientific research that facilitates the translation of findings from basic science to practical applications, and vice versa.

We believe that this book series should advance a new frontier in systems sciences by presenting theoretical and conceptual frameworks, as well as theories for design and application, for twenty-first-century socioeconomic systems in a translational and transdisciplinary context.

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Preface

At the beginning of this book, we would like to express our deepest pleasure and honor to have an opportunity to publish the book for the future of Simulation Gaming(S/G) and Active Learning (AL) to all contributors.

S/G and AL have similar roots in about 50 years ago. ISAGA (International Simulation and Gaming Association) was established in 1969 and recognized as an academic discipline in 1970 by publishing its own journal (Simulation & Gaming) regularly. The origin of AL was said to be from 1960 to 1970 to complain one-way, low-motivated lectures in American Higher Education. University recognized reconstruction of lectures and mind-set of teachers are urgent issue and tried to resolve the situation by introducing Faculty Development. It was mostly driven by scholars in education field. They made many inventions, improvements, tips, and theories that have been accepted as academic discipline.

Contrary, practitioners of S/G came from various backgrounds, for example, Language, Psychology, Business, Engineering. Thousands of games have been developed, but without being known by others, nearly same numbers of S/Gs have been disappeared. There are some considerable reasons. Firstly, many games are developed as a part of education, not as a research. Research accompanies duty of publication, but education doesn't have. Secondly, most S/Gs were created by individual teachers who used S/G in their curriculum and were not interested enough in sharing their gaming experiences with others.

AL has strength in its advantage of theories, and S/G has strength in its variety, possibility, and fun. If those two streams merge, we can create strong interdisciplinary science, which consists of quite a lot of people, practices, and sophisticated doctrines.

It is obvious that if S/G was used in teaching, it is one of the style of AL. However, in order to merge these two disciplines, S/G needs to formulate more persuasive theory. To figure out such theory commonly recognized and understood, we have to record, publish, and share more ideas in both sides. As we already mentioned, there are quite a lot of missing games. We have to create a database of S/G, to unite our ideas, and to consider new S/G for the next generation, so to say, Neo Simulation Gaming, possible to merge with AL. That is the reason why we publish this book now.

Current practices and researches of S/Gs were gathered in the 49th International Conference of ISAGA hosted by the Thai Simulation Gaming Association (ThaiSim) on July 9–13, 2018, at Salaya Campus, Mahidol University, Nakhon Pathom, Thailand. A total of 160 participants from 20 countries introduced their ideas. After the conference, editors selected 60 papers that are suitable for our purpose to describe the future of S/G in relation of AL. Editors read all stories and suggested authors to improve the quality of contributions. We sought reader-centered book: starting from easy practices, gradually going up to complex trials, and finally powerful discussions forecasting the future. The editors introduced 48 papers' contents to find out interesting papers for the readers. Therefore, we don't consider this is a post proceeding; this is a book independent from ISAGA2018.

Now it is your turn. You can start your journey to seek Neo Simulation and Gaming toward Active Learning era. We wish you enjoy our book and be able to co-work in some opportunities.

Guide to 50 Papers: Toolbox of S/Gs and ALs

The purpose of this book is to summarize the latest achievements of Simulation Gaming (S/G) with the need to enhance Active Learning (AL) as an urgent issue for higher education. In this section, as a chief-editor, I tried to summarize 51 papers in my words. For busy people, it would work as a quick reference.

Part I: Various Applications of S&G

In this part, we selected eight articles that represent cutting-edge usage of S/G. As the world of S/G grows, its application increases. S/G always welcomes new challenges. Huyakorn (pp. 3–12) tried to apply S/G for promotion of diversity in modern society and created the game to understand the importance of co-living. Tantawichen, Mizuyama, and Nonaka (pp. 13–22), in a bold move, extended S/G to predict unreleased movie by simulation to reconsider business model in cinematographic industry. Sripian, Nimnual, Hemathugsin, and Fongranon (pp. 23–34) described how to create an educational game called HalluciFear to train awfulness of drug abuse. Mongkolwat, Prachyabrued, Siriapisith, Hu, and Shih (pp. 35–52) introduced the current usage of S/G in medical sector in detail. Zhang and Meijer (pp. 53–66) proposed a brand new simulation of patient transportation and its education for the ambulance dispatcher, the ambulance station manager, and the hospital logical manager. Pérez Rivera, Mes, and van Hillegersberg (pp. 67–76) introduced a new simulation game called “Trucks & Barges” to educate on planning challenges in synchromodal transport through competition between players. Especially during a sudden onset (natural) disaster, stakeholders from the humanitarian field and airport management need to work closely together to guarantee the most efficient way of handling issues. Therefore, Freese, Meesters, and Van de Walle (pp. 77–88) examined three different methods (discussion rounds with experts, gaming-related method, simulation game) to facilitate interactions and knowledge exchange between those groups. Their results can also be used in any other areas where different stakeholders need to work together. Gaming is used in Chemistry Education.

Shibata, Ido, Ito, and Sato (pp. 89–98) developed a new game to help their students to understand easily the periodic table of the chemistry syllabus, by using the idea of Sugoroku, the 3D Japanese game.

Part II: S/G to Learn Business

Business Simulation Gaming is the one of the oldest target in S/G. Although the principle of business is clear, there are many challenges to improve business learning. Gomi and Tanino (pp. 101–110) focused on business finance and tried to evaluate the effectiveness of game-based learning on financial statements. By creating and conducting a new game for their students, they got good results. Destyanto, Hidatyatno, Moeis, and Iman (pp. 111–122) developed a game to improve financial skills and proved its effectiveness. Besides, they achieved innovation to let game players join the co-creator of the game. This is a good practice of game development-based learning. Podgorski (pp. 123–128) presented project that focuses on augmented reality learning game design as a new way of teaching financial indicators like the return on investment (ROI). The scenario of business to analysis depends on a place where player is at the moment. In each scenario, a player has to make 15 decisions about the most important aspects of business. Weber, Warmelink, Martinisi, Buijtenweg, Hitchinson, and Mayer (pp. 129–136) applied S/G for professional education. Their goal was to let participants recognize the contribution of executives to the success of organizational growth. Kaneko, Hamada, and Hiji (pp. 137–146) tried to gamify supply chain collaboration. “BASE-SCC” is a game to assemble smartphone, and they testified its effectiveness both in Japanese and Thai universities. Kobayashi and Yoshida (pp. 147–156) applied S/G in economics education for kids and also used smartphone manufacturing as an example. Pattamoroj and Rompho testified gaming in a MBA course, evaluated the relationship between their business game score and grade point average (GPA) on their related subjects, and proved the effectiveness of gaming. Roukuni, Lukosch, and Verbraeck (pp. 157–166) pointed out that an innovative idea and its implementation were not directly connected and built an S/G framework to bridge the gap.

Part III: S/G to Raise Consciousness for the Environment

In this part, we introduce S/G development to raise consciousness for the environment. In the first paper, Zaima (pp. 179–190) introduced the usage of simulation to let students grasp burdens by using green multidimensional bookkeeping system supported by material flow diagram. Phoomirat, Akkapiphat, and Dumrongrojwatthana (pp. 191–200) developed “Green Roof Game” to raise awareness of the players to increase greenery in urban space and confirmed its effectiveness. Suzuki, Nakai, and Ogihara (pp. 201–210) figured out a new framework of S/G to contribute to design renewable energy policies. Kurahashi (pp. 211–220) simulated the power supply system of Japan, which was deregulated in 2016. By using agent-based simulation, he achieved modeling two-sided (power generation and distribution) electricity market under the new law. Navinit, Suwanna, Sena, and Nareenuch (pp. 221–234) hosted Active Learning in North-Eastern Thailand. They proposed local residents to participate in the role-play to resolve their water piping issues and succeeded in improving people's understanding.

Part IV: S/G to Understand Disaster Management

In this part, we seek effective ways of Active Learning for disaster management by using S/G. Toyoda and Kanegae (pp. 237–246) introduced trials for community-based disaster risk reduction by using both S/G and problem-based learning (PBL). Shimizu, Tomeno, Crosta, Merucuri, Ono, Kanegae, and Rizzi (pp. 257–266) figured out the framework of S/G to consider the relationship of disaster victims by focusing on the quality of life and information mismatch. Sakai, Shimizu, Toyoda, and Kanegae (pp. 247–256) created a new S/G model focusing on tourist evacuation in the disaster period and proposed to prepare for disaster by stakeholders of the sightseeing areas.

Part V: S/G with the Latest Technology

A development of Information and Communications Technology (ICT), Virtual Reality (VR), and Artificial Intelligence (AI) possesses large potential in future S/G and AL. Many people are trying to implement such technology in S/G. Ćwil, Wardaszko, Dąbrowski, and Chojecki (pp. 269–280) explained esports, new stream of technology, and compared the players' satisfaction in 17 major esports and their related systems. Nattawuttisit (pp. 281–292) reported the trials of AI chatbot dolls in the smartphone application for preschool kids and confirmed its effectiveness. Wilang (pp. 293–302) introduced the usage of VR headset for language learning and confirmed that VR could accelerate the students' understanding and learning motivations. Jakubowski (pp. 303–312) introduced a risk management game by using Augmented Reality technology and summarized its merits and problems for its further improvement.

Part VI: S/G for Consensus Building and Knowledge Management

S/G is also researched from the aspects of consensus building. In the field of urban design, how to build a blueprint of future city by using stakeholders' current assets is difficult to imagine, forecast, or show. Kaneda, Mizuko, Ueda, and Cui (pp. 315–324) tried to gamify such consensus building process based on discussions among players, based on simulations in economics. To improve a society, there are many social projects. However, it is quite difficult to measure their effectiveness. Hirunsalee and Punyakumpol (pp. 325–334) proposed new S/G to evaluate social impacts of such projects' outcomes. Ito, Kitani, Oyamada, and Hanamatsu (pp. 335–346) focused on a very simple approach to consensus by using the Affinity Diagram, commonly known as KJ Method by group work. They testified their method in their university as an Active Learning practice. Rounges, Lo, Angeletti, Meijer, and Verbraeck (pp. 347–354) sought how to enhance Knowledge Management (KM) by using S/G in organizations. To achieve their purpose, they created new gaming "OV-SAAL" based on their past research. The purpose of the research of Pinmaneenopparat, Punyawong, Huaihongthong, Khunnala, Jumsri, Tungsukruthai, Wimolsakcharoen, and Dumrongrojwatthana (pp. 355–364) is to lead to common understandings on the integration of socioeconomic and implementation of ecosystem. They hosted field workshops in the rural areas of Thailand to protect community forest sustainably and successfully raised people's interest to maintain it. Ono and Kimura (pp. 365–374) have been doing research on how to manage snow disasters. They focused on the collaborations commonly seen in areas of heavy snow and built a conceptual framework to confront snow removal by using S/G. In the research on consensus building, it was found that some persons continued to be stressed despite agreement. In such case, the implementation will be difficult. Oyamada, Ishikawa, Kumagai, and Kitani (pp. 375–384) proposed that the way to avoid such feelings was to use "Wadakamari" in Japanese by using S/G.

Part VII: S/G for Consensus Building and Knowledge Management

The difference between AI and S/G should be found in human commitment both in terms of quantity and frequency. If AI agent plays a game, AI never makes a mistake. However, human beings are not computers. In the real-life practice of S/G, we sometimes get angry, excited, and depressed and make mistakes, since we have emotions. Kamm (pp. 387–396) identified the stigmatization of acute social withdrawal ("hikikomori" in Japanese) as a continuing, serious issue. Within S/G, he proposed the use of "live-action role-plays" (larp) as a method to oppose stereotypes by building understanding through direct experiences. Shalbafan and Leigh (pp. 397–406) developed S/G called "Hooshmand-1" for several years. This is a simulation of a player's confused emotions for unexpected external stress on a business project. In this paper, they respond to the framework for considering decision-making under uncertainty. Rithdaychar (pp. 407–412) directly challenged emotion, by using a game called "This is Me" and succeeded to increase the score for own review, self-confidence, and so on. Rizzi has developed the game called "City of Emotions." Oțoiu and Rizzi (pp. 413–422) tried their game in Romania, with S/G less developed in this country. They proved S/G works very well, since it directly affects human emotions. Rizzi and Guarino (pp. 423–434) also tried City of Emotions with people in an area devastated by earthquake in Italy and confirmed that the game has encouraged them.

Part VIII: Neo S/G; Forecasting the New Era of S/G and AL

The last part of this book provides hints to forecast Neo S/G in the coming decade in relationship with Active Learning (AL). To construct the draft of Neo S/G, we need to review many important ideas that are common in S/G society. Otieno (pp. 435–442) explained Active Learning under the advanced concept called Rich Environments for Active Learning (REAL) and argued its effectiveness on AL by using PBL. Nakamura (pp. 443–452) pointed out that a physical environment for AL is essential for its success. She also mentioned that it was important to keep participant's mental environment. Based on her experiences, Nakamura showed how to improve quality of learning by using S/G.

In order to improve the effective implementation of four widely used persuasive game design principles, Erdbrink, Kortmann, and Verbraeck (pp. 453–462) theoretically explored their context dependency with the elaboration likelihood model as a framework. Several scenarios describe how these principles can either enhance or reduce the motivation and/or ability of the player to elaborate on the persuasive message of the game. Kurapati, Bekebrede, Lukosch, Kourounioti, Freese, and Verbraaeck (pp. 463–472) pointed out that the comparison of learning effect between digital and nondigital game is less developed. They hosted an experiment by using the same topic. The result of the performance was similar, that is, both of them had good and bad surfaces. Hamada, Panuwatwanich, Kaneko, Hiji, Burunchai, Choompolanomakhun, and Sri-on (pp. 485–504) tried to maximize the power of a board game. They tried to make a board game of construction industry. To save time and to avoid complexity, they applied two principles: the Cutting-Off principle, which was not to include minor story, and the Gradualism principle, which was not to let the student hurry. They separated the construction game into three stages. The reality of the S/G accompanies the risk that it becomes more difficult. Wardaszko (pp. 473–484) analyzed the problems of viewpoints of both the S/G designer and the player. To promote S/G or AL, we need a skilled teacher. Matsuda (pp. 505–514) created an S/G called "virtual lesson game" to train instructors.

Debriefing has been considered as a necessary step of gaming for a long time within the S/G community. However, this idea is not common in other fields or with new participants. According to Kikkawa, Kriz, and Sugiura's (pp. 515–524) international collaborative research, the learning achievement among many countries was studied. In this paper, they compared S/G session with debriefing and without debriefing in Austria and Japan and found debriefing was significantly important. Teach and Szot (pp. 525–536) hosted large-scale survey in US universities, proved debriefing was effective in American universities, and pointed out that quality difference of debriefing has close relationship with satisfaction of students. Kornevs, Hauge, and Meijer (pp. 537–552) focused on the importance of validation of S/G. By adapting Q methodology and based on attribution theory, they introduced a new method to validate the effectiveness of learning. Harviainen and Meriläinen (pp. 553–560) argued that recent gamification in the educational contexts must make sure whether it is truly working or not. Through careful literature review, they pointed out a combination of engagement, challenge level, and the role of reflection with fun that would lead students to attain effective learning.

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Contents

Part II S&G to Learn Business

Part III S&G to Learn Environmental Issues

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Paola Rizzi Msc in urban planning, MBA, is a Professor at the University of L’Aquila of Urban Design and Planning. She is also a Founder and Director of ISAGA Summer School (with Willy Kriz). She has designed and conducted gaming simulation in urban planning and design, decision-making process, environmental education, emergency and risk preparedness and prevention, and disaster mitigation. She was and is the Consultant of public institution like APAT-ISPRA. She taught urban gaming simulation design since the 1990s in different countries such as Poland, Germany, Austria, Romania, Russia, Thailand, the USA, and Japan. She has been a Visiting Research Professor at Ritsumeikan University.

Vinod Dumblekar MBA, PhD, is the Founder and CEO of MANTIS, a 16-year-old brand in business simulation games. He has designed and conducted games in business operations and strategy, corporate strategy, marketing and brand management, entrepreneurship, project management, and team interactions for career managers and management students. He has conducted games at over 80 management and engineering institutes and over 50 business firms in nearly 30 Indian cities and in Dubai, Austria, and Thailand. He is an avid Researcher and has published papers on simulation games, marketing, finance, learning, and management psychology. His papers on games were presented at ISAGA conferences at Munich, Atlanta, Singapore, and Thailand.

Part I
Various Applications of S&G

Introducing Arrival City Game for Neighborhood Diversity

Pongpisit Huyakorn

Abstract There are many ongoing issues with social cohesion and immigrant integration in urban neighborhoods. The promotion of diversity in local neighborhoods is one of the integral solutions for immigrant integration. However, past evidence suggests that Thai people have a terribly limited understanding of the notion of diversity. The research objectives are (1) to evaluate the residents' perception of understanding and acceptance toward the concept of immigrant integration and neighborhood coexisting diversity and (2) to find out the effect of a gaming simulation on the resident and the immigrant. We introduce the Diverse Arrival Game as a game to promote diversity and immigrant integration. The results show that the game improved perceptions in both groups toward neighborhood diversity. The game has the ability to prompt the acceptance of the diversity concept and ultimately leads to a new local initiative for diverse neighborhood planning.

Keywords Diversity · Immigrant integration · Gaming simulation · Neighborhood planning

1 Gaming Simulation as a Tool to Promote Immigrant Integration Introduction

The borders of the world seem to diminish, as we are moving into the era of diversity or one would consider it to be an era of super-diversity. Against the backdrop of immigrant issues, various countries have to rely on the movement of people for the decades to come. The members of Southeast Asia are among those countries. In the year 2015, aiming for stronger economic development in the whole region, they initiated the ASEAN Economic Community to encourage the flow of skilled migrants in the territory. Several national and regional policies were nominated for smoother integration. Thailand who is ranked among the top 15 countries of migrant

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destination in the world will remain as the major destination in AEC. Unfortunately, the local neighborhoods that are the area where the host and the newcomer interact were overlooked. They are the places which have to cope with the impact of immigrant firsthand including more housing and services demands, social tension, and diversified needs. Researchers in the field of immigrant integration have been proposing that the diversity in the local community should be adopted as the main solution for immigrant integration [1–5]. It is the realm that promotes "commonplace diversity" [6].

Gaming simulation (GS) is a reproduction of reality. On the complex relation between simulation and reality, Rizzi described that "The one that seems to be the most appropriate is gaming simulation: a gestalt (form, scheme and representation) where a significant model of reality (simulation) is working (on the basis of rules) due to participants' decisions (players/roles)." The description is an elaborated version of the definition by Duke [7] "that attributes to gaming simulation the function of a continuously updated physical, symbolic, conceptual etc., map. This map becomes the only instrument capable to reach the idea of the present and of possible futures" [8].

The concept of the gaming simulation that is related with this study was mainly considered in two aspects; the first one is a tool for learning and second one is about a collaboration improvement tool. There have been many studies about gaming simulations and a lot of them showed that gaming simulations could be applied as both a learning tool and a communication tool together. There are a variety of advantages of GS in the aspect of learning tool. In addition to that in the view of many scholars, gaming simulation allows participants to develop a global perspective, to connect learning with real-world situations, and to get close to the realities of a sophisticated world [9].

As a communication tool to improve collaboration, gaming simulation makes complex information simple and understandable, and game is a tool to structure communication in complex situations, discussion and brainstorming, and exchange of thought, knowledge, information, and opinion. Crucially for diversity context, GS shows more capability to consider diverse perspectives on the problem at hand than do various other types of media. As stated by Duke "the multilogue, variety of interpersonal interactions (such as persuasion and negotiation) occur quite naturally among game players" [7]. The nature of gaming was exceptionally helpful when we are trying to create mutual partnerships among a wider variety of stakeholders.

As seen in the former studies about gaming simulation, it has the advantages of a knowledge transfer tool. It is also a good communication tool for the player who participates in a gaming simulation activity. Thus, it is very suitable to be applied as an introduction tool to the concept of diversity and the dynamic of migration. The gaming simulation in this research has efficacies as learning and as a communication tool.

As learning or education tool, gaming simulations offer the benefits of both experiential and generative learning that provide an enhanced learning experience which, in this case, is about the concept of diversity and immigration integration. Promsaka also believed that the simulation is a communication technique, which is capable to convey a message that falls between the understandable simplicity for the public and the expert-level difficulty. Additionally, this simulation technique can be used as a communication tool for urban planning and design in which it can be transferred from a traditional computerized simulation into the gaming simulation. Promsaka further pointed out that a sophisticated simulation, which provides a complex aspect of reality, can be represented by a pleasant and enjoyable game. Gaming simulation offers the players a chance to play and make changes to a mock-up of reality, in order to broaden and deepen their understanding of the reality that surrounds them. Besides, "the gaming simulation offers representatives of stakeholders the opportunity to meet each other, discuss and exchange their different information and opinions on a specific issue, which enable a fruitful communication avoiding a risky judgment on wrong terms" [10].

2 Game Design and Mechanism

The processing mechanisms of the game are as follows: (1) The immigrants are motivated by jobs and quality of living; afterward they migrate to the city (Arrival City), resulting in (2) the lack of urban resources/utilities such as healthcare, police, and electric power; subsequently the player needs to (3) utilize land use management as a main tool to try to plan the land use policy, develop the infrastructure, and control the vulnerability, and lastly, (4) there will be a chance for every player to take part in mayoral election (see Fig. 1).

The game board is square in shape with the circular shape of a town center in the middle; the land parcels in the game are owned by both the public (in this case government) and private (investor) (see Fig. 2). All the players will take part in managing the land, for their income, for their house, etc. Accordingly, the topic of urban

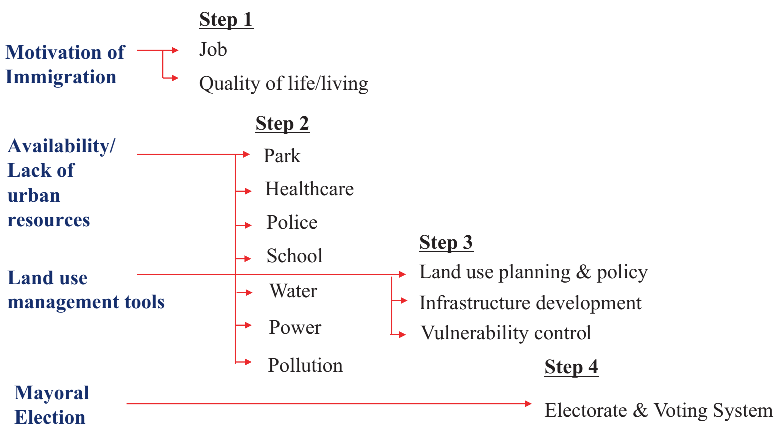

Fig. 1 Processing mechanism

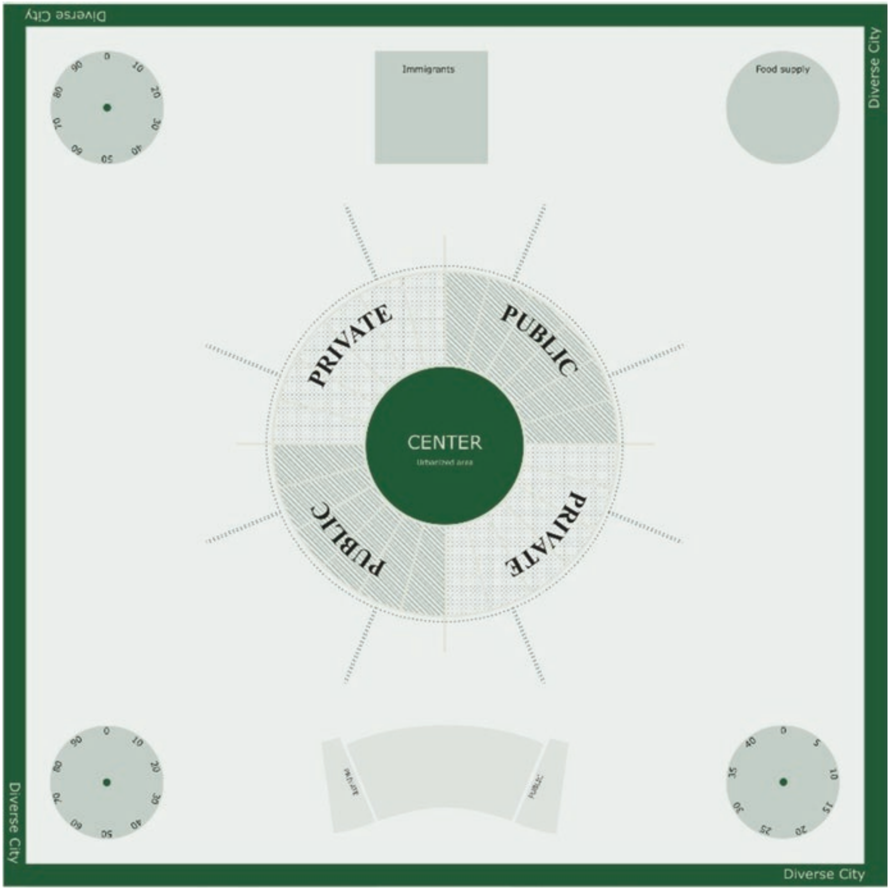

Fig. 2 Board of diverse arrival game

migration was changed to international immigration into the local neighborhood to make it more appropriate for the case study of Thailand. All the players from the four different roles of immigrant, resident, investor, and government have to take part in the development of the city (Arrival City). The government is the main allocator of the city policy and land management, the investor is the job contributor in the city as well as developer of the land, and lastly, the resident and immigrant have to compete for the jobs and the accommodations in Arrival City. After all the players take action according to their roles, all four teams are obliged to come together to participate in city planning, which they must try to find solutions for Arrival City together. Each turn becomes increasingly challenging as greater waves of immigrants continue to come into the city that could cause additional problems and disruption to Arrival City. As the players are not experts in the field of planning, in the game we provide option cards for them to help them make decisions. For example, the government team can choose to provide incentives to the investor, adjust the property tax, evict the illegal settlement, etc. Moreover, as the role of government is peculiarly complex and they have to consider several more issues than the others, the government role is granted access to the computerized Excel sheets that provide detailed information of the situation of Arrival City, such as the consumption, crime index, city vulnerabilities, etc.

Throughout the mechanism of the game, it will be extremely difficult for the players if they decide to play and make decisions only within the role they play; thus, they need to learn to work with each other and eventually realize that they can also live and work with immigrants, wherewith they understand the role of immigrant in an urban system (see Fig. 2).

The neighborhood we implemented the game in was Wat Ket neighborhood, the only neighborhood in Chiang Mai that contains four religious buildings (Buddhist temple, Sikh temple, Christian church, and Muslim mosque) from four different religions and also has many nationalities such as Chinese, Thai, Cambodian, and British residing in it. Traditionally, it was a very harmonious neighborhood with the residents of all groups coming together to do various local activities. But recently, with increasingly diverse newcomers, all of the people started to drift apart. The date of the activity was on 7 February 2016, and the follow-up interview was on 5 March 2016. The main languages of the activities were English and Thai.

We tried to have as diverse as possible group of samples for the research through the snowball method. Our research samples included people from 13 countries, who identified their ethnicity as Thai, Chinese, Japanese, British, American, German, Italian, Taiwanese, Spanish, Australian, Burmese, Lao, and Cambodian. The largest ethnic group among the immigrants was Burmese. Interviewees' duration of stay in the neighborhood varies from a few weeks, months, a couple of years, to several decades. The longest consecutive durations of stay in the neighborhood are 31, 27, 25, and 20 years.

There were 57 women and 43 men. Most samples are between 31 and 45 years of age. The second largest age group is 46–60 years old. We also had people aged 18–30 and over 60. The youngest four samples were 18, 23, and 24 years old, while the eldest three were 68 and 70. The group contained persons who live by themselves, couples, single parents, couples with children, a multigenerational family, and people who live in a form of shared housing (e.g., shared house with relative). The largest groups of interviewees live alone, have a partner and children, or are single parents with children.

In terms of the socioeconomic status (SES) of the samples, referring to income and education levels and type of occupation, the sample is quite diverse, but the majorities are in a lower-middle or middle SES with at least a high school degree. Albeit our aim is to promote the notion of diversity and immigrant integration, all of these attributes of the sample will not be the main consideration of our research, but we will rather consider each one of them as one individual and focus on the impact of the gaming simulation on their perception toward neighborhood diversity and the difference in degree of impact between immigrants and Thai residents instead.

In order to measure the impact of the gaming simulation on their perception toward neighborhood diversity, we conducted a pretest questionnaire asking them to rate from (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree with these following quotations: (1) It is good to live near people who are different, (2) We should promote more diversity in our neighborhood, (3) Urban planning is related to immigrant integration, (4) We should be more open to immigrants, (5) Our neighborhood is diverse, and (6) Immigrants are an integral part of urban development.

After that, we randomly assigned them to 5 groups of 20 people (10 immigrants, 10 native residents); then in each group, they formed a team of 5 people (must include both immigrant and native) to play the 4 roles of the game. The game session took around 2 hours for every group, and after the game, we asked them again to do the same questionnaire for the posttest.

3 Effect of the Game on Resident Perception

In this chapter we will investigate the different results of the Diverse Arrival Game. As there was a huge gap between the immigrant and native resident samples' perception, we think it is necessary to show three different figures, which elaborate three sets of sample group as follows: Table 1 shows all 100 samples, Table 2 represents the pretest and posttest results of immigrant group perception toward diversity,

Table 1 Pretest and posttest results of resident perception toward diversity (N = 100)

Question	Pretest result	Posttest result
1. It is good to live near people who are different	2.50	4.00
2. We should promote more diversity in our neighborhood	2.50	3.78
3. Urban planning is related to immigrant integration	2.49	4.20
4. We should be more open to immigrants	2.50	3.36
5. Our neighborhood is diverse	3.21	3.56
6. Immigrants are an integral part of urban development	2.88	3.56

Table 2 Pretest and posttest results of immigrant perception toward diversity (N = 50)

Question	Pretest result	Posttest result
1. It is good to live near people who are different	3.00	4.30
2. We should promote more diversity in our neighborhood	3.20	4.38
3. Urban planning is related to immigrant integration	2.78	4.40
4. We should be more open to immigrants	3.40	4.00
5. Our neighborhood is diverse	3.66	4.00
6. Immigrants are an integral part of urban development	4.00	4.12

Table 3 Pretest and posttest results of native resident perception toward diversity (N = 50)

Question	Pretest result	Posttest result
1. It is good to live near people who are different	2.00	3.70
2. We should promote more diversity in our neighborhood	1.80	3.18
3. Urban planning is related to immigrant integration	2.20	4.00
4. We should be more open to immigrants	1.60	2.72
5. Our neighborhood is diverse	2.76	3.12
6. Immigrants are an integral part of urban development	1.76	3.00

and Table 3 shows pretest and posttest results of the native resident perception toward diversity.

Overall, there were improvements in all of the resident's perception toward diversity as follows: (1) "It is good to live near people who are different," (2) "We should promote more diversity in our neighborhood," (3) "Urban planning is related to immigrant integration," and (4) "Immigrant is an integral part of urban development." There were no significant changes in (1) "Our neighborhood is diverse" and (2) "We should be more open to immigrants" (see Table 1). The residents perceived that there is the need to promote diversity and that living with people who are different is not such a bad idea. This is crucial, as we learned from the study of IOM. We made a breakthrough if we considered the general attitude toward the migrants. Moreover, residents also thought that urban planning connects with immigrant integration; this change of attitude will create a huge impact on the community.

The starting point of the immigrant group was relatively higher than that of the native resident especially in these categories, (1) "We should be more open to immigrant," (2) "Immigrants are an integral part of urban development," and (3) "Our neighborhood is diverse" (all in agree level); thus we cannot witness any major change to them. However, for the remaining three, there were significant changes: (1) "It is good to live near people who are different," (2) "We should promote more diversity in our neighborhood," and (3) "Urban planning is related to immigrant integration" (see Table 2). Besides the three categories in which they agreed already, the immigrants changed their mind that it is good to live with people from different backgrounds; together with that there should be the promotion of diversity in the neighborhood and urban planning can be one of the tools to deal with immigrant integration.

The residents in our research were not much different from the majority of the nation when it comes to perception toward the immigrants as well as their understanding of the urban diversity concept. We can clearly see the negative feelings of the residents in their pretest as follows: (1) "It is good to live near people who are different," (2) "We should promote more diversity in our neighborhood," (3) "Urban planning is related to immigrant integration," (4) "We should be more open to immigrant," and (5) "Immigrants are an integral part of urban development." But the game seemed to help them agree that it is good to live near people who are different and that urban planning is related to immigrant integration. Nevertheless, the perceptions just became neutral in the following three: (1) “We should promote more diversity in our neighborhood,” (2) “We should be more open to immigrants,” and (3) “Immigrants are an integral part of urban development.” As per “Our neighborhood is diverse,” there was not much change, remaining neutral (see Table 3).

The differences between the immigrants’ perception and residents’ perception are not that surprising, as they are supported by existing literature about immigration in Thailand. However, if we consider the impact of the change to their perception, there was a higher degree of change in the resident group; notably, they could agree to live in the vicinity with people who are different from them. However, they are still reluctant to be more open to immigrants, as the overall results in this case shows that they still remained neutral. This may be related to the chance to encounter and interact with the immigrant directly.

The following statements from participants might clarify these results: “Now I think that it is quite good to live in the area with many different kind of people but we need more occasions to interact with them too, otherwise, there will still be the bad stereotype about some of them still” (R3, F, 27, native resident) and “Before, even though we have been living for 4 years now, we rarely talk and interact with the local Thais, this game event gave us a great chance to do that, and it also helps us by pointing many issues we (immigrant) have been experiencing” (R28, F, 37, immigrant).

Surprisingly, gaming sessions have not stopped after we left the neighborhood; numerous people took the idea home and started playing the game to promote cultural diversity with their kids (interestingly, they have been exchanging diversified ideas of the game from diverse groups of people which are residing in the area). These games included traditional play as well as the popular board game.

4 Discussion and Final Remark

The results show that the game can improve perceptions among both of the groups toward neighborhood diversity. One of the most prominent attributes of the game is the ability to promote mutual understanding among the local stakeholders and later on stimulate a powerful dialogue that eventually leads to the new local initiative for diverse neighborhood planning.

According to the experiment results, the Diverse Arrival Game shows a very good potential as an education tool for immigrant integration and neighborhood coexisting diversity. Players also learn about land use planning and its relation with the immigrant phenomenon. It has proved to be a very attractive tool for urban planners to use as a tool to teach people about land use management planning; it might be able also to simplify and attract more stakeholders to join the planning process.

Gaming simulation is also an excellent communication tool due to the mechanism of the game that enables the players to put themselves in other peoples’ shoes, in our case the role of immigrant and resident; likewise, gaming simulations make the environment of the interaction more relaxed and friendly. It has potential to help the majority of Thai native residents understand the difficulty of being immigrants themselves and begin to consider more about the immigrant's circumstances. And as strongly valued by Duke and Rizzi, gaming simulation can possibly be an alternative language for urban planning/design. Importantly, one of the most notable attributes of gaming simulation as a tool for immigrant integration and coexisting diversity is that it can stimulate mutual understanding and concerted respect among the residents. This is one of the ways that we can move beyond the clichéd stigma of dissimilarity, be it socioeconomic, age, or sexual difference, and truly pursue the notion of diversity.

Not only the Diverse Arrival showed us the key attribute as a tool for better neighborhood diversity and immigrant integration. In the case of Wat Ket neighborhood, the game could also promote the notion of active learning that keeps going after the game session. The game activities in the local area are good learning medium for people from different generations and countries of origin as well as diverse cultural backgrounds. We recommended that it will prove to be an extremely attractive education tool for active learning for children and innovative tool for higher education such as university level as well as lifelong learning opportunity for adult and elder.

Ultimately, we have to remark that for further study, social media tools need to be carefully investigated. As some studies started to explore into the issue of virtual space, Kesten noted that "the use of social media, virtual spaces, networks and platforms was mentioned by many immigrants, across age, gender, class and ethnicity, as a key instrument to keep up-to-date with activities and social networks in their neighborhood, and to build local social cohesion. The usage of new technologies and new media seems to cut across generations" [11]. Gaming simulation, with the proper development process, implementation, and debriefing, can be both a technical and mechanical filter, which can assist us for the integration of the two visual and actual worlds altogether, in the time that the boundary between the two realities is not so clear as it used to be a decade ago anymore.

References

1. Alexander M (2003) Comparing local policies toward migrants as an expression of host-stranger Relations. PhD thesis, University of Amsterdam, Amsterdam
2. Bosswick W, Lüken-Klaßen D, Heckman F (2007) Eurofound, housing and integration of migrants in Europe, Luxembourg. Publications Office of the European Union, Luxembourg
3. Dixon J, Durrheim K, Tredoux C (2011) From divided space to shared space, how might environment psychology help us to understand and overcome the tenacity of racial segregation? Hogrefe Publishing, Göttingen
4. Huddleston T, Tjaden JD (2012) How immigrants experience integration. King Baudouin Foundation, Brussels
5. Migration Policy Institute (2014) Skilled immigrants in the global economy: prospects for international cooperation on recognition of foreign qualifications. MPI, Washington, DC

6. Wessendorf S (2011) Commonplace diversity and the ‘ethos of mixing’: perceptions of difference in a London neighbourhood. MMG working paper 11(9). Max Planck Institute for the Study of Religious and Ethnic Diversity, Göttingen
7. Duke RD (1974) Gaming: the Future’s language. Sage, New York
8. Rizzi P (2011) Slang, language or metalanguage/on the fleetingness of word. Czasopismo Techniczne Architektura 108(1):330–337
9. Faria AJ, Dickinson JR (1994) Simulation gaming for sales management training. J Manag Dev 13(1):47–59
10. Promsaka S, Huyakorn P, Rizzi P (2014) Urban gaming simulation for enhancing disaster resilience. A social learning tool for modern disaster risk management. TeMA J Land Use Mobility Environ, Special issue June 2014:841–851
11. Kesten J, Raco M, Colomb C, Moreira De Souza T, Freire Trigo S (2015) Fieldwork inhabitants. UCL, London

Designing a Human Computation Game for Enhancing Early-Phase Movie Box Office Prediction

Johmphot Tantawichien, Hajime Mizuyama, and Tomomi Nonaka

Abstract Movie production is riddled with subjectivity and uncertainty. Each decision made can affect both quality and financial aspects of movies. Previously, various mathematical box office prediction models were proposed, but they focused at the time near the movie release, while earlier predictions would have more benefits to production team. Prediction market was suggested to have good predictability, but it still has some problems. In this study, we designed a human computation game for improving mathematical model performance in early phases which limits what information player knows about the movie at different time and introduces improved mechanics to make the game more similar to the actual movie production. After the experiments, we found that the proposed human computation game did improve mathematical prediction model performance, used in this study, but with limited working conditions. Future work should consider using more complex mathematical models, improving game design, and gathering more data for further validation.

Keywords Box office prediction · Movie industry · Business game

1 Introduction

Movies are difficult to evaluate their quality and predict how they will perform in the market. Researchers suggested that popular appeal of crowd does not always agree with critical ratings [1] and there is lack of strong correlation between critical rating and box office revenue [2], but a few low-budget movies can benefit from

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Table 1 Movie production phases

Phases	Duration	What production team do
Development	6 months-multiple years	Focus on developing story/screenplay and gaining budget from the studio
Pre-production	3–12 months	Prepare for the movie shoot, i.e., planning schedule, find locations
Production	2–12 weeks	Record raw footage for the movie
Post-production	2–12 months	Raw footage is edited. Sound and special effects are added to create the final release version of the movie
Release/distribution	1–2 months	The movie is completed and ready for the release. The movie is then shipped to theaters and screened to audiences

positive critical ratings [3]. Revenue from theatrical release or box office revenue is a primary income of a movie and used as an industry standard measurement of success. Every decision made might have some effect to the final product, and no one knows in advance if the decision will turn out to be positive or negative to the movie. Decision-makers of the studio need to carefully select what should be made into a movie, how to sell their movies, and how to make "right" decisions to make the movie rise above its competitors in the market. In general, movie production can be roughly divided into five phases (Table 1).

Researchers tried to create models to predict box office performance from various sources, such as financial data and metadata [4], Wikipedia activity level from editors and viewers [5], movie scripts analysis [6], search volume [7], and prediction market [8–10]. A few researches have been used as a prominent basis of this study.

A study by Mestryán et al. proposed a prediction model using Wikipedia activity [5]. They collected activities on Wikipedia pages, corresponding to the movie. They examined the correlation between activities and movie revenue and found that correlation of page views and revenue is at the highest at the time of movie release. Then, they created a prediction model based on multivariate linear regression. Not only Wikipedia activity model has a good performance at a few days before release (R2 = 0.94) but also at a month before release (R2 = 0.925).

Another notable prediction market is Hollywood Stock Exchange (HSX). Researchers suggested that HSX has a good predictability. Doshi built single-variable linear regression models from HSX, IMDb, Rotten Tomatoes, Box Office Mojo each, and multivariable linear regression model (contained all variables) to predict final delist price on HSX and actual revenue. HSX delist price model turned out to be the second-best predictor behind multilinear model [8]. Karniouchina studied about the relation between HSX predictions and actual revenue. While the study found that virtual market can predict success of new products effectively, there were some inefficiencies of using HSX as a predictor as players tend to overlook some aspects of movies, use gambling strategy, have multiple accounts for testing strategies, and be manipulated by studios [10]. From our observation, we thought penalty of withdrawing from movies in HSX is unduly lenient. Players can sell their shares at any time. Whether they actually lose or gain money depends on share price and their timing of transaction, regardless of the movie's actual performance in the market. Such occurrences may have a harmful effect on the prediction performance, especially in the early phases.

In this study, our main objective is to make a human computation game to improve the performance of prediction model in early phases of movie production. Previously, researchers mostly focused on predictions when the movie is close to being released. Despite the satisfactory results from those models, the movie is almost finalized at this time. Production team would have got more benefits if the predictions have been made earlier. Our hypothesis is a human computation game should provide additional data from players that can be used to improve prediction model performance. New penalty mechanic should encourage players to be more committed to a movie.

2 Data Collection

Movie-related data are collected from Box Office Mojo, IMDb, Rotten Tomatoes, and Wikipedia's page views. The total of 200 movies in top 100 box office during 2014–2015 (approximately 90% of annual total revenue is concentrated in top 100) and 29 upcoming movies released in the USA were gathered. We were not able to gather Wikipedia page views from 2013 and older, due to the tool (stats.grok.se) becoming unavailable and six upcoming movies that have been moved from its release date.

The past movie dataset has two outliers: Star Wars: The Force Awakens and Jurassic World. While both movies are rare occurrences in movie industry, these movies are significant in terms of revenue (936 and 652 million USD, combined to 14% of total annual US domestic revenue of 2015). For the analysis, we decided to use two datasets: dataset 1, a full 200-movie dataset, and dataset 2 with outliers removed (198 movies).

3 Baseline Model

To create a baseline model for US domestic revenue prediction, we took a similar approach to Mestryán et al.'s research [5]. Two hundred movies from 2014 and 2015 box office top 100 were used. Features were separated into four phases according to Table 2.

Studio, directors, actors, and movie's anticipation were derived into numerical data by using Wikipedia page views, started from a year before the movie release to the month of movie release. Then, 13-month page views data was aggregated into a number. The baseline model uses modified second-degree polynomial regression and leave-one-out cross-validation strategy with dataset 1 and dataset 2. Afterward, we refined model using feature selection. At the end, we got the final version of baseline models in which every irrelevant term was removed from the model.

Table 2 Information gain during four phases of movie production

Phases	Binary	Numerical	Derived using Wikipedia page views
1. Development	Sequel	Production budget	Studio
	Adapted		
2. Pre-production	–	–	Directors
			Actors
3. Production	–	Number of theater during release	Movie's anticipation
4. Post-production	–	IMDB's rating	–
		Rotten Tomatoes' rating	

4 Human Computation Game

4.1 Purpose

The objectives of designing a game are to enhance performance of baseline model and explore a new mechanic which might help mitigate problems of traditional prediction market for early-phase movie box office prediction. To solve the penalty problem, we use movies itself as commodities and production budget as the price. Players have to pay for the whole movie budget until the movie is completed. If they withdraw from the movie, they would lose all previous investments for that movie. This mechanism should force players to think more thoroughly and avoid overreacting. Also, we try to limit the information players see when they make decisions by making information availability similar to that of real movie production. Players have to spend their resources to obtain additional information and rely more on the information known in early phases.

4.2 Game Design

The game is designed as a single-player game with two stages, utilizing different datasets: stage 1 (past movies stage) with top 100 from 2014–2015 (100 from each year) for training a prediction model and stage 2 (upcoming movies stage) with 29 upcoming movies for validation. Players are required to complete at least one substage of stage 1 before continuing to stage 2. Stage 1 has 12 (+5) periods and stage 2 has 4 (+5) periods with extra time, up to 5 time periods, should players need to finish any movie projects.

In game database, movies are categorized into four groups by budget and randomized with category-limit restrictions. Each time period has different number of movies from budget groups. Each movie project has six phases, similar to five phases of movie production with the addition of "initial" phase, a state before players initiate the project which does not require time to complete. Therefore, a movie project requires five time periods to complete: one time period for each phase starting from development until getting revenue at a time period after release phase.

In the game, players are tasked to choose which movies they believe should be profitable, based on the information they see. Players have two resources: cash and gold coins. Cash can be used for investing in movie projects, and gold coins can be used for revealing movie's metadata. Players will get more gold coins each time they forward to the next time period. Cash can only be earned by receiving revenue back from movie releases. The objective for players in stage 1 is to maximize the profit from movie project investment. Their profit will be compared with other players. For stage 2, players have to choose which movies should make the most profit based on limited cash. Later, they can see what they have chosen compared to other players (Fig. 1).

When the game starts, players begin the game with an initial amount of cash and gold coins. Players can explore new movie projects in market page. Initially, players can only see project ID, total budget, and genres. More features will become available cumulatively at each phase as the movie project progresses. New movie projects will appear at every time period as old movie projects, if players do not invest, will disappear from market page. There is no restriction on how many projects a player can invest if that player has enough resources. Players can do the following actions (Table 3) in the game.

If the project is initiated, it will appear in the portfolio, and development phase starts. Later, players need to keep investing more cash into the project at each phase to advance the project to the next phase. The total amount of investments is equal to production budget of the movie. If players become disinterested in investing in the movie, the project can be terminated, but players will lose all previously invested cash. Before moving to the next time period, players must complete all mandatory transactions ("invest more" and "cash out") with all movie projects in portfolio. If players do not have enough cash to complete all transactions, players will be forced to terminate some projects. Once no mandatory transaction remains, players can continue to the next time period. Any decisions made are not reversible, and players cannot go back to the previous time period.

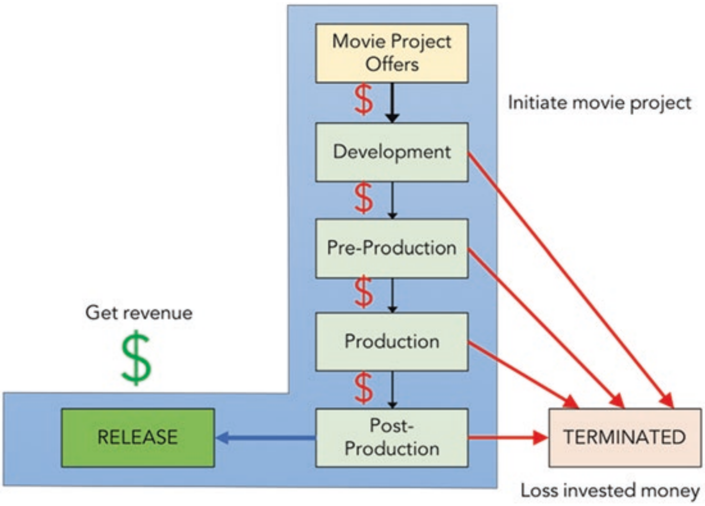

Fig. 1 Game flow of a single movie from initiation until cash out with \$ = Cash

Table 3 Actions in the game

Actions	Explanations
Initiate	Pay cash
	Add the movie to portfolio
	Start development phase
Invest more	Pay cash
	Advance to the next phase
Terminate	Remove the movie from portfolio
	Lose all invested cash (does not need to invest more into the movie)
Cash out	Receive cash from theatrical release into your fund
	The movie is indicated as "completed" and removed from portfolio
Set waiting for release	Waiting for the actual box office result of theatrical release
Invest all	Shortcuts for "Invest More" for all movies in portfolio
Cash out all	Shortcuts for "Cash Out" for all movies in portfolio
Reveal a hidden feature	Pay gold coin(s)
	The hidden feature is revealed
Forward to the next period	Indicate that player finishes all transactions in any given time period
	+1 to your game time

Once the movie project reaches release phase, players can cash out the movie (stage 1) or set the movie to waiting for release (stage 2) after waiting for one time period. After cash out, players will receive a certain amount of cash from movie release. Cash amount is based on modified actual revenue of the movie (50% of US domestic revenue) which is the estimation of actual revenue with theaters' sale portion, marketing cost – operating costs excluded. In stage 2, players can see which movies other players have chosen.

4.3 *Experiments*

The game was developed using Django framework. The parameters such as amount of cash and gold coin were determined from testing. After testing, the web application was deployed and made accessible by public via a URL (boxofficegame.azurewebsites.net). The URL was posted on Reddit (r/movies, r/filmmaker, r/samplesize) and SurveyTandem as we targeted frequent moviegoers and general audiences. Every player's actions in the game involved with movie projects were recorded to the database in which we can inspect and replicate what players did with movie projects. Only completed games were used for analysis. Overall, 42 people had participated and played the game. We collected 30 usable instances of stage 1 (substages 4 and 5) and 24 usable instances of stage 2 for further analysis.

Table 4 Result for 9 movies (#7–92) of baseline model and baseline model with game, trained using movies from December to November of 2014–2015 (excluding Star Wars: TFA)

	Baseline model			Enhanced baseline model		
Phase	MSE	R^2 score	Adj. R^2 score	MSE	R^2 score	Adj. R^2 score
1	0.712	0.364	0.319	0.655	0.422	0.336
2	0.775	0.316	0.269	0.667	0.411	0.323
3	0.313	0.724	0.656	0.341	0.723	0.646
4	0.327	0.712	0.610	0.582	0.486	0.262

5 Enhanced Baseline Model

From the collected transaction data, we added "average amount of investment of a movie" into baseline model. The enhanced baseline model used the same metadata and Wikipedia page views data, with an addition of transaction data from stage 1: substages 4 and 5 (year 2014 and 2015). The enhanced model uses second-degree polynomial regression with modifications and leave-one-out cross-validation with dataset 2, same as baseline model. We've tried to create another version which utilizes information transactions of the game. However, the result did not show that the model benefited from using information transaction data.

For further validation, we chose 9 upcoming movies (#7–92) from 29 movies from stage 2 of the game, similar range to training data. The actual revenue data of upcoming movies was collected on January 28, 2018. After a trial with dataset 2 as training data, we suspected that the model with game was sensitive to outliers. Thus, we selected 39 past movies from November to December 2014 and 2015 as training data instead, shown in Table 4.

6 Result Analysis

From the results, we can conclude that the proposed human computation game has increased the performance of our baseline model. Further testing with more complex mathematical models is needed whether the game is beneficial to mathematical prediction models. Despite the improvements, the proposed model with game performed well only within a certain range (around top 100 of annual box office ranking and excluding ultrahigh revenue movies) which might be the result from only having limited number of movies in training dataset. For predicting revenue of outliers, traditional mathematical models still outperformed proposed model.

Generally, players made correct decisions of choosing profitable movies. Nonetheless, gameplay data revealed that players did not always make right selections if the movie was an unexpected failure; thus the model suffered as a result. Two examples in upcoming movie dataset are "Downsizing" and "The Disaster Artist." Despite neither of the movies is box office success, both have all recipes for success. Nonetheless, Downsizing got negative words of mouth after the release. On the other hand, The Disaster Artist was well received by both critics and audiences, but the movie itself is probably too niche for general audiences. We speculated that our players consist most of movie enthusiasts and thus skewed the data toward such specialty movies.

During building of baseline models, we found that originality, studio, and director are irrelevant to high box office revenue. We speculated that originality and famous directors do not have much impacts in overall box office; only a very few movies from famous books or famous directors would be recognizable. For studio, we only examined top 100 of box office. As we found that budget is highly correlated to revenue, only a few studios can finance movies at this range (the big six studios in Hollywood). There might not be a variety of different studios between movies in top 100 box office. On the other hand, we discovered that budget, anticipation, and the number of opening theaters are highly correlated to high box office revenue, but we speculated that budget itself is a cause for high anticipation and high number of opening theaters as high-budget movies can afford enormous marketing cost.

7 Limitations

Studios might have different motives to produce a movie. Studios can use movies to advertise audiences to other contents and movie-related merchandises which can generate additional revenue streams for the studios and thus justify the decision to make movies. Also, marketing, operating, and distribution costs are harder to track and isolated down to a single movie as these costs spread across multiple regions, while production cost is typically published in print media for each movie.

Another problem of our own during the experiment is the amount of data gathered from the game was less than what we expected, which the game design itself might be a part of blame. The game itself takes long time to complete and thus reduces entertaining aspect of the game. Also, we found it was difficult in finding platform/community for game release. Lack of players might affect the creation of game-enhanced model. It is possible that better game-enhanced models can be created with more gameplay data.

8 Conclusions

Making decisions in movie production is complicated due to subjective and uncertain nature. Every decision made can affect quality and marketability of the movie. Prior researches tried to create mathematical models to predict revenue of movies, but only a few researches focused on the beginning of movie production. Furthermore, we found that penalty mechanic in traditional prediction market does not penalize users much for withdrawing from a security.

In this study, we found that our baseline model does not perform well if information is limited in early phases of movie production. We propose a human computation game, designed for enhancing mathematical model in early phases. A proposed game includes mechanism which lets players make investments of movie projects, but players have to spend resources to gain additional information about the movie for decision-making. The proposed game was played by participants from multiple communities. Each action performed by players was collected for enhancement of baseline model. Overall, players seemed to make decisions for movie investments more carefully.

Gameplay data is used to enhance baseline model with "average amount of investment per player." The result shows that proposed human computation game can increase the performance of our baseline model in early phases, albeit with some limitations. While game-enhanced baseline model outperformed normal baseline model in early phases, enhanced model only worked well within limited range and was vulnerable to outliers. Players made good choices of profitable movies, but sometimes they got tricked by promising movies that turn out to be box office failures.

Future works should consider using more complex mathematical models with human computation game to improve the performance and for further validation of this framework. The game design could be improved to widen its operating range or explore how to deal with outliers and test with more audiences to gain more data. Also, increasing of player's engagement and the appropriate introduction of complex game mechanics should lead to higher quality of collected data. Another way worth considering to improve the game is to change the design into a multiplayer game and let players compete with each other. In addition, other aspects of movies such as its contents or locale preference should be explored in future researches as well.

References

1. Holbrook MB (1999) Popular appeal versus expert judgments of motion pictures. J Consum Res 26(2):144–155
2. King T (2007) Does film criticism affect box office earnings? Evidence from movies released in the U.S. in 2003. J Cult Econ 31(3):171–186
3. Gemser G, Van Oostrum M, Leenders MAAM (2007) The impact of film reviews on the box office performance of art house versus mainstream motion pictures. J Cult Econ 31(1):43–63
4. Lash MT, Zhao K (2016) Early prediction of movie success: the who, what, and when of profitability. arXiv preprint arXiv:1506.05382v2
5. Mestryán M, Yasseri T, Kertész J (2012) Early prediction of movie box office success based on Wikipedia activity big data. arXiv preprint arXiv:1211.0970
6. Eliashberg J, Hui SK, Zhang J (2014) Assessing box office performance using movie script: a kernel-based approach. IEEE Trans Knowl Data Eng 26(11):2638–2648
7. Panaligan R, Chen A (2013) Quantifying movie magic with Google search. Google, California
8. Doshi L (2010) Using sentiment and social network analyses to predict opening-movie box-office success. Master thesis, Massachusetts Institute of Technology

9. Gruca TS, Berg J, Ciprino M (2003) The effect of electronic markets on forecasts of new product success. Inf Syst Front 5:95–105
10. Karniouchina EV (2011) Are virtual markets efficient predictors of new product success? The case of the Hollywood stock exchange. J Prod Innov Manag 28:470–484

HalluciFear: Educational Game About Drug Addiction

Peeraya Sripian, Ratchadawan Nimnual, Thammarat Hemathugsin, and Kanokporn Fongranon

Abstract In Thailand, drug abuse is perceived as the number one social problem, ranked by the Thai population. Adolescent drug abuse, although decreased in total number, surprisingly increased among younger youths compared to before. This work presents "HalluciFear," an educational 3D horror game with the first-person view that relates drugs' side effect with fear. The game imitates vision effect resulting from lysergic acid diethylamide (LSD) substance abuse. The targeted players are Thai people ages 13 or above, the ages that are believed to be in a high risk of becoming victims of drug abuse. Upon evaluation of the game, the authors used a satisfactory survey for regular players and game content survey for specialists. The evaluation result showed the average game quality, and overall user's satisfaction was good with the averages of 4.16 and 3.91, respectively.

Keywords 3D game · Drug abuse prevention · Educational game · LSD · Horror game

1 Introduction

The Thai government's drug policy is centered upon "zero-tolerance" by eradicating drug consumption and production with the imposition of harsh punishment for drug-related crimes, ranging from mandatory detention to the death penalty. Although the drug laws attempt to note that the people who use drugs are patients, not criminals, the enforcement of the law often, however, results in incarceration of a drug abuser. The policy is said to be very conservative and often viewed as the

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contravention of international human rights law. The slow implementation of harm reduction or more effective treatment policies, the actions of the polices and attitudes of health workers, and the existence of compulsory treatment often block drug users from accessing voluntary treatment and health and harm reduction services.

Although Thailand is no longer a significant source of any illicit drug, it is still an important transit point for drugs originating in other South-east Asian countries. According to a 2014 report [1] from Stanford researcher, 1.2 million people were involved in illegal drug activities across Thailand. The total number of drug cases saw a 41% increase from 2013 to 2014. New groups of drug traffickers are mobilizing while existing groups are still active. The younger drug users will eventually become drug dealers as they get older. The number of drug users below 15 years of age has increased dramatically. Young people are increasingly using "Yaabaa (crazy medicine)" and "Kratom (*Mitragyna*) [2]." The ingestion method of these drugs is mostly smoking, followed by oral injection and injecting. In addition to the critical harm and threat, which is an acquisitive crime, and the impact on health and well-being associated with consumption, drug abuses result in the spread of HIV by people who inject the drug. The country is listed as a high-priority country by the United Nations Office on Drugs and Crimes (UNODC) HIV Program.

Lysergic acid diethylamide (LSD), also known as acid, is typically used mainly as a recreational drug and for spiritual reasons. While it does not appear to be additive, the body tolerance with increasing doses could occur. The most significant adverse effect was impairment of mental functioning while intoxicated. There are no known treatments for addiction if it occurs. Thailand's Narcotics Act institutes LSD to category 1, similar to heroin and amphetamine.

This problem is a serious threat, which affects a person's mind, body, and brain development, especially in children and young adults. Adolescents are at high risk of using drugs, which can lead to drug abuse, social problem, and crime. Recently, it has been found that young adults in Thailand tend to use a mixture of substances, ranging from substances that are easy to acquire and are believed to be less harmful, resulting in difficult treatment and long-term addiction.

The best solution to the drug abuse problem is to prevent it from happening. It is significant to reach young people with effective, fact-based drug education before they start experimenting with drugs. Gaming is a method of education that is gaining attention due to its popularity with younger audiences. In Thailand, more than 62% of the population has access to the Internet and PC game [3], both by purchasing or free play via Stream, UPlay, and so on. Research in [4] used an arcade-style computer game based on operant learning task to engage young people in drug education and found that it successfully achieved awareness of the drug through tolerance message. Hence, gamification can be an effective way of transmitting such educational information without being perceived as a lesson.

This research aims at developing "HalluciFear" game to provide educational information on drug abuse and the corresponding disadvantage. The targeted players are Thai people ages 13 or above, the ages that are currently high risk to become victims of drug abuse.

2 Literature Review

2.1 LSD

LSD, known as "acid," is one of the most potent, mood-changing chemicals. The effects of LSD are unpredictable. Normally, the first effects of LSD are experienced 30–90 minutes after taking the drug. The body temperature can become higher or lower, while the blood pressure and heart rate either increase or decrease. Sweating or chills are not uncommon. LSD users often experience loss of appetite, sleeplessness, dry mouth, and tremors. Visual changes are among the more common effects – the user can become fixated on the intensity of certain colors. Extreme changes in mood, anywhere from a spaced-out "bliss" to intense terror, are also experienced. The LSD user is unable to tell which sensations are created by the drug and which are part of reality. They also feel the urge to keep taking more of the drug in order to re-experience the same sensation. "Bad trip" can go on for up to 12 hours. Some people never recover from an acid-induced psychosis [5].

2.2 Common Fear

Fear is an emotion that protects us from the threats in our surroundings. There are ten human fears that every member of society deals with throughout their life such as failure, death, rejection, ridicule, loneliness, misery, disappointment, pain, the unknown, and losing your freedom [6, 7].

2.3 Game Designing Theory

The related theory that was used to design the game is called "the element tetrad." The element tetrad is the set of components or elements that were used in designing games, which were presented by Jesse Schell [8], the author of *The Art of Game Design*. The components in the element tetrad are as follows:

2.3.1 Mechanics

Mechanics are used to making the game system more interesting and more effective:

- Objective is some action or things that assign the player's action to win the game.
- Player relationship is the way that the player plays or interacts with the game such as a single player versus the game, the player versus another player, and so on.

- Rules refer to things that the player should or must do in order to make the progress in the game.
- Boundaries refer to the area or things that fixate the player in the game.
- Resources are things that are used by the player in the game such as the player's health, score, weapons, and so on.

2.3.2 Aesthetics

Aesthetics are things that can make the game more visually and audibly appealing. Aesthetics can be used in game design in order to suggest the player's feeling toward the game or the game's theme.

2.3.3 Story

Every game has a story to tell what happens in the game. This project use "Traditional Dramatic: Five-Act Structure" to design the game. Fig. 1 depicts the structure used in this research.

2.3.4 Technology

Every game uses various techniques to support the game system. This can make the game playable or even more enjoyable [9].

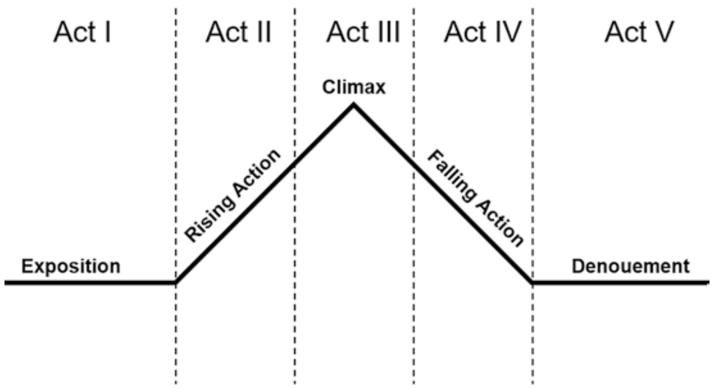

Fig. 1 Traditional dramatic "Five-Act" structure that is usually used to assist the author to write a story for plays or games. It is composed of exposition, rising action, climax, falling action, and denouement

3 Game Implementation

"HalluciFear" game was developed by using Unity game engine to make the 3D horror game with the first-person view. Moreover, the element tetrad in [8] was used as the designing guideline to specify the game element and game feel. Common fears and LSD information such as visual hallucination in Fig. 2 and the scary city roughly as the draft shown in Fig. 3 were used to design the game's aesthetics to make the game more frightening and more realistic.

The game story begins with a boy who has a family problem. Every day, he would sneak into a deserted building. He usually climbed up to the rooftop to take a nap, just to escape from his own family.

Fig. 2 Game design example. This scene shows hallucination, an effect of LSD abuse

Fig. 3 Game design example. This scene is a rough draft of the game's cut scene

One day, he heard the strange sound coming from the building. The sound seems like the scream of pain. The boy then went inside the building, and found a crazy man. He tried to get away from that crazy man but he was cornered that he had no choice but to go deeper in to the building. Then he encountered a secret experimental zone for some "drug." As the boy tries to find the way to escape from the building, he was shot with a general anesthesia by a staff member, and he was brought to test with a drug. The drug made him see hallucinations. So it was even harder to escape from the building. Finally, he could escape and was treated back to normal.

4 Result of Game Development

"HalluciFear" is a 3D horror game with the first-person view. The objective of this game is to provide educational information on drug abuse and the corresponding disadvantage. The game imitates vision effect from LSD drug abuse. This section explains the features in the game with supporting figures.

4.1 Start Menu

The user can select "New game" to start a new game from the beginning or "Continue" for continuing the play from the previous time (Fig. 4). The game begins with a story, narrated using animation video as in Fig. 5 to engage the user.

Fig. 4 Start menu of the game. User can choose between "new game" to begin a story or "continue" from previous play

Fig. 5 For a new user, the game begins with a story of a man in his dream walking to an old research building. This shows an animation at the beginning of the game

4.2 Character Control System

The user will control a game character as first-person view. The control is done via keyboard “w” for forward, “a” for left, “s” for reverse, and “d” for right direction. Also, the user can control the camera view using a mouse. In addition, “f” can be used for turning on or off the light.

4.3 Twirl System

To simulate the LSD effect on human vision, we put twirl system in some position/ scene. The user will see a twisted scene for sometime when moving to that position. Figure 6 shows an example of the twirl system.

4.4 Game Artificial Intelligence System

In some scenes, the player will encounter an enemy. When the enemy approaches the player, the enemy will attack the player causing the blood gage to drop one level. If the blood gage drops for three times, the game is over. Figure 7 left and right shows enemies in the game.

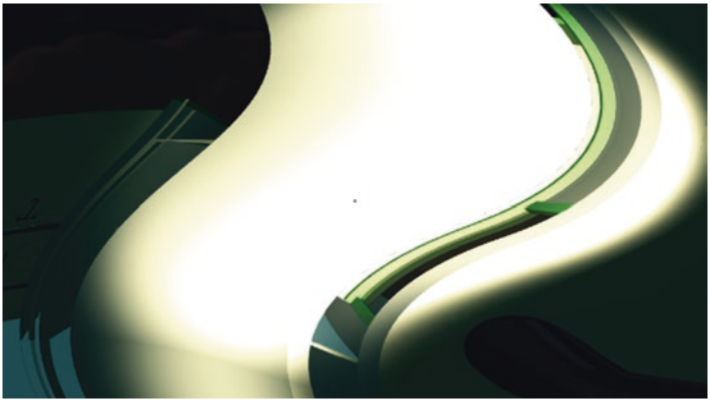

Fig. 6 Twirl system is used in some scene to visualize LSD visual hallucination

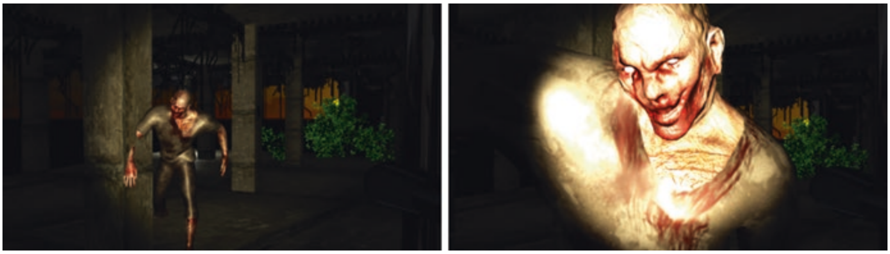

Fig. 7 Enemy characters that will appear randomly to follow the main character, creating fearful emotion (left). An enemy that gets close will attack immediately (right)

4.5 The Game Sound Effect and Background Music

The sound effect includes short-period sound effect for horror game such as jump scare sound effect, people screaming, and enemy yelling. In addition, user interface sounds are used, such as button clicking, warping, and entering a new scene.

4.6 The User Interface Used in the Game

In some scene, UI is used for ease of understanding such as “reading the document”; the user can press “E” or “e” on the keyboard, moving the scroll bar up and down to read the document. Warping point or teleporting point are labeled with “Up,” “Down,” or arrow.

Fig. 8 Jump scare in a raw image file format

4.7 Jump Scare

At some point, the user will encounter jump scare [10], a technique often used in horror films and video games, intended to scare the audience by surprising them with an abrupt change in image or event, usually co-occurring with a loud, frightening sound. Fig. 8 shows the raw image used as a jump scare in the game.

5 Game Evaluation

The evaluation questionnaire was used for game evaluation. The evaluation is divided into three types, and the analysis is done by computing the mean score of each evaluation criteria. The highest score is 5.00.

5.1 Evaluation by Experts

Three experts in game development, either working in game industry or working as a game designer, evaluated the game in four-game design aspects: gameplay system, game sound effect and background music, game aesthetic, and game storyline. The evaluation results are shown in Table 1.

5.2 Evaluation by a Former Drug Addict

The game content is evaluated by an anonymous former drug addict. The former drug addict comments that the hallucination effect is similar to the real hallucination. The score for these criteria was 4.00.

Table 1 The game evaluation results by experts

No.	Evaluation criteria	Average score	S.D.	Interpretation
1	Gameplay system	4.25	0.96	Very good
2	Game sound effect and background music	4.67	0.53	Very good
3	Game aesthetic	4.00	0.61	Good
4	Game storyline	4.13	0.89	Good

Table 2 Game evaluation result by students

No.	Evaluation criteria	Average score	S.D.	Interpretation
1	Gameplay system	3.92	0.59	Good
2	Game sound effect and background music	4.13	0.59	Good
3	Game aesthetic	3.87	0.71	Good
4	Game storyline	3.72	0.58	Good

5.3 Evaluation by User Satisfaction Survey

User satisfactory survey was done with students who like to play the game. We collect 30 participants with a voluntary selection, age range 13–18 years old. The participants will fill out the survey after playing the game.

The survey included five criteria: the gameplay system, game sound effect and background music, game aesthetic, game storyline, and game content. For the game content, we asked questions like “After playing the game, you feel that you practically understand the effect of LSD addiction more than before playing the game” or “After playing the game, you feel fear of LSD more than before playing the game. Maximum score (5.00) is given in the case of strongly agree, and the minimum score is given in the case of strongly disagree. The evaluation results are shown in Table 2.

6 Conclusion

This research aims to develop “HalluciFear” game to prevent drug abuse by using the Unity game engine to make the 3D horror game with the first-person view. The game imitates vision effect from LSD drug abuse. Moreover, common fears and element tetrad were used to design the game’s aesthetics. Questionnaires were used to evaluate the results of this project, such as game quality and user’s satisfaction.

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References

1. Saingam D et al (2014) Validation of Krathom (Mitragyna speciosa Korth.) Dependence Scale (KDS): a dependence screen for internationally emerging psychoactive substance. Subst Abus 35(3):276–283
2. An inside look at drug addiction in Thailand, http://scopeblog.stanford.edu/2016/04/05/an-inside-look-at-drug-addiction-in-thailand. Accessed 21 June 2018
3. Electronic Transactions Development Agency (Public Organization) Thailand internet user profile in 2016, https://issuu.com/peerasakchanchaiwittaya/docs/thailand_internet_user_profile_2016. Accessed 21 June 2018
4. Strang J (2000) Is an arcade-style computer game an effective medium for providing drug education to schoolchildren? Educ Health 13(3):404–406
5. Foundation for a Drug-Free World International (2008) The truth about LSD, Los Angeles
6. Medrano C (2011) Top 10 strong human fears, http://listverse.com/2011/09/30/top-10-strong-human-fears. Accessed 21 June 2018
7. Layton J (2005) How fear works, HowStuffWorks.com, http://science.howstuffworks.com/life/inside-the-mind/emotions/fear5.htm. Accessed 19 Nov 2018
8. Schell J (2014) The art of game design: a book of lenses, 2nd edn. A K Peters/CRC Press, New York
9. Gibson J (2014) Introduction to game design, prototyping, and development: from concept to playable game with Unity and C#. Addison Wesley, Upper Saddle River, NJ
10. Muir JK (2013) Horror films FAQ: all that's left to know about Slashers, Vampires, Zombies, Aliens, and more, Applause Theatre and Cinema Books

A Perspective on the Needs for Simulation and Gaming Technology in Outpatient Care

Pattanasak Mongkolwat, Mores Prachyabrued, Thanongchai Siriapisith, Chih-Lin Hu, and Timothy K. Shih

Abstract A prediction of the size of the global healthcare industry in 2020 is to pass over 50 times larger than simulation and gaming industry. For the size AR and VR application markets is to reach $US 35 billion in 2025. Simulation, gaming, AR, and VR technologies have provided great benefits to healthcare providers and consumers. For medical professionals, activity-based medical simulation mimicking clinical scenarios has been a cornerstone of medical training since the eighteenth century. Today, medical computing simulation and gaming enhance training scenarios and experiences. It also increases confidence and reduces skeptical among medical professionals about the technologies' usefulness and effectiveness. This article focuses on the needs of patients and healthcare professionals in developing countries where the caregivers have been overwhelming with medical services provided to outpatients. Advancement in medical research and innovation generated tremendous health information required by caregivers to provide accurate, effective, and swift treatment and cure for patients. Traditional health information systems and user interfaces do not provide effective display, search, retrieve, and record patient information. Applying simulation and gaming technology techniques and methods can create effective healthcare systems and applications to better serve outpatients. This creates a large research and economic opportunity for the computer simulation and gaming industry.

Keywords AR and VR in healthcare · Gaming and simulation technologies · Medical information representation · Outpatient care

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1 Introduction

By 2020 the size of global healthcare industry will reach $US 8.7 trillion [1], while the game market and various simulation markets will be around $US 128.5 [2] and $US 45.72 [3] billion, respectively. The size of the augmented reality (AR) and virtual reality (VR) application markets could reach $US 35 billion in 2025, including $US 5.1 billion from applications related to medicine [4]. The medicine market size will be over 43 times bigger than simulation, gaming, VR, and AR combined. The global health information technology (IT) market is predicted to be $US 280 billion by 2021 [5]. It may be unwarranted to compare medicine with these computing technologies because everyone will need medical care eventually. After all, a good quality of life is the most important to all human beings. The global healthcare market presents tremendous upside opportunity to apply gaming and simulation technology to advance medical research and services.

Gaming, simulation, AR, and VR technology have provided great benefits to healthcare providers and consumers. Situation and activity-based medical learning simulation duplicating clinical scenarios have been a linchpin of medical training for medical professionals since the eighteenth century. These types of trainings have been done to prepare them for more practical on-the-job trainings. Computing health simulations covers (1) design of operational issues such as workflow and efficient use of resources; (2) predictions of epidemiology, health policy, and health promotion; (3) clinical decision support system; (4) emergency planning; and (5) forecasting and allocating resources [6–8]. Medical education today is partially relied on electronic medical record [9], simulation, and gaming applications. These modern computer technologies assist in enhancing advance and complex medical training scenarios and experiences. They increase trainees' confidence and reduce skepticalness among medical professionals of the benefits of modern training methods. These same technologies also have health-related benefits and therapeutic to patients.

2 Purpose

This article describes the needs of healthcare professionals who need better outpatient medical software applications and systems. These professionals in developing countries have been overwhelmed with medical services provided to a large number of patients [10] who visit outpatient centers in public hospitals each working day. For example, Siriraj Hospital, one of the largest public hospitals and medical schools located in Bangkok, Thailand, receives over 10,000 outpatients each working day. A single physician, either a general or specialty practitioner, may see outpatients up to 50 patients per day as compared to 11–20 patients in the USA [11]. The article offers historical perspective of healthcare needs for IT to manage complexity, reduce costs, and increase efficiency in global healthcare systems. It also offers a new outlook for a design and implementation of outpatient applications, deviated from the traditional information gathering and representation.

3 Background

Computing technology has always been a critical part in human health since the mid-1960s. At the early stages of using the technology, an electronic medical record (EMR) was not what we know it today because of the extreme high cost for computing resources. For example, 1 gigabyte storage in 1966 was about $1.05 million, and today it would be just $0.02 cent [12]. Wang 2200 in 1973 would cost $18,722, and Apple II in 1977 would cost $5079 in today's dollars [13]. The early parting of this section provides a brief overview of IT roles in healthcare and followed by known health information standards and graphical interface of medical applications. The section closes by depicting overworked healthcare workers.

3.1 Historical Perspective of the Needs for IT in Healthcare

The Medicare (hospital and medical insurance) and Medicaid (for people with disabilities and long-term care and low-income families) were signed into law by President Lyndon B. Johnson in 1965 [14]. IBM mainframe was used to process around 19 million Medicare identification cards [15]. Computing resources in the 1960s were too extremely expensive as compared to today resources. In the early 1970s, the first EMR [16] was used in a few large healthcare institutions. It was still too expensive in both computer hardware and software. In the 1980s, insurance reimbursements were tightly coupled with medication ordered for patients. Personal computers and standalone software applications worked together with the mainframe computers via local computing network and/or dedicated computing network to process clinical and financial transactions. An early version of how to store and manage medical imaging data was proposed by American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) in 1983. However, it was not used because of high costs and performance of computer hardware equipment required. In the 1990s, affordable server, personal computers, and computer networking infused expanded clinical departmental solutions. Health information standards started to emerge and define to manage increased complexity of exchanging electronic health information and integrating wide variety of health information systems. During this period, healthcare institutions also have started to be acquired or merged for economic reasons. Health IT system integrations and migrations (both software systems and data format on storage devices) have become a significant part in IT operations. Reimbursement based on fee-for-service, focusing on quantity over quality, has become less desirable methods of payment in the 2000s. Because this type of service contributes to the rapid rise of healthcare costs in the USA annually, healthcare insurers and the US government want to slow down the rising costs and unnecessary medical procedures performed on patients. They are focusing on value-based or outcome-based patient care services. With ubiquitous and affordable computing devices, IT solutions assist healthcare providers to focus more on preventive care and wellness, prevention of unnecessary hospitalizations and readmissions, safeguard medication and prescription errors, patient education, and care coordination between different healthcare providers to offer comprehensive view of patients under care. With smartphones, IoT-enabled devices, and personally wearable devices, monitoring, reporting, and communicating between healthcare providers and patients have become seamless and more effective. The next section describes how medical information is defined and used.

3.2 Healthcare Information Sources and Standards

Patients' health information from various sources must be collected, processed, verified, and presented to healthcare providers in an efficient and effective manner for assisting medical diagnosis and treatments. There are three core medical standards, namely, medical information, medical lexicon, and medical imaging standard.

3.2.1 Health Informatics Standards for Interoperability

Health Level 7 (HL7) [17, 18] was founded in 1987 to provide health informatics comprehensive framework and related standards for health information systems (e.g., electronic medical record or EMR) to store, query/retrieve, exchange, integrate, and share of electronic health information between software systems. HL7 was created to support clinical and management practice as well as delivery and evaluation of health services. It has two versions of messaging standard, namely, versions 2 and 3. Version 3 provides well-defined information model that is much more precise and less ambiguous. Version 2 message format and communication framework are the most widely used messaging standards in healthcare industry worldwide for over two decades. It covers healthcare activities from clinical to administrative issues such as admission, order, result reporting, appointment, scheduling, blood bank, summaries, referrals, clinical trials, transfer, discharge, and claims attachment. Results from laboratory tests of any type of specimen collected from human, animal, and environmental can be reported using HL7 messages.

With the popularity and ease of use of RESTful protocol, HL7 FHIR® [19] combines simplicity and large implementation base of HL7 version 2, well-designed information structure, and less optionality from version 3 and CDA®. FHIR® consists of resources that can be thought of as collections of medical forms containing clinical and administrative information. They can be captured and shared. The data is exchanging as a JSON or XML object. FHIR® is suitable for use in a wide variety of contexts such as web-based EMR, EMR-based data sharing between healthcare providers, smartphone apps, and cloud computing. FHIR® resources can easily (if available) be gathered to create a complete view of the current status of a patient that assists real-world clinical and administrative scenarios.

The next important standard is electronic data interchange (EDI) protocol X12 [20]. It is used to transmit healthcare data between computer systems and applications required by the Health Insurance Portability and Accountability Act (HIPAA) of 1996. EDI transactions can be delivered using web-based, point-to-point, mobile EDI, EDI VAN, and AS2 [21]. EDI uses standard transaction sets, called insurance/health series (INS), e.g., patient information (275), healthcare claim transaction (837), healthcare claim payment/advice transaction (835), benefit enrollment and maintenance (834), and healthcare claim status request (276) [22]. Finally, data quality standard is spearheaded by a not-for-profit International Association of Master Data Quality Managers [23] to avoid poor-quality descriptions and inaccurate information. The organization defines how data characteristics are used in finance, healthcare, manufacturing, and processing.

3.2.2 Medical Lexicon

A dictionary of medical science is called a medical lexicon. It consists of words used in medicine. Medical terminology uses medical lexicon to precisely describe the human anatomy and physiology that include body parts and functions, biological processes, and procedures performed upon them. Since a number of medical words in medical terminology, lexicon, and concepts are quite large and keep on growing due to new discoveries, missing required terms, and classification needs, many medical professional organizations define their own codes associated to their terminologies to fit their needs and purposes such as ICD-10 [24], SNOMED CT© [25], CPT [26], RxNorm [27], LONIC© [28], and RadLex™ [29]. Currently, SNOMED CT© medical terminology has over 311,000 active concepts and provides the core general terminology for the electronic health record (EHR) for coding diseases. A code typically consists of at least four attributes that are unique code (e.g., alphanumeric code), code description – a precise description of what the code represents, a version number, and coding scheme designator identifying organization or person who created the code.

For example, a patient with sinus infection, the SNOMED CT© code would be (75498004, acute bacterial sinusitis (disorder), 2018.02.01, SNOMED CT). With multiple organizations define their own medical terminology for their usage, there are many redundant and overlapped terminologies. The Unified Medical Language System (UMLS) [30] has a compilation of body of bioinformatics and medical terminologies to form a unique body of knowledge that can be considered as a comprehensive ontology and thesaurus of biomedical and health-related concepts, their synonymous names, and their relationships.

For a given medical report, when medical terminologies are used, there are more than one way of describing the same thing. Natural language processing (NLP) techniques may not be able to process and extract complex and shorthand format to describe patient own descriptions and medical diagnosis. There is a need for a coder to perform a medical classification or coding. The coder assigns a unique code (e.g., 75498004) to each medical concept found in a medical report. Well-coded medical report from each medical visit can be gathered and used to provide physician overall longitudinal health information and current problem lists and medications of a patient.

3.2.3 DICOM

Digital Imaging Communications in Medicine (DICOM) [31] has its root from ACR-NEMA 300 in 1985. It is a major medical imaging standard that defines how medical imaging and ancillary information are captured, formatted, stored, secured, distributed (e.g., query, retrieve, and DICOMweb™), displayed, and managed (including workflow). Medical imaging modalities are being used in medical specialties, e.g., cardiology, radiology, pathology, or ophthalmology, to further investigate a patient's symptoms that cannot be seen visually and/or from physical examination. Imaging reports are additional and valuable source of medical information that provides thorough view of medical conditions of a patient.

3.3 Creating Patient Data Warehouse for Medical Presentations

Medical information can come from many health standards stated in the previous sections, specializing in specific medical domains. Retrieving that information in real time and processing them require considerable amount of time that physicians cannot afford to wait for combined results to display. The need to create precomputed medical information for each patient and store the information in a data warehouse for an immediate use and display becomes very important. To illustrate this concept is to start looking at an example of a blood test or hematology blood test. The hemoglobin represents red blood cells that use to carry oxygen for your body and bring back carbon dioxide back to your lung. Figures 1 and 2 depict blood test results. Typically, physicians can see a result from a single timepoint on a monitor screen. They must create a mental picture of hemoglobin values. This is just one data point among hundreds of data points that physicians may have to be informed. To display this type of value in graphical format with trending indication would be more effective and informative. The next section describes the current user interface (UI) design for medical applications.

HEMATOLOGY

Source	Lab No.	Requestor	Order date	Specimen Received	Report Time
0115	17911507911020	N/A	25-12-17 08:39	25-12-17 09:17	25-12-17 10:15

Orderable Item	Value	Units	H/L	Ref Range	Perf. Lab
CBC					
Hemoglobin	**9.5**	**g/dl**	**L**	**12.0-14.9**	**11**
Hematocrit	**31.1**	**%**	**L**	**37.0-45.7**	**11**
Rbc count	**3.54**	**x 10*6/ul**	**L**	**4.0-5.5**	**11**
MCV	87.9	fl		80.4-95.9	11
MCH	26.8	pg		25.0-31.2	11
MCHC	30.5	g/dl		30.2-34.2	11

Fig. 1 A blood test result from a single timepoint

HEMATOLOGY Number of dates to display 5

◀ Past results Later results ▶

	Ref Range	Units	20-09-16 16:00 Chuda Rujitharanawong	09-01-17 08:52 N/A	01-05-17 09:06 อ.นพ.ทวีศักดิ์ แทนวันดี	28-08-17 09:00 N/A	25-12-17 09:17 N/A
Hemoglobin	12.0-14.9	g/dl	11.9	11.9	11.6	10.2	9.5
Hematocrit	37.0-45.7	%	38.0	37.8	36.8	32.4	31.1
Rbc count	4.0-5.5	x 10*6/ul	4.07	4.08	3.97	3.50	3.54
MCV	80.4-95.9	fl	93.4	92.6	92.7	92.6	87.9
MCH	25.0-31.2	pg	29.2	29.2	29.2	29.1	26.8
MCHC	30.2-34.2	g/dl	31.3	31.5	31.5	31.5	30.5
Red cell distribution RDW	11.7-15.0	%	16.3	15.0	15.8	16.5	17.4
Wbc count	4.4-10.3	x 10*3 /ul	3.52	3.28	2.52	3.10	3.35
NRC/ 100 WBC			0.0	0.0	0.0	0.0	0.0
Platelet count	179-435	x 10*3 /ul	136	112	101	100	146

Fig. 2 A combined blood test from different timepoints with visual cues

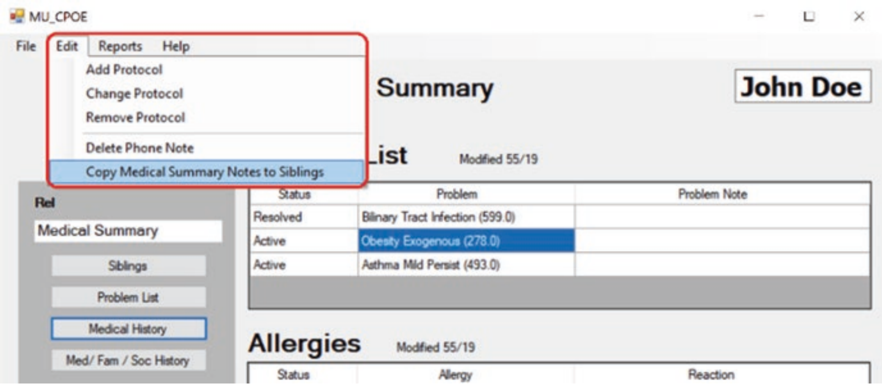

Fig. 3 A menu-driven and drop-down list depicting copying functionality of the software to copy medical summary from one sibling to another sibling to have consistent information between siblings

3.4 User Interface in Medical Applications

Current EMR or electronic health record (EHR) implementations of UI approach have been used for the past three decades with some variations. The fundamental design is based on a window area and divides into sections. Navigational areas may contain a combination of menus with drop-down list to choose available features, tabs, list of items, or buttons for selecting information to be presented (Figs. 3, 4, 5 and 6). These areas are typically organized by medical specialties, functionalities, and workflow. Most of the areas are dedicated to present relevant information based on a selected item. Many EMR applications also have an area where scanned

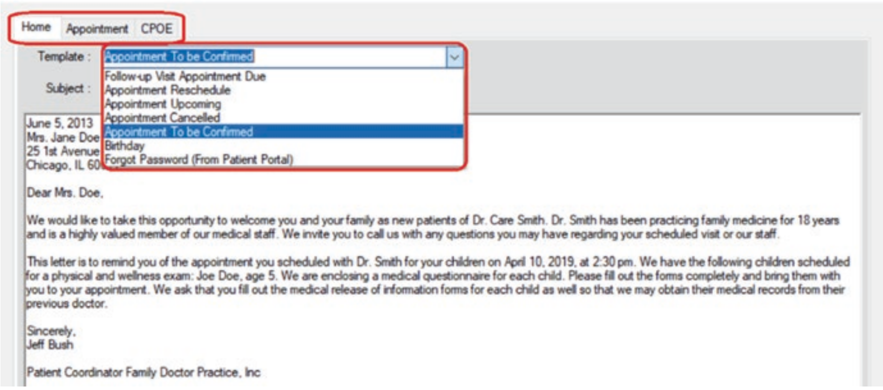

Fig. 4 A tab style with drop-down list

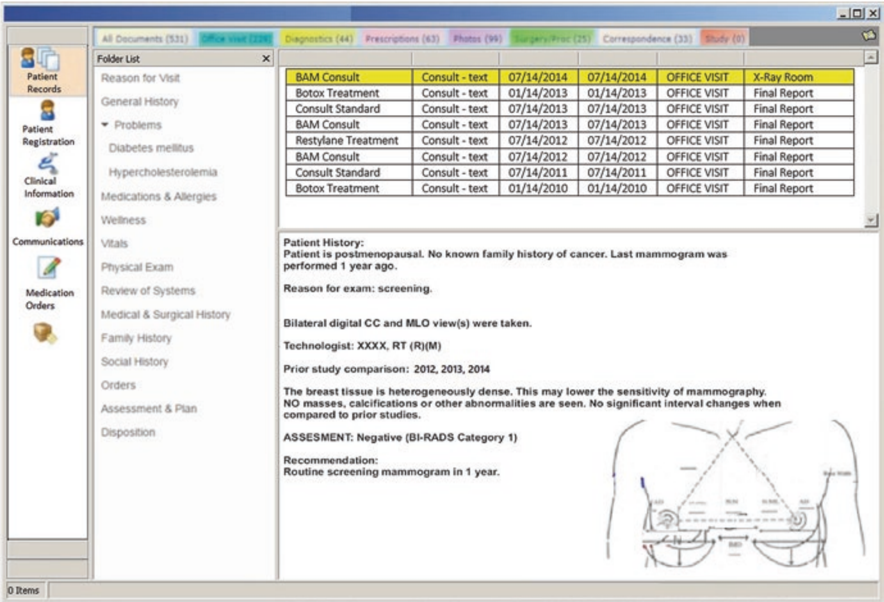

Fig. 5 Microsoft Outlook style menu and a scanned report in the displaying area

documents can be displayed (Fig. 5) because it is still much easier for healthcare workers to write down on papers. Other software applications may have pop-up window on top of the main window (Fig. 6). This approach of navigation is a menu-driven interface. It focuses on making functionalities of software programs available to users of the programs. The users are active participants in searching, entering, and selecting information to be displayed and updated.

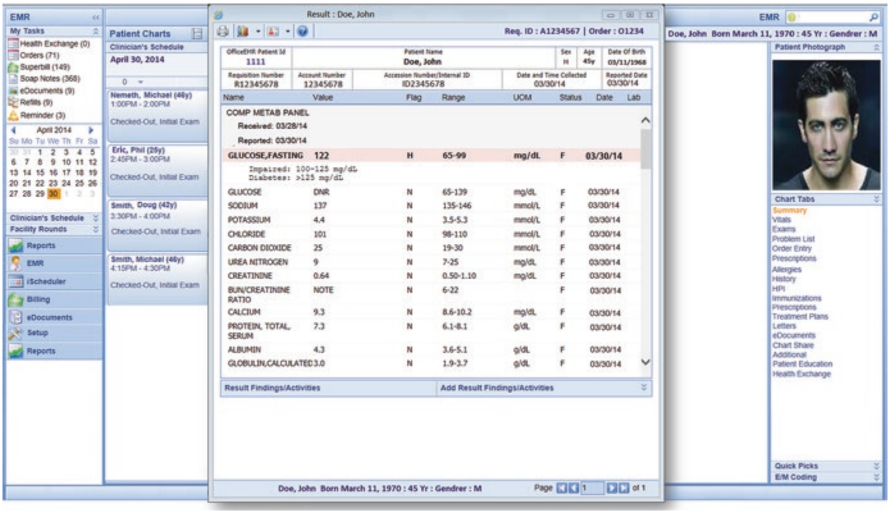

Fig. 6 Main window with a pop-up window on top

Users of these types of systems must be trained to find what they are looking for or what information that may be available to them. This approach of information visualization requires users to actively search and provide inputs (mouse clicks or typing on a keyboard). Since information may be categorized by functions (appointment, reports, etc.) and medical specialties (EMR or general medicine, radiology, pathology, laboratory, etc.), medical personnel, especially physicians, must perform similar tasks with each patient they are in consultation with. These are time-consuming activities that take physicians' valuable time from their patients because the physicians must interface with health software applications. The physicians may create each patient problem list in their mind. An important medical information may be ignored or forgotten by the physicians and/or not mentioning by their patients. A new approach of UI development is warranted to present relevant information automatically at the time of a medical visit.

3.5 *Overworked Healthcare Professionals*

The United Nations defines country classifications into three categories: developed economies, economies in transition, and developing economies. Healthcare professionals in the last two categories are overwhelmed with the large number of patients that they must take care of daily. In economies in transition countries where transportation pathways and communication channels are available at an acceptable level, an access to healthcare facilities can be achieved by a large majority of the population in those countries. Because these people have achieved mid-level of socioeconomic status, they can afford a higher cost of medicine and treatments as compared to people who are living in developing economies. However, most of those people still cannot afford to pay for premium medical services offered in private hospitals. People in those countries always seek affordable healthcare services from public healthcare facilities, especially university-based teaching hospitals where most difficult medical cases end up. The problems of overcrowding and long wait times have plagued outpatient care in these types of teaching hospitals. Improvement methods have been studied and proposed [7, 32, 33]. However, they have not proposed any improvements and changes to UI in healthcare applications that provide comprehensive view of a patient's individual medical records.

The growth trend for teaching hospitals in Thailand is to increase number of outpatient exam rooms, inpatient beds, and medical specialties and subspecialties. This article focuses on outpatient facilities because an average number of outpatients visiting a university-based teaching hospital are over 10,000 per working day (Figs. 7 and 8). The large number of patients creates congested areas and high possibility of the risk of contracting each other's diseases. Physicians on duty must provide acute, follow-up, chronic, and preventive care to those patients. On average, physicians would see more than 30 to 70 patients per day. During a patient visit, physicians spend considerable time on computer screen searching for and reading existing medical conditions. They must record medical findings and care provided to patients. Healthcare staff needs better computing and visualizing technology solutions to support outpatient care services.

Fig. 7 An outpatient waiting area of a medical specialty area

Fig. 8 An outpatient registration area

3.6 Examination Rooms

A typical design of outpatient examination room consists of consulting table with a computer, a few chairs for a physician and a patient, medical exam table, and physical examination instruments. Figures 9 and 10 depict a setting of an examination room. In a busy medical practice, a single physician may rotate two to three examination rooms with help from nurses. They ready patients, provide standard vital sign measurements, and record chief of complaint for a medical visit. The physician must search and review for relevant medical history, medical test and laboratory results, and current medications form EHR. In a busy medical practice, the total amount of time required performing these activities on EHR from each physician is considerable. A better approach to automatically assemble and present health information to physician should be supported.

4 AR, VR, Gaming, and Simulation in Healthcare

Advancement in computer graphics hardware and software, displaying technology, haptics devices, robotics, and other gaming controllers and technology and touchless peripheral devices have advanced medical knowledge and training in medical imaging diagnostics, simulation of preoperative planning and intraoperative navigation, and surgical training. These medical simulations enable surgical teams to

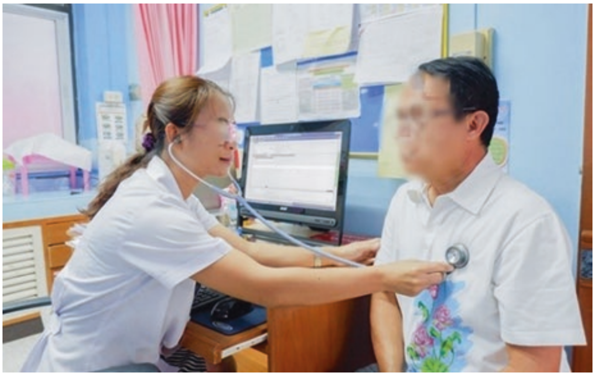

Fig. 9 A physician performing a physical examination

Fig. 10 A traditional fully fitted examination room

consult and plan a surgery approach before they operate on an actual patient. A haptic device ensures an immersive experience and interaction because it allows users to hold and control the device motion. At the same time, the user receives force feedback depending on their on-screen or virtual environment actions. A motion simulation system is applied in the field of medicine to train medical personnel, increase effectiveness, and instill confidence to face real-life situations. This type of training does not require trauma on human subjects and putting them at risk. The contribution of simulation technology, gaming technology, and gamification for healthcare activities have been important instruments to improve patients' well-being ranging from children to retirees [6, 7, 34–46].

However, these technologies have not been applied to assist day-to-day activities of healthcare providers. In the past, the exorbitant price tags on the hardware technology, e.g., high-performance computer system and graphics card, advanced display monitor, and gaming peripherals and other input devices, prohibit wider use of these technologies. Those prices have come down to an acceptable level to apply the technologies in the outpatient setting environments.

4.1 Target Area

The work in this article focuses on introducing a new design of software UI that is working in conjunction with displaying devices, AR, gaming, and simulation technology for healthcare workers to provide safe, fast, and effective care for patients in outpatient care settings. With rapid advances in medical technology, research from bench-to-bedside, and drug development outcomes, they can improve the quality of patients' life and extend their longevity. With these advancements, large amount of information and materials that healthcare professionals are responsible for reviewing and tracking have overwhelmed them each day. They are at risk of early burnout and making mistakes and poorer choices of medical treatments. The next section provides the current status of an initial stage of research and development of integrating health medical information systems to provide consolidated view of medical history of a given patient visiting an outpatient office.

5 Applying the Technologies to Outpatient Care Setting

Two critical components required to make outpatient software application become a reality are dashboard framework and unified healthcare data. The framework is built on top of gamification using game engine and modeling/animation tools. Health data will be fed into the framework automatically based on the identity of a patient detected by a 3D camera. A physician who is taking care of the patient receives pertinent medical information about the patient's relevant pre-existing and current conditions and longitudinal records. The physician can focus majority of attention to the patient by listening and examining medical conditions and explaining care given, including working with nurses to provide further required medical assistance.

The second main component is to create holistic view of medical records for each patient. Any patient's healthcare data are typically stored on one or more software systems. Each system has its own databases. For a monolithic hospital information system, it comes from a single software company. It is most likely that the system has a single database with multiple tables associated with each medical specialty. For some heterogeneous systems, best products for each medical specialty are integrated together to form a single healthcare application platform. Each of this system also has its own database, which may or may not be the same type of database, e.g., Oracle, Microsoft SQL, MySQL, and NoSQL. Regardless of what the database backend is, there is a need to perform extract, transfer, and load (ETL) to create a unified database that contains healthcare data points. A data point is a smallest unit of data that can be used to construct, arrange, and display health information holistically with longitudinal timepoints on a single patient dashboard. The hardest part would be to get an agreement from hospital software system vendors to export their healthcare data to a unified database.

With that in mind, we have started to work with a few medical doctors at Siriraj Hospital. They are very interested in the project since it has a good potential to cut significant amount of time for physicians' routine examination in outpatient care setting. We are exploring a system based on a transparent monitor similar to Fig. 11. The monitor presents relevant patient information to the doctor while supporting face-to-face communication simultaneously. This can contribute to good doctor-patient relationship. The transparent monitor can act as an AR display allowing information to be superimposed on the patient. We have started to search for a transparent monitor or similar technology. Only a few manufactures produce transparent monitors for retail businesses. A high-quality OLED transparent monitor from LG should be coming out to market by the end of this year. From our discussion with the Siriraj doctors, there is some concern that the presence of the monitor may hinder communication between the doctor and the patient. Some physicians may think of the monitor as an obstruction between them and their patients. We will explore different monitor placements and display solutions for the best possible setup while consulting with physicians responsible for outpatients and ergonomic engineers. Figure 12 portrays a design of an adjustable display arm on a consulting table.

We will focus on graphical presentation of information including the use of avatar to improve the interface usability. As such, game or graphics engine will be useful. Figure 13 depicts some early designs of outpatient UI, where information from several sources, e.g., laboratory, pathology, and radiology, converge into a patient dashboard. Voice commands and touch interaction may be useful and will be investigated.

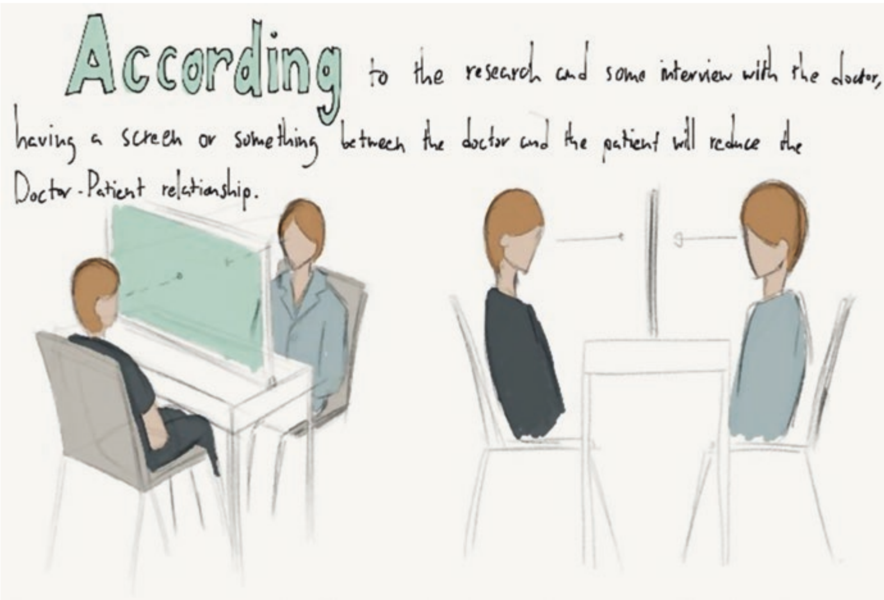

Fig. 11 A possible seating and monitor placement between a doctor and a patient

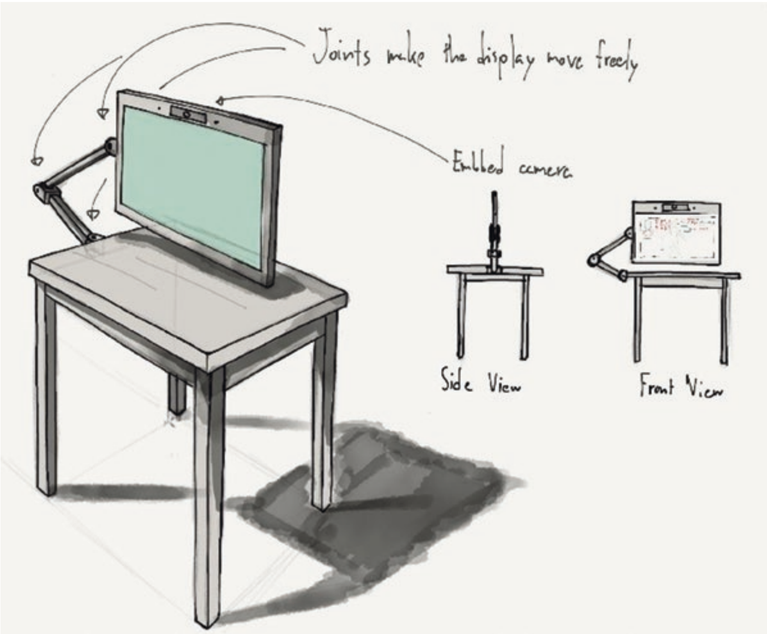

Fig. 12 A design of a desk with mechanical arm and a transparent monitor

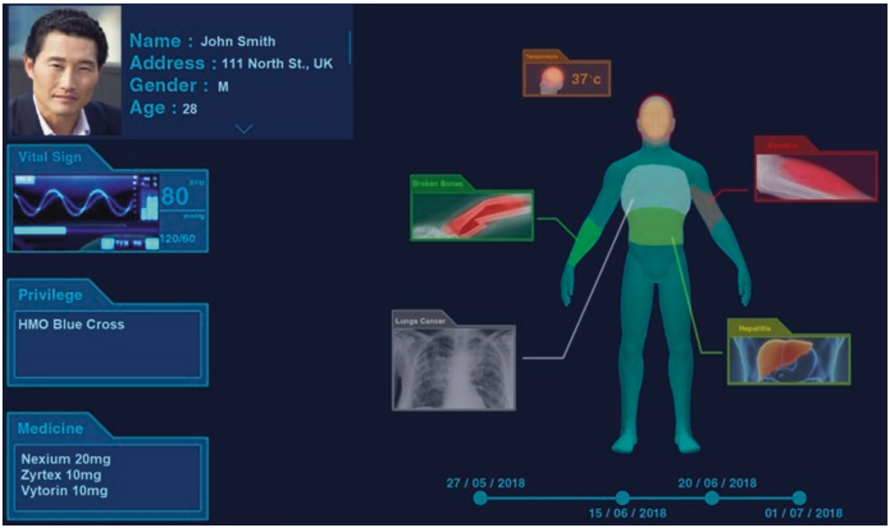

Fig. 13 An early design of UI for outpatient care

6 Conclusion and Future Work

The project is in its early stage. Significant works still lie ahead. Three major tasks are patient dashboard framework, unified database, and advanced display unit. The framework will be built upon Unity game engine and Maya® 3D. It shall have a new design for futuristic UI window frame and displaying contents. The unified patient database will be built on top of MySQL and NoSQL database. We are in a discussion with the doctors from Siriraj Hospital about medical information that can be retrieved from hospital information system. At the beginning stage, we are going to focus on information from the radiology department since the doctors who are working with us designed and built the radiology information system. Lastly, our early research has shown that some OLED transparent monitor provides a very good graphic and picture quality for AR environment. However, an early prototype of the monitor costs over half a million baht. The price is not attainable for outpatient deployment. But, LG is going to make and market a transparent OLED monitor in the second half of this year. The pricing should come down to an affordable level. We are also exploring transparent holographic rear projection film 3D and holographic effect projection screen, used in the movie Minority Report. We will adopt one of the displaying technologies mentioned in our project as AR technology and transparent monitor will provide physicians and other healthcare workers a comprehensive view of patients' conditions without them waring any displaying devices on their heads.

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References

1. Deloitte (2018) Global Health care outlook, Deloitte, 2018 https://www2.deloitte.com/tr/en/pages/life-sciences-and-healthcare/articles/2018-global-health-care-outlook.html. Accessed 21 Feb 2019
2. McDonald E (2017) The global games market will reach $108.9 billion in 2017 with Mobile taking 42%, newzoo, 2017/4/20 https://newzoo.com/insights/articles/the-global-games-market-will-reach-108-9-billion-in-2017-with-mobile-taking-42/. Accessed 21 Feb 2019
3. Rohan (2015) Motion simulation market worth $45.72 Billion by 2020, 2015/4 https://www.marketsandmarkets.com/PressReleases/motion-simulation.asp. Accessed 21 Feb 2019
4. Statista (2018) Forecast size of the augmented and virtual reality (VR/AR) market worldwide in 2020 and 2025, by segment, The Statistics Portal, 2018/5 https://www.statista.com/statistics/610112/worldwide-forecast-augmented-and-mixed-reality-software-market-by-segment/. Accessed 21 Feb 2019
5. Leventhal R, Report (2017) Global healthcare IT market to hit $280B by 2021, healthcare innovation, 2017/3/10 https://www.healthcare-informatics.com/news-item/ehr/report-global-healthcare-it-market-hit-280b-2021. Accessed 21 Feb 2019

6. Mielczarek B, Uzialko-Mydlikowska J (2010) Application of computer simulation modeling in the health care sector: a survey. Simulation 88(2):197–216
7. Norouzzadeh S, Riebling N, Carter L, Conigliaro J, Doerfler ME, Simulation modeling to optimize healthcare delivery in an outpatient clinic, 2015/5/6, Winter Simulation Conference (WSC), Huntington Beach, CA, 1355–1366
8. J. Song, Y. Qiu and Z. Liu, A real-time access control of patient service in the outpatient clinic, in IEEE Trans Autom Sci Eng, 758–771
9. Zandieh SO et al (2008) Challenges to EHR implementation in electronic- versus paper-based office practices. J Gen Int Med, 2008/3/28 23(6):755–761
10. Saengpassa C (2015) It's time to fix Thailand's dire healthcare system, The Nation, 2015/10/27 http://www.nationmultimedia.com/politics/Its-time-to-fix-Thailands-dire-healthcare-system-30271664.html. Accessed 21 Feb 2019
11. Number of patients that physicians in the U.S. saw per day from 2012 to 2016 (2018), The Statistics Portal, 2018/5. https://www.statista.com/statistics/613959/us-physicans-patients-seen-per-day/. Accessed 21 Feb 2019
12. Mearian L (2017) CW@50: data storage goes from $1M to 2 cents per gigabyte (+video) 2018/06 https://images.techhive.com/assets/2017/4/10/cw-50th-anniversary-storage-trends.pdf. Accessed 21 Feb 2019
13. Evan C, Michael BS, Samuel S (2016) The cost of a computer the year you were born, 2016/4/15 https://247wallst.com/special-report/2016/4/15/how-much-a-computer-cost-the-year-you-were-born/3/. Accessed 21 Feb 2019
14. CMS (2018) CMS' program history - Medicare & Medicaid 2018/6/20 https://www.cms.gov/About-CMS/Agency-information/History/. Accessed 21 Feb 2019
15. IBM (2018) History of IBM 1960s - 1966, 2018/4 https://www-03.ibm.com/ibm/history/history/year_1966.html. Accessed 21 Feb 2019
16. The University of Scranton, EMR: The Progress to 100% Electronic Medical Records https://elearning.scranton.edu/resource/health-human-services/emr_the-progress-to-100-percent-electronic-medical-records. Accessed 21 Feb 2019
17. HL7 (2018) About HL7, 2018 http://www.hl7.org/about/index.cfm?ref=common. Accessed 21 Feb 2019
18. Spronk R (2014) The early history of health level 7, Whitepaper, 2014/9/5 http://www.ringholm.com/docs/the_early_history_of_health_level_7_HL7.htm. Accessed 21 Feb 2019
19. HL7 (2018) HL7 Fast Healthcare Interoperability Resources Specification (FHIR®), DSTU Release 1, 2018 http://www.hl7.org/implement/standards/product_brief.cfm?product_id=343. Accessed 21 Feb 2019
20. Electronic data interchange (2018) https://en.wikipedia.org/wiki/Electronic_data_interchange. Accessed 21 Feb 2019
21. EDI Basics (2018) Different Types of EDI and a Range of Approaches to Enabling EDI Across a Trading Community, 2018 https://www.edibasics.com/types-of-edi/. Accessed 21 Feb 2019
22. X12 Document List (2018) https://en.wikipedia.org/wiki/X12_Document_List. Accessed 21 Feb 2019
23. ECCMA (2018) https://eccma.org/. Accessed 21 Feb 2019
24. ICD-10 Version:2010 (2018), http://apps.who.int/classifications/icd10/browse/2010/en. Accessed 21 Feb 2019
25. SNOMED CT (2018) SNOMED International determines global standards for health terms, an essential part of improving the health of humankind, 2018 https://www.snomed.org/snomed-ct. Access 21 Feb 2019
26. American Medical Association (2018) CPT® (Current Procedural Terminology), 2018 https://www.ama-assn.org/practice-management/cpt-current-procedural-terminology. Accessed 21 Feb 2019
27. RxNorm (2018) https://www.nlm.nih.gov/research/umls/rxnorm/ Accessed 21 Feb 2019
28. LOINC (2018) https://en.wikipedia.org/wiki/LOINC. Accessed 21 Feb 2019
29. RadLex (2018) https://www.rsna.org/RadLex.aspx. Accessed 21 Feb 2019

30. Unified Medical Language System® (UMLS®) (2018) https://www.nlm.nih.gov/research/umls/knowledge_sources/metathesaurus/. Accessed 21 Feb 2019
31. DICOM. Digital Imaging Communications in Medicine (DICOM) (2018) https://www.dicomstandard.org/. Accessed 21 Feb 2019
32. Danforth KN et al (2014) Electronic clinical surveillance to improve outpatient care: diverse applications within an. Integr Deliv Syst 2(1):921
33. Sun J et al (2017) Reducing waiting time and raising outpatient satisfaction in a Chinese public tertiary general hospital-an interrupted time series study. BMC Public Health 17(668):1–11
34. Virtual (2014) Augmented reality and serious games for healthcare 1. Intelligent systems reference library. Springer, Berlin Heidelberg
35. Albua M, Atackb L, Srivastavaa I (2015) Simulation and gaming to promote health education: results of a usability test. Health Educ J 74(2):244–254
36. Anderson GO (2016) Video games: attitudes and habits of adults age 50-plus. 2016/5 https://www.aarp.org/research/topics/technology/info-2016/electronic-gaming-research-adults-50plus.html. Accessed 21 Feb 2019
37. Baranowski T et al (2016) Games for health for children-current status and needed research, vol 5, pp 1), 1–1),12
38. Feinstein RE, Yager J (2017) A live threat violence simulation exercise for psychiatric outpatient departments: AValuable aid to training in violence prevention. Acad Psychiatry
39. Fernández-Aranda F et al (2012) Video games as a complementary therapy tool in mental disorders: PlayMancer, a European multicentre study. J Ment Health 21(4):364–374
40. Ficklscherer A et al (2014) Testing the feasibility and safety of the Nintendo Wii gaming console in orthopedic rehabilitation: a pilot randomized controlled study. Arch Med Sci 12(6):1273–1278
41. Gauthier LV et al (2017) Video game rehabilitation for outpatient stroke (VIGoROUS): protocol for a multicenter comparative effectiveness trial of inhome gamified constraint-induced movement therapy for rehabilitation of chronic upper extremity hemiparesis. BMC Neurol 17(109):1–18
42. Johnson D et al (2016) Gamification for health and wellbeing: a systematic review of the literature. Internet Interv 6:89–106
43. Lemheney AJ et al (2016) Developing virtual reality simulations for office-based medical emergencies. Virtual World Res 9(1):1–18
44. Rendon AA et al (2012) The effect of virtual reality gaming on dynamic balance in older adults. Age Ageing 41:549–552
45. Gentry S et al. (2016) Serious gaming and gamification interventions for health professional education, Cochrane Database of Systematic Reviews
46. Wattanasoontorn V, Hernandez RJG, Sbert M (2012) Serious games for e-health care, In 25th annual conference on computer animation and social agents (CASA 2012)

A Simulation Game of Patient Transportation

Chen Zhang and Sebastiaan Meijer

Abstract The handling of patients is a complex process. The training and education of patient transportation workers are meant to ensure efficiency and health outcomes. A simulation game, joined by personnel with working experience or prospective professionals in the healthcare system, is a lifelike medium for improving decision-makings in nonrational operation management. However, few examples are known in regard to synthesizing complex systems, such as clinical facilities, into healthcare simulation games. In order to fill this gap, this work proposes the adopt theory and reports the development of a simulation game that reconciles patient handling with the support of different types of simulation techniques. The simulation game has a physical entity simulator as its back end and a panel of command and control for each player as its front end. The physical entity simulator is based on the interactions of mobile agents. Agent-based modeling targets the correct level of representation of the operative environment. The simulation game is tested with managers who have more than 10 years of working experience with patient flow management in pediatric care. Reflections from players indicate that modeling and abstraction using an agent model are an efficient synthesis of complex systems. The theory, methods, and results of this study are expected to contribute to the development of simulation games that can be applied in health service provision, in general, and in patient transportation, in particular.

Keywords Gaming · Simulation · Pediatric · Patient · Logistics

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1 Introduction

The first constructive model of a dynamic multi-agent system was the Schelling segregation model for investigating housing and neighborhood preferences [1]. Since then, agent-based modeling has been used as a tool for problem-solving or attaining a better understanding of complex social-technical systems. Not only is agent-based modeling relied upon for understanding emergence, but it also provides an analytical way of optimizing engineering systems, such as logistics and transportation [2], healthcare [3], ecosystems [4], and others [5, 6], to obtain exact solutions.

The simulation could be an explicit paradigm of how a modeler perceives a "system" philosophically, such as discrete-event simulation, system dynamics, and agent-based modeling [7]. As modern forms of hybrid simulation games, agent-based modeling and social simulation are combined with the classical gaming simulation approaches [8, 9]. Among the different techniques, individual-based models are innovative in their encapsulation of beliefs, desires, and intentions of individuals in a decentralized delivery structure. The modeling of agents' attributes, rules, and their environment recreates the decision-making processes in various network topologies, enabling the occurrence that is hard to define on a personal scale. This makes agent-based modeling a suitable language for developing business simulation games that are carried out by autonomous, decentralized, and objective-oriented ownership entities.

The simulation game (SG), together with simulations, serious games and participatory simulations, could be highly physical models for validating agent systems and operational archetypes. Anand et al. [10] positioned agent-based modeling and participatory SG with regard to the data and information collection for defining environments. In particular, SG fits the anatomy of an agent system given its capacity to encapsulate interdependencies and dynamic natures. It also adds more value to design future-proof systems without sufficient data or evidence. Linking the agent models with role-playing games is demonstrated to be a powerful planning tool for city management in Ligtenberg et al.'s works [11]. In addition to urban planning, serious games, driven by a computer simulation, are assistive technologies for the training and education of skill sets related to production [12] and manufacturing business management [13]. For safety engineering, simulation and games could be used as instrumental and educational methods in order to develop skills and competencies in escalating situations [14].

The literature contains few gamified logistical simulations in the patient transportation subject domain. Most works with simulation models, developed during research into pediatric emergency care, are redistributing the values in the existing service network by optimizing operation management [15]. The simulation models show the promises in healthcare management. However, without gamification, the simulation might not be able to facilitate the training and learning at the relational and extended abstract levels in the structure of observed learning outcome (SOLO) taxonomy [16]. This type of engineering simulation that solely computes a process might hinder the activation of learners, the validation of effective strategies, social relations, as well as the possibility of investigating real-time decision-making processes that involve human factors. The integration of simulation and game might recreate the formal and informal organizational structures in clinical environments but with reduced complexity and a higher level of engagement. Therefore, the following research questions become the central interests of this paper:

- How do we theorize SG for the better handling of business management?
- What is the correct level of modeling and abstraction in SG [17]?

In this work, we propose the adopt theory intended to constructively align the development of SG for the adequate training and education of nontechnical skills observing the trend of contemporary logistics applications moving forward. Following this, we look into the development of an SG for patient transportation to connect the empirical findings with the proposed framework. The design of the SG keeps an open perspective on the different viewpoints and activates participants in their peer-learning experiences.

2 Theorizing Simulation Game

An SG is an autonomous, (de)centralized, objective-oriented, proactive, and translational/transdisciplinary social interaction for the adoption of effective strategies in the service network, as Fig. 1 presents. The first four elements reflect how the objects model and the perspectives of the participants are reflected. The last element is producing output from running SG.

It is essential to theorize SG for the cumulative knowledge observed behind the empirical studies. In addition to the fundamental elements that all SG contain [18], the adopt theory explains the required characteristics for the better handling of current business challenges. An SG being autonomous means that players, enabled by the SG, have control over their behavior to solve a management puzzle. The deci-

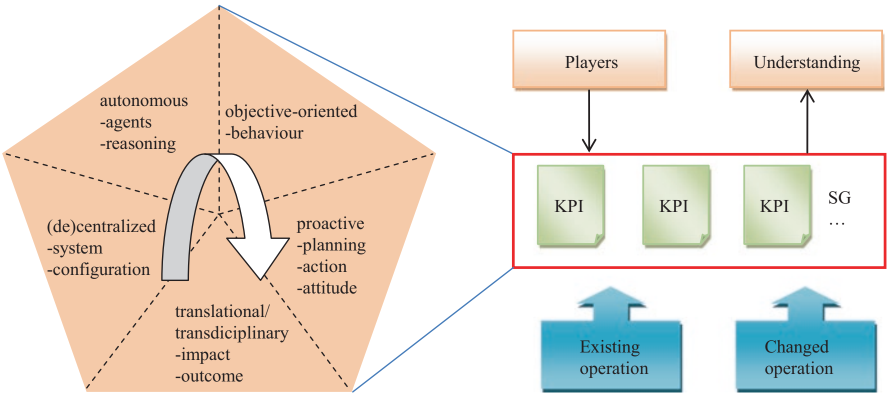

Fig. 1 *Adopt* theory

sions are free to break boundaries and formulate new social bonds in the simulated reality. An SG being (de)centralized means that players are situated in a service network topology with the delegation, encouraging communication between teammates. An SG could be of a centralized form if the network deploys centralized authority rather than parallel functioning. An SG being objective-oriented means that operational archetypes, such as balancing, optimization, and prioritization, are present in rational agents. Therein, we have many utility strategies to choose from and program in simulation vendors, such as the one used in this work, AnyLogic [19]. An SG being proactive means that players are exposed to adverse, or an unexpected event, which is mostly for the sake of learning objectives, since improved awareness of risks facilitates process improvement in safety and quality management [20]. Nonpunitive response to adverse events is a significant improvement of the safety culture in the healthcare organization [21]. An SG being translational/transdisciplinary means that the SG could be for research, education, or a hybrid of both, which becomes the enabler for participants' successful engagements in different disciplines, academia and/or non-academia.

A simulation game is used to simulate an existing real system and process [17]. An SG designed to teach, elaborate, and perform research and training on a target group and particular context [22] is considered to be the continuation of the theory into a content science. Performance indicators provide stimuli for changed behaviors or organizational models.

3 Simulation Game Design

3.1 Physical Simulation

This SG for patient transportation is developed based on the multi-agent language. Figure 2 presents the semantic. This is the runtime semantic of Unified Modeling Language, a frequently chosen formalism for the description of object-oriented simulation models. This set of classes specifies the attributes and operations of agents. Agents are goal-oriented, and their triggering behaviors include simulating patients, selecting higher-level destinations, and assigning ambulances. The activity inaugurates as long as the local hospitals disseminate requests for transfer and end when the patient arrives at a destination by a maintained ambulance. The transfer only happens to severe and critically ill patients.

The SG will get participants to recognize the environment and activate them to achieve the intended learning outcomes. We implement the following rationale. Different players as first-line managers in the line organization have different access to information. The SG starts with patient admission, which is followed by the triage process. Hospital congestion levels are calculated based on the number of admitted patients, the number of delayed patients, and bed capacity. If the decision is made to relocate the patient to another hospital, the player, as logistical manager, has to call the ambulance dispatcher for a patient transportation service. Patients

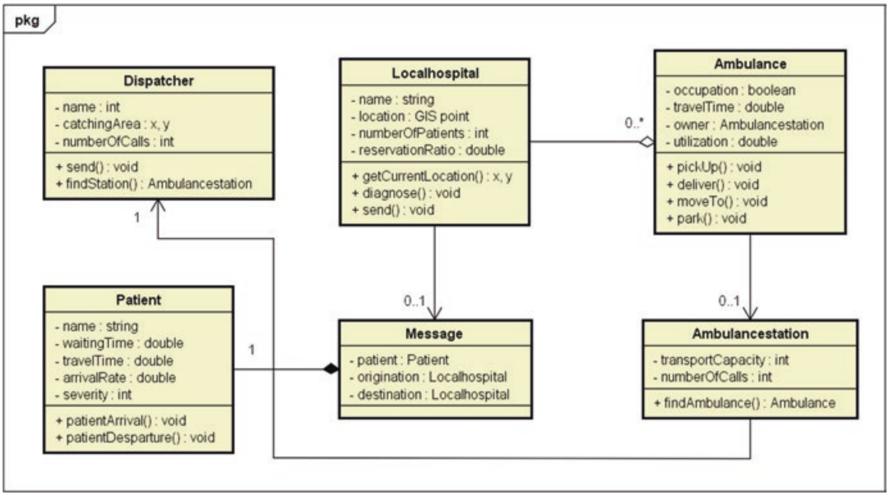

Fig. 2 Multi-agent language for specifying attributes, operations and the interdependency

will not be allowed admittance when all beds are full. Only station managers and the dispatcher may use ambulances. Bed utilization is only visible to the person responsible for hospital logistics. Due to information asymmetry, decisions correspond to the exact conditions of the stakeholders. The second rationale is that transportation coordination is the only focus, rather than processes inside hospitals. The user is encouraged to reduce healthcare impacts by balancing flows of patients and ambulances. A combined physical simulator and the players' abilities to exert impacts recognize the adopt theory as proposed.

3.1.1 Decentralized Service System Topology

The urban road transportation network physically connects the caregivers—the duration of transportation on the road network is based on geographical spatial representation. Duration of service in the hospitals is assumed to follow exponential distributions. The dispersed operational costs, as well as patients' waiting and travel times, are aggregated and visualized in the information retrieval system. The reactions of the user can exert influences on patient waiting lists, travel time, waiting time, and fleet operation in the service network. The topology is changeable but is usually predefined by the SG instructor, and simulation inputs might vary across sessions.

3.1.2 Autonomous Agents

Agents place in the continuous space of the infrastructure network and resources in the healthcare delivery. The road network connects the hospitals. Vehicles operate between the hospitals, local health centers, and ambulance stations. The vehicle is assumed to find the shortest path between locations, adapting to the threshold of the response time. In addition to programmed rules, the communication between the person responsible for hospital logistics, the dispatcher, and the ambulance stations can be affected by the states of agents. Since agent behavior in the model depends on the decisions and access to resources of the players, the transportation is based on not only the states of resources but also the players' command and control in a timely and appropriate manner.

3.1.3 Objective-Oriented Behaviors

Ground ambulances are active mobile resource units and can have different fleet sizes at different hospitals. The fleets are the message receivers of transportation proposals and react according to the order. The ambulances are modeled as nonhierarchically operated. The fleets have access to the information of the road network and identify the road segments that minimize travel times. A routing subagent is embedded within the ambulance agent to receive the proposal and motivate the vehicle. As Fig. 3 presents, the SG is designed in AnyLogic, a simulation integrated development environment that enables insights and optimizations in business applications and the integration of personal digital assistants that allow the players to record their decisions in different scenarios.

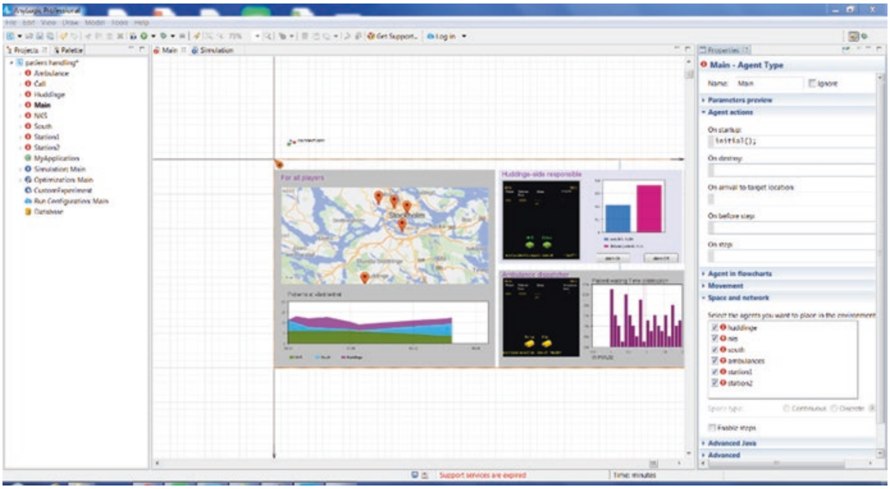

Fig. 3 Canvas of SG design, based on AnyLogic

3.2 Command and Control

The SG is computer-managed with full participation from the learners. Control panels allow the players to enter content into the SG. The control panel for each user is explicitly outlined with information retrieval and decision-making interactions based on real patient transportation [Fig. 3]. The command and control of players can manipulate autonomous agents between states in the simulation at runtime.

3.2.1 Ambulance Dispatcher

As Fig. 4 presents, the transportation proposals are generated from hospitals. They proceed to the ambulance dispatcher after spatial locations are set up on the cartographic representation. The population of agents is created with relevant attributes and operates for patient transportation. The transportation proposal is defined by the hospital manager based on the endurance of the patient. Referring and receiving hospitals could apply to a specialized hospital in the network. The ambulance dispatcher is informed by the time-stamped receipt and holds information about the seriousness (through an on-off alarm by a hospital) and circumstance of the patient. The hospitals might transmit alarms to the dispatcher in conditions of reduced bed capacity or a large number of delayed patients. The ambulance dispatcher is responsible for communicating the transportation proposal to a selected ambulance station by taking into consideration the transportation capacity.

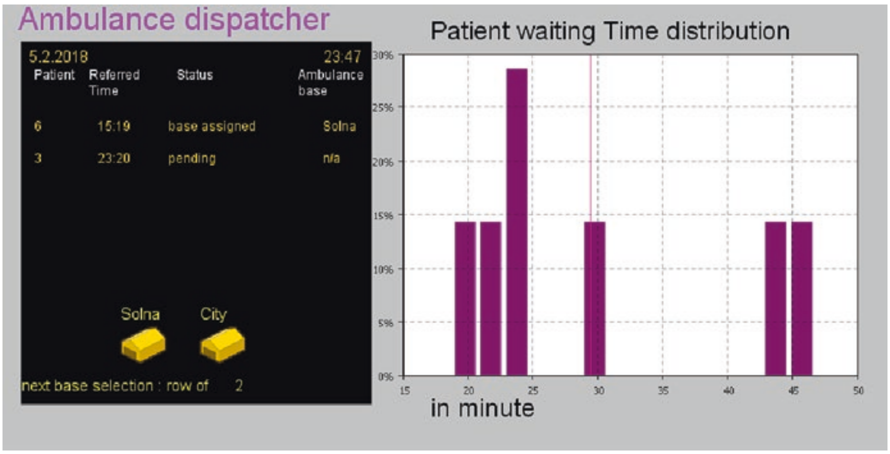

Fig. 4 Control panel for the ambulance dispatcher

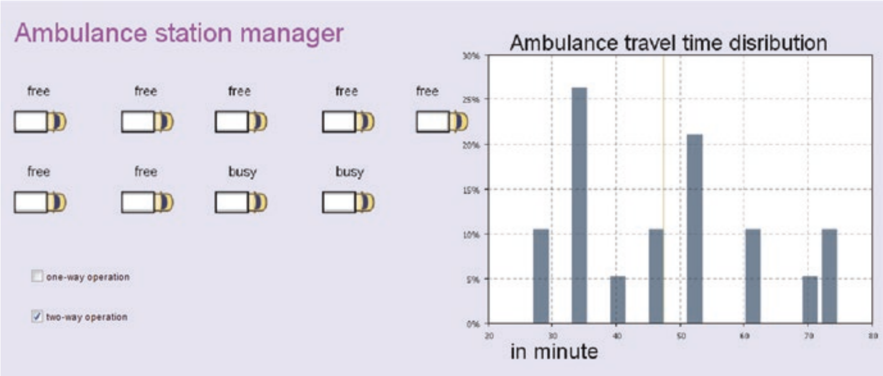

Fig. 5 Control panel for the ambulance station manager

3.2.2 Ambulance Station Manager

As Fig. 5 presents, ambulance in-and-out flows are the system behavior of patient transportation with spatial diversities. The operative conditions of ambulances between the hospital and the ambulance station are determined by a set of rules, including the response time threshold (9 minutes) and the maintenance time window (after five rolls or 120 minutes) in this network. The threshold is achievable by adapting the route and speed of the vehicle. The number of delayed patients might increase if all the ambulances dight up. Proposals are subject to different urgencies, origins, and destinations. Vehicular operation strategy is subject to the player's recognition of capacity, resource availability, and demand. An efficiency-oriented operation strategy might achieve a substantive reduction in the length of the waiting list but require extreme rolls of the ambulance faculty.

3.2.3 Hospital Logistics Manager

As Fig. 6 presents, the hospital has the standard medical pathway of triage, diagnosis, and discharge. The triage reveals the acute situations of the patients. The hospital makes decisions regarding further treatment or hospitalization. In case of further treatment, the recipient hospital has to be suggested to the ambulance dispatcher. Information regarding the recipient hospital and the status of the patient is updated as long as the transport proposal is made.

4 Use Case Example

The SG addresses an open, multidimensional system with many perspectives. The dimensions and perspectives implemented in the use case include:

Fig. 6 Control panel for the hospital logistics manager

- Productivity at the regional level
- Resource availability of providers
- Sustainability of the working environment

The use case incorporates a comparison of two fleet distribution strategies: (a) two-way distribution (an ambulance has a fixed owner ambulance base for maintenance) and (b) one-way distribution (ambulances are free from return point restrictions). The first scenario recreates a situation in which ambulances need to recycle especially used staff at their owners' location, whereas the second scenario allows for punctuality in any healthcare infrastructure. The second scenario is expected to be more flexible and productive concerning patient wait and travel time savings; however, the practice might not be in the best interest of ambulance base managers because it is more likely to generate extreme rolls on the faculty.

Local health centers that send a certain proportion of received patients to specialized hospitals are in the residential areas of Farsta, Hagsätra, Högdalen, Huddinge, Sätra, Teleponplan, and Liljeholmen. Farsta and Hagsätra are highlighted by the darker gray in presentation—the local health centers there prioritize more the faster discharge of patients. The three main hospitals that send and receive patients during role-playing are located in Solna, Södermalm, and Huddinge. The ambulance stations are placed in the city centers and Solna. The physical model is parametrized before the operation. Switching between operation strategies for circulating the ambulances is possible at runtime, including the one-way and the two-way operation strategies. A full hospital can send a maximum of three alarms to the station dashboard so that the station manager is prompted to attain capacity for that hospital first. These pieces of information and materials present to the participants working with daily operative management of patient flow through the pediatric emergency department of Karolinska University Hospital at Solna, Stockholm. The scenarios are intended to be close to actual experiences. This consideration is to facilitate the flow with personnel in healthcare systems that are more used to recognize the patterns in their day-to-day patient handlings. The instructor initiates the SG with the patient arrival and priority patterns of the 2017 operating year to contemplate the aspects of patient movement and, explicitly, of need-based assessments on a typical working day.

Statistical approximations generate patient flows. The details of statistical approval would not be included in this work.

Participants are recommended to reflect upon the following points as intended learning outcomes after an operation of 72 hours in the model unit:

- Describe the complexity of healthcare practice.
- Associate operational strategies and their relevance to the indicators.
- Speculate what types of insights could be obtained for patient flows and resources.

The one-way operation strategy saves on patient waiting time and fleet utilization. In the two-way scenario, the number of patients with prolonged hospital stays is nearly 15 during peak hours (Fig. 7). However, this is reduced to below 15 in the one-way scenario for almost all secondary intermediate facilities. The latter also experiences a reduced utilization of the fleet. Although the utilization variation is still considerable, the one-way operation strategy is preferred about reducing waiting times without adding vehicles.

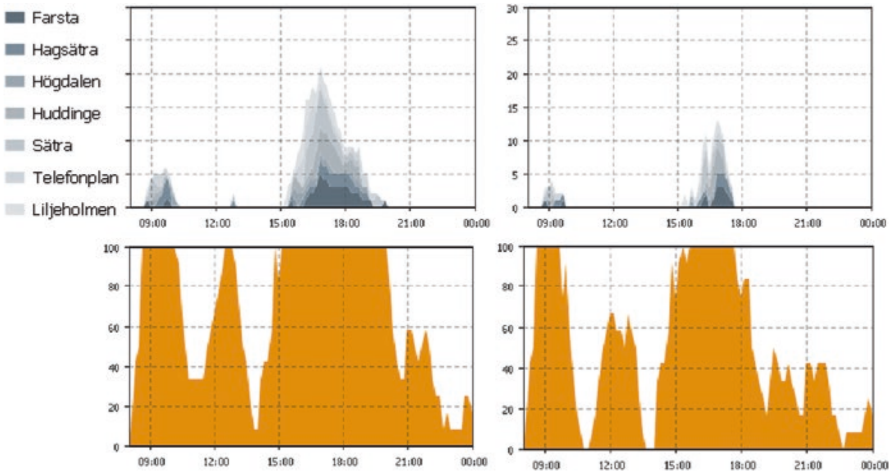

Fig. 7 Comparing run experiments. Top-left, an hour-by-hour count of patient waiting times in the two-way scenario; top-right, an hour-by-hour count of patient waiting times in the one-way scenario; bottom-left, an hour-by-hour fleet utilization ratio (in percentages) in the two-way scenario; bottom-right, an hour-by-hour fleet utilization ratio (in percentages) in the one-way scenario

5 Discussion

An SG for active learning in the management of patient flows should help to construct a declarative knowledge base needed for deep learning and improving participants' knowledge and experiences related to nontechnical skills. The SG will, however, not be a passive substation. A computer-based SG may add the perspectives of the game principals that own the model. Depositing these insulated understandings from fields into a game might distort the participant's acquirement of intended learning outcomes. The challenge in medical education is the role definition of the facilitator and game principal in the context of the teacher/learner/curriculum framework [23]—as resource material providers, game principals will provide proper adjuncts and prevent healthcare people from obtaining incorrect cues.

Prevising the performance of complex systems over time is difficult. The collective behavior of agents, as shown in Fig. 7, is not definable at the individual level. However, simulations could recreate clinical facilities and produce an emergence. The example of patient transportation shows that, even though micro-interaction is known and is common practice in patient handling, emergence could still arise with a list of delayed patients in hospitals, depending on how the players act in the simulated scenarios.

Based on discussions with physicians, the SG reproduces the way the pediatric emergency department of Karolinska University Hospital works on a daily basis, especially the fact that some patients are merely admitted into the emergency department without assured developments. This integration is vital to support the development of the tool in the practical context [24]. However, the delivery of patients is not like sending goods and parcels since the patients are not equivalent. For highly specialized hospitals, they tend to assign away patients already assessed and those that are just in need of some bed capacity; otherwise, they receive many more patients who require an individual health planning. For the hospital manager, the appearance of a person who needs a bed is sometimes required to move other patients already inward. The emphasis should be extended to training humanistic dimensions of care during medical education [25]. Practically, this means that internal and external transportations are linked to each other. These details are recommended for expanding the simulation. Nevertheless, the SG is simple enough and understandable since players can see their capacity and the needs of patients. A substantial abstraction of the realm, such as the agent system used in this work, does not compromise the recognition of one's role in a healthcare system and the delivery of the message that internal and external transportation are both critical and need to be managed properly.

Patient flow is an integral element of the planning of the healthcare system, and bed allocation is an intricate part of transportation. It would be useful to have different types of beds and tiers of movability, unmovability, and moveable patients with reduced safety and quality. For people who are not used to computer games, design elements need to build up the narrative for the players to reconvene their situations. As the SG is being developed, not only the personnel who are part of the quality and safety control at the children's hospital but also the clinical leaders will be invited to this gaming exercise. The next step is to test the SG with a specialized transportation system. To develop an online version, launch the AnyLogic simulation from external applications arranged in such a way to replace the practice of multiple computers simultaneously viewing the same console game.

6 Conclusions

Simulation models provide meaningful scenarios in which the nontechnical skills of managers, coordinators, and decision-makers can be trained [26]. Through simulation gaming, passive learners in curriculum-based medical education have the possibility of being active during an interactive workshop. However, interaction with sophisticated computer simulations strains the limitations of cognitive processes [27]. Therefore, for pedagogical reasons, it is essential that guides of medical professionals are the foundations of gaming narratives. Learners could play an active role in their learning by choosing a topic from the intended learning outcomes. Thus, players would stay focused in the SG to make comparisons and contracts regarding the relationship between workload and safety care.

The growing expectations regarding productive care require tools of simulation, SG, serious games, participatory simulations, and more for the training, education, and hands-on sessions of managers in healthcare organizations. Such tools can improve nontechnical skills about the validation of operation strategies, changed informal organizational structures, or improved working environment and culture on a daily basis. In this work, an SG of patient transportation is created that involves an ambulance dispatcher, ambulance station manager, and hospital logistical manager. Autonomous human-machine agents, reasoning, and a decentralized system are applied to pursue translational outcomes. The correct level of abstraction is achievable without distorting the motivations.

A fully developed infrastructure, in the form of a cyber-physical system, will facilitate the understanding of interactions between technology and health and validate relevant operational models. Furthermore, it might facilitate the capacity planning of selecting ambulance station locations, which is commonly handled by a governing optimization algorithm, and the development of organizational models that could support the discussion of stakeholders with competing interests.

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References

1. Schelling TC (1971) Dynamic models of segregation. J Math Sociol 1:143–186
2. Holmgren J, Davidsson P, Persson JA, Ramstedt L (2012) TAPAS: a multi-agent-based model for simulation of transport chains. Simul Model Pract Theory 23:1–18

3. Kalton A, Falconer E, Docherty J, Alevras D, Brann D, Johnson K (2016) Multi-agent-based simulation of a complex ecosystem of mental health care. J Med Syst 40
4. Carayannis EG, Provance M, Grigoroudis E (2016) Entrepreneurship ecosystems: an agent-based simulation approach. J Technol Transf 41:631–653
5. Sternberg H, Norrman A (2017) The physical internet – review, analysis and future research agenda. Int J Phys Distrib Logist Manag 47:736–762
6. Sun Y, Zhang C, Dong K, Lang M (2018) Multiagent modelling and simulation of a physical internet enabled rail-road intermodal transport system. Urban Rail Transit 4:141–154
7. Borshchev A (2013) The big book of simulation modeling: multimethod modeling with AnyLogic 6, AnyLogic North America, New Jersey, pp: 25–36
8. Deguchi H (2004) Economics as an agent-based complex system toward agent-based social systems sciences. Springer Japan, Tokyo
9. Kaneda T (2012) On a formalization of agent-based social systems – as a common basis for modeling gaming simulation and agent-based social simulation. Jpn J Gaming Simul 22:5–15
10. Anand N, Meijer D, van Duin JHR, Tavasszy L, Meijer S (2016) Validation of an agent based model using a participatory simulation gaming approach: the case of city logistics. Transp Res Part C Emerg Technol 71:489–499
11. Ligtenberg A, van Lammeren RJA, Bregt AK, Beulens AJM (2010) Validation of an agent-based model for spatial planning: a role-playing approach. Comput Environ Urban Syst 34:424–434
12. Mizuyama H, Nonaka T, Yoshikawa Y, Miki K (2016) ColPMan: a serious game for practicing collaborative production management. In: Simulation and gaming in the network society. Springer, Singapore, pp 185–197
13. Hamada R, Kaneko T, Hiji M (2018) Development of BASE manufacturing business board game. In: Lukosch HK, Bekebrede G, Kortmann R (eds) Simulation gaming. Applications for sustainable cities and smart infrastructures. Springer International Publishing, Cham, pp 34–40
14. Kriz WC, Manahl W (2018) Gaming simulation as a science of design approach. In: Naweed A, Wardaszko M, Leigh E, Meijer S (eds) Intersections in simulation and gaming. Springer International Publishing, Cham, pp 380–393
15. Hung GR, Kissoon N (2009) Impact of an observation unit and an emergency department-admitted patient transfer mandate in decreasing overcrowding in a pediatric emergency department: a discrete event simulation exercise. Pediatr Emerg Care 25:160–163
16. Biggs JB, Collis KF (1982) Origin and description of the SOLO taxonomy. In: Evaluating the quality of learning. Elsevier, pp 17–31
17. Klabbers JHG (2008) The magic circle: principles of gaming & simulation, 2nd edn. Sense Publ, Rotterdam
18. Klabbers JHG (1999) Three easy pieces: a taxonomy on gaming. In: Sounders D, Severn J (eds) Simulation & gaming yearbook. Simulation and games for strategy and policy planning. Kogan Page, London, pp 16–33
19. AnyLogic (2017) AnyLogic–Multimethod Simulation Software, https://www.anylogic.com. Accessed 31 Sept 2017
20. Unbeck M, Dalen N, Muren O, Lillkrona U, Härenstam KP (2010) Healthcare processes must be improved to reduce the occurrence of orthopaedic adverse events: healthcare processes improvement to reduce occurrence of orthopaedic events. Scand J Caring Sci 24:671–677
21. Savage C, Gaffney FA, Hussain-Alkhateeb L, Olsson Ackheim P, Henricson G, Antoniadou I, Hedsköld M, Pukk Härenstam K (2017) Safer paediatric surgical teams: a 5-year evaluation of crew resource management implementation and outcomes. Int J Qual Health Care 29:853–860
22. Kriz WC (2010) A systemic-constructivist approach to the facilitation and debriefing of simulations and games. Simul Gaming 41:663–680
23. R.M. Harden JC (2000) AMEE guide no 20: the good teacher is more than a lecturer - the twelve roles of the teacher. Med Teach 22:334–347
24. Greenblat CS, Duke RD (1975) Gaming simulation: rationale, design, and applications. Halsted Press/Wiley, New York

25. William T, Branch J, Kern D, Haidet P, Weissmann P, Gracey CF, Mitchell G, Inui T (2001) Teaching the human dimensions of Care in Clinical Settings. JAMA 286:1067–1074
26. Zhang C, Grandits T, Härenstam KP, Hauge JB, Meijer S (2018) A systematic literature review of simulation models for non-technical skill training in healthcare logistics. Adv Simul 3:15
27. Holzinger A, Kickmeier-Rust MD, Wassertheurer S, Hessinger M (2009) Learning performance with interactive simulations in medical education: lessons learned from results of learning complex physiological models with the HAEMOdynamics SIMulator. Comput Educ 52:292–301

A Simulation Game for Anticipatory Scheduling of Synchromodal Transport

Arturo E. Pérez Rivera, Martijn R. K. Mes, and Jos van Hillegersberg

Abstract In this paper, we explore the use of serious gaming to raise awareness about some of the trade-offs in anticipatory scheduling of synchromodal transport and to educate on how to optimize these trade-offs. We design and implement a game, called *Trucks & Barges*, which simulates a logistics service provider that needs to assign containers to barges and trucks on a daily basis. The game consists of various types of game modes in which the player can either manually plan the containers or use advanced decision support. The game includes a leaderboard such that players can compete against each other. We discuss how active learning by means of the game facilitates the adoption of an anticipatory perspective when scheduling synchromodal transport operations.

Keywords Simulation games · Anticipatory scheduling · Synchromodal transport

1 Introduction

Within the logistics industry, there is an increasing interest in predictive and prescriptive analytics, using the abundance of data available to improve transport planning. Techniques from Operations Research and Machine Learning offer opportunities to translate the information into decision support for human planners. In the area of intermodal transport, these trends have led to synchromodal transport. Synchromodal transport involves mode-free booking (easily switching between modalities) where transport plans require a careful balance of time, cost, and service levels. A challenge for logistics service providers (LSPs) is to provide appropriate decision support and to stimulate a "mental switch" for human planners toward a synchromodal way of working and the use of decision support. A serious game

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allows them to experience this and to become convinced about the advantages it may bring.

LSPs offering synchromodal transport often seek to consolidate as many containers as possible for the long haul in order to achieve economies of scale. However, consolidating many containers in a single mode (e.g., barge, train) may result in a high number of calls/stops of that mode due to different destinations of containers consolidated. The trade-off between consolidating containers and postponing containers to form groups with similar destinations is challenging due to the random arrival of containers. In this paper, we describe a game where the player has to decide whether to assign containers to a high-capacity mode (a barge) or a low-capacity mode (a truck) or to postpone their transport. The goal is to minimize the total costs over a planning horizon, where the costs of the high-capacity mode depend on the destinations visited. This problem was inspired by a Dutch LSP that transports containers between the eastern part of the country and the Port of Rotterdam (see [1]).

In the area of complex business processes, serious games have become increasingly important for training and education [2]. For example, supply-chain interactions within external and internal actors have been taught in computer simulation games such as the MIT Beer Game [3] and the Fresh Connection. However, in the area of freight transport, simulation games have not been as widely used as in the supply-chain field, even though their potential has been recognized [4]. The games that have been developed in this area are mostly used for raising awareness about the interaction among different actors in a transport system [5]. For example, games such as the Rail Cargo Challenge [6] raise awareness about the collaboration among rail operators, terminal operators, and freight forwarders. Similarly, the distributed barge planning game [7] simulates the interaction between barge and terminal operators, and the rail cargo management game [8] simulates the interaction among transporters, clients, and network managers. Games about training a single actor are scarce and focus mostly on passenger or public transport as seen in the review of [4]. Examples of such games that are closely related to ours are SynchroMania [9], the follow-up game MasterShipper, and the Modal Manager game [10]. Our game contributes to effectively teach students and professionals new decision paradigms in a threefold manner. First, we design a game that enables the player to experience the challenges related to transport planning. Second, we enable the player to experience decision support using advanced optimization algorithms. Third, we use challenging and competitive game components [11] that enable the testing and measuring of the effectiveness of raising awareness and educating about some of the trade-offs in anticipatory freight scheduling of synchromodal transport.

In the remainder of this paper, we describe our freight transport game *Trucks & Barges*. We subsequently describe the game mechanics (Sect. 2), game scenarios (Sect. 3), verification and validation of our game (Sect. 4), possible uses of our game (Sect. 5), and end with conclusions (Sect. 6).

2 Game Mechanics

The player takes the role of an LSP planner who schedules the transport of containers from the hinterland to a deep-sea port using trucks and barges. The capacity of the barge is limited, but there are an unlimited number of trucks. Every day, the player assigns containers to the barge and trucks of that day. New containers arrive each day, and each container is characterized by its destination, release day, and time-window length. There are three destinations, or terminals, in the deep-sea port: *red*, *green*, and *blue*. There are two types of release day: *same-day* and *next-day*. Containers with a same-day release can be transported on the day they arrive, while those with next-day release can only be transported from the next day onward. Time-window lengths can be 1, 2, or 3 days after the release day. Both the daily barge and the trucks take 1 day to bring a container to its destination, meaning that a container with a time-window of one must be transported today.

To make the gaming experience engaging and fun, we built a digital game of the aforementioned transport situation after an initial board-game prototype (see Sect. 4). The main playing screen is shown in Fig. 1 (cost information on the right is only shown when the player presses the info button). Containers are colored according to their destination and are located in one of two container yards. The container yard closest to the bottom left corner of the screen contains containers that are released for transport, and the yard closest to the top right corner contains container that are to be released (i.e., can be transported from tomorrow onward). Furthermore, containers are labeled with a white number in the middle according to their current time-window, which decreases as days pass. To schedule the transport of containers, the player can drag and drop containers from the left container yard into the barge or a truck. The player can also drag and drop containers out of the barge, or the

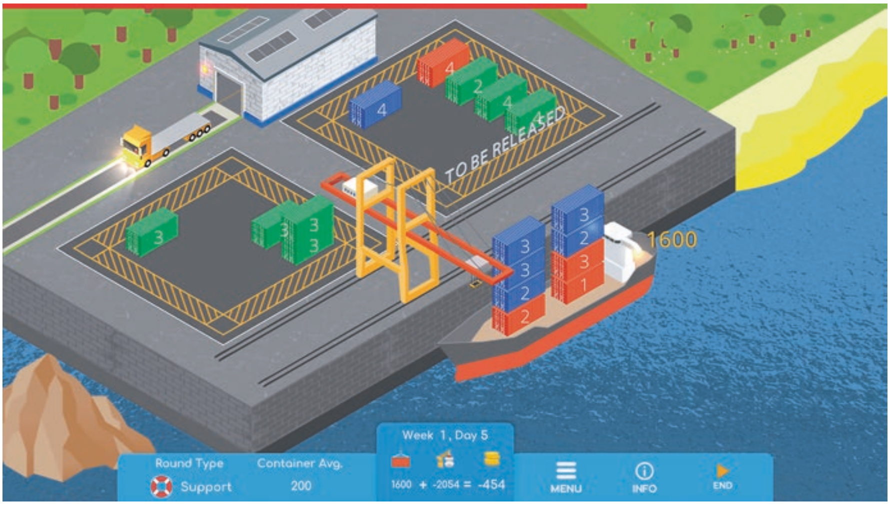

Fig. 1 Main playing screen of the game

trucks, back into the left container yard. The daily plan is finalized and executed when the end button is pressed or when the maximum time for a day's decision has elapsed, which is indicated by the red progress bar at the top of the screen.

The game is played in turns. Each turn corresponds to a day within a working week of 5 days. In each turn, the player has three possible decisions for each container in the yard of released containers: (i) transport by barge today, (ii) transport by truck today, or (iii) postpone its transport to a future day. The first two options result in *immediate costs*, which are displayed next to the barge or the trucks, whereas the third option does not. However, all options also influence the decisions on future days and their costs. At the end of each turn, containers that had a time-window of one and were not transported will be automatically assigned to the trucks. Then, the barge and the trucks depart (animation), and a day report is presented to the player with the costs of his or her decisions. In the transition to the next turn, two things happen: (i) containers to be released the next day (i.e., containers in the right yard) are moved to the left yard and (ii) new containers arrive to the two container yards. The turns continue until the end of the week, where the game "cleans" the containers that were left and assigns cleaning costs to the player. At the end of a week, the player gets a report on his or her costs for each day and the cleanup costs.

The goal of the player is to deliver all containers with the minimum total costs over all weeks. For the barge, there are two cost components: a setup cost and a variable cost. The setup cost depends on the combination of destinations visited. The variable cost depends also on the destination but is added per container consolidated in the barge. For the trucks, there is only a variable cost component that depends on the destination and is incurred per container transported. These costs are accessible by the player through the info button, as shown in Fig. 1. Besides these immediate costs, the planner also has access to estimated future costs in a special *support mode* (as opposed to the *normal mode* where this information is not shown). The estimated future costs are determined using the approximate dynamic programming (ADP) algorithm from [1]. This algorithm learns the weights of a linear regression model, using features of the state as explanatory variables (e.g., number of urgent containers and number or red containers). The regression model gives an estimate of the future costs/savings resulting from a specific player's decision. These estimated costs/savings of the current decision are displayed in the center tab of the main screen, together with the immediate costs of the current decision. The sum of the two supports the player in his/her decisions.

We play the game in rounds, where a *round* consists of a pre-defined number of weeks where a player is in the same mode. In addition to the normal and support modes, we use a *practice mode* to control the learning effect present when playing the game and, with these, make better comparisons between the normal and support mode. At the end of a round, a round report is displayed. The round report has a special indicator: the performance in the last week of that round. We believe this is a good indicator to compare players, since during the first weeks, learning effects of a new type of round may occur.

The game also has a dynamic *leaderboard* (see Fig. 2), where players can see the real-time costs of all players active in the session. For all players, the average costs per container in the current and best round so far are shown, together with the progress of the player. For the top 3 players, graphs with the average costs per container

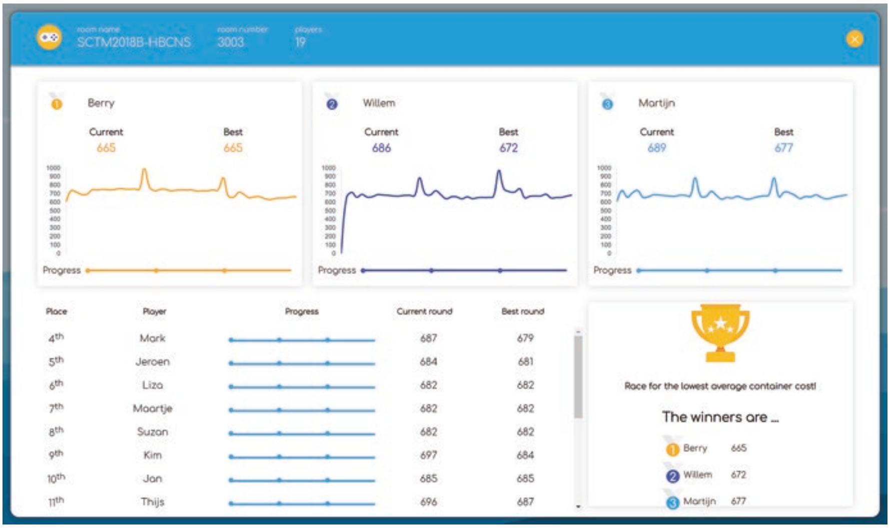

Fig. 2 Leaderboard showing the performance of all players within a given game room

per day are shown. A final top 3 of players that completely finished the game is shown in the bottom right corner. Before starting a game session, players have to enter a nickname and room-key that determines the web-based leaderboard where costs will be posted to. The *room-key* is a unique identifier for a game session defined by the game master. All costs and decisions, per player and per room-key, are stored centrally, in a web server.

The game can be seen as a single-player game with competition elements, i.e., a player's decisions with corresponding results do not depend on other players, but to boost competitiveness, players do receive live updates of the other players within the same session through the dynamic leaderboard. Hence, the game can be played by any number of players. The playing time depends on the time limit for the daily decision, which is typically 30–60 seconds. Hence, the duration for a typical gaming session with two game scenarios, each having three rounds of 3 weeks, is 45–90 minutes. The game has a web-based version that supports the use of different devices (e.g., laptop, tablet, etc.) and platforms.

3 Game Scenarios

For the objective of the game, we distinguish between the players and the game master. For the players, the objective is to educate them on (i) intermodal planning problems, (ii) the benefits and challenges in anticipatory scheduling, and (iii) the benefits of decision support. For the game master, the objective is to enable him/her to study the behavior of participants, their awareness about the trade-offs in anticipatory scheduling, their learning process, and the way they respond to various forms/sources of decision support.

To achieve these objectives, the game master can define the following settings: (i) the sequence of different round types to be played, (ii) the number of weeks per round, (iii) the randomization setting, (iv) lists with initial states and orders, (v) cost structure, (vi) barge capacity, and (vii) basic function weights for advanced decision support. The order list determines the scheduling situations that the player will face, such as a large number of different containers most of the days or a small number of predictable containers every day. The state list determines the containers that the player encounters at the beginning of each week. The randomization settings describe whether initial states and orders are randomly selected from the lists or are predetermined by the game master. Using these settings, the game master can represent a large number of LSP characteristics and influence the trade-offs a players faces with respect to postponement, consolidation, and mode choice. Hence, the flexibility in game scenarios allows the game master to decide on which aspects/benefits of anticipatory scheduling to educate on.

4 Verification and Validation

Before the implementation of our ideas in a web-based game, we developed a board-game prototype of our design. Several tests were carried out with colleagues and students, and several adaptations were made. In the board-game version, the game master had to manually move out containers that were transported, enter decisions in a spreadsheet model to compute costs, and add new containers for the next day. In the digital version, all of these steps are carried out by the game code. For verifying that the game code worked as expected, we performed three types of tests. First, we created a spreadsheet model of the game and compared the outcomes of the game with those of the spreadsheet model. Second, we played the game using extreme scenarios (e.g., many containers) and with unorthodox scheduling decisions. Third, we compared the results of players with those of heuristic policies and the ADP policy from [1].

Naturally, these steps revealed bugs and glitches in the game. Together with the game programmers,[1] we iterated over these steps until a satisfactory game version was achieved. For validating the game, various gaming sessions were organized with students from our educational programs as well as researchers from various Dutch universities. In these gaming sessions, we observed that the main differences among players occurred in (i) how well they interpreted the idea of decision support (expected long-term impact of a decision), (ii) how often players consulted the cost information, and (iii) whether players identified the differences in arrival patterns of the different container types (colors). After these validation steps, the game was ready to be deployed and is currently being used within various courses at various universities.

[1] Pineapple Studios www.pineapplestudios.nl

Lebesque et al. [6] distinguished five key elements of an effective learning environment in the context of serious games. Our game includes each of these elements. First, *active participation* is achieved by giving the player complete control of the outcome of the game. This control plays a crucial role in the support mode, since strictly following the support might not always be the best strategy. Furthermore, the dynamic leaderboard increases the involvement of a player in his or her decisions. Second, our game *challenges* the player, as game scenarios can vary with increasing difficulty, and scores of other participants as well as the performance achieved by the heuristics and the ADP policy (all shown on the leaderboard) challenge players to improve themselves. Third, *interaction* is achieved through the leaderboard, where players can compare their scores and discuss their strategies. Fourth, *feedback* is achieved through the day, week, round, and game reports within the game as well as through the leaderboard. The reports and leaderboard not only show the current performance but also the performance over time. Finally, *flow and engagement* relates to the fun side of the game; from our test sessions, we experienced that players remain enthusiastic, motivated, and involved in the game.

5 Game Use

The didactic and competitive aspects make our game ideal for use in sessions with a group of players playing simultaneously and receiving feedback during, and after, the rounds are played. We discuss three possible uses of our game:

- **Pre-defined research scenarios.** Here the game master pre-defines all initial states and orders and calculates the performance that can be obtained for each round using different scheduling policies (see Sect. 4). The main purpose of such session is to study the increase in awareness or the learning of a scheduling concept. Consider a gaming session with LSP planners, where the purpose is to measure awareness of the benefits of using anticipatory scheduling support. The game master can, for example, first do a practice round with everyone and then divide the group into two parts: one playing a normal round followed by a support round and the other playing a support round followed by a normal round. Since the game master has control over all orders, the support round can look the same for every player. In such case, the game master can measure cost differences between the normal and support mode among players with a high degree of repeatability and reliability.
- **Pre-defined competitive scenarios.** Here the game master pre-defines initial states and orders as in the previous scenario or uses the randomized setting but with a known random seed, such that random initial states and orders are replicable. The main purpose of such session is to enable players to compare themselves against other players and initiate discussions among them about their performance. Consider, for example, a gaming session with logistics practitioners where the purpose is to challenge the traditional paradigm of consolidating

as much freight as possible. The game master can define scenarios where sending a full barge does not lead to the optimal results. After playing a round, the game master can start the discussion by showing the leaderboard and the decisions made by the best players (or the decisions proposed by the planning support), and players can share their planning paradigms.

- **Randomized scenarios.** In this type of gaming session, the randomized setting is used without a pre-defined seed value, and the presence of a game master is not required. The purpose of this type of gaming session is primarily entertainment. We created a number of pre-defined scenarios and a public version of the leaderboard containing the *all-time best scores* of each pre-defined scenario.

6 Conclusions

In this paper, we designed a serious game to raise awareness about trade-offs in anticipatory scheduling of synchromodal transport and to facilitate active learning in understanding and optimizing these trade-offs. We designed the game based on a common single-trip long-haul container transport problem where containers have different destinations and time-windows. The game can be played in different modes, which help the player to minimize the logistical costs to various extents, and has several mechanisms to foster their engagement and competitiveness. The game master can define various settings of the game, which allows him or her to have different purposes for different target audiences.

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References

1. Pérez Rivera AE, Mes MRK (2017) Anticipatory freight selection in intermodal long-haul round-trips. Transportation Res E-Log 105(Supplement C):176–194
2. Faria A, Hutchinson D, Wellington WJ, Gold S (2009) Developments in business gaming: a review of the past 40 yeddars. Simul Gaming 40(4):464–487
3. Sterman JD (1989) Modeling managerial behavior: misperceptions of feedback in a dynamic decision making experiment. Manag Sci 35(3):321–339
4. Raghothama J, Meijer SA (2014) A review of gaming simulation in transportation. In: Meijer SA, Smeds R (eds) Frontiers in gaming simulation: 44th international simulation and gaming association conference, ISAGA 2013, Stockholm, Sweden, June 24–28, 2013. Springer, Cham, pp 237–244
5. Rossetti RJ, Almeida JE, Kokkinogenis Z, Goncalves J (2013) Playing transportation seriously: applications of serious games to artificial transportation systems. IEEE Intell Syst 28(4):107–112
6. Lebesque L, van Meijeren J, de Boer M, Kosterman S (2017) Serious gaming for logistics. Preparing for the future. Technical report, TNO

7. Mes MRK, Iacob ME, van Hillegersberg J (2014) A distributed barge planning game. In: Meijer SA, Smeds R (eds) Frontiers in gaming simulation: 44th international simulation and gaming association conference, ISAGA 2013, Stockholm, Sweden, June 24–28, 2013. Springer, Cham, pp 214–221
8. Meijer SA, Mayer IS, van Luipen J, Weitenberg N (2012) Gaming rail cargo management: exploring and validating alternative modes of organization. Simul Gaming 43(1):85–101
9. Buiel E, Visschedijk G, Lebesque L, Lucassen I, van Riessen B, van Rijn, A, te Brake G (2015) Synchro mania-design and evaluation of a serious game creating a mind shift in transport planning. In: 46th International Simulation and Gaming Association Conference, ISAGA, pp 1–12
10. Kurapati S, Kourounioti I, Lukosch H, Tavasszy L, Verbraeck A (2018) Fostering sustainable transportation operations through corridor management: a simulation gaming approach. Sustainability 10(2)
11. Pasin F, Giroux H (2011) The impact of a simulation game on operations management education. Comput Educ 57(1):1240–1254

From Discussions to Games: Facilitating Interactions Between Experts from Aviation and Humanitarian Aid

Maria Freese, Kenny Meesters, and Bartel Van de Walle

Abstract This paper concentrates on methods to facilitate interactions and knowledge exchange between different expert groups. The specific case examined is on expert groups from the aviation and humanitarian context. Both are highly complex, multidisciplinary systems where stakeholders work under high time pressure and uncertainty and in a complex decision-making environment. Especially during a sudden on-set (natural) disaster, stakeholders from the humanitarian field and airport management need to work closely together to guarantee the most efficient way of handling issues like overwhelmed customs officials, unsolicited aid donations and unsafe or unprepared warehouses. While several approaches are available, the question still remains: which method works best to create a mutual understanding between these two worlds. To answer it, three different approaches have been examined: (1) discussion rounds with experts, (2) gaming-related method and (3) simulation game. The set-ups as well as the results will be described and pros and cons of each method discussed.

Keywords Serious games · Airport game · Disaster management · Humanitarian aid · Airports · Complex systems

1 Introduction

In aviation as well as in the humanitarian context, different stakeholders work under high time pressure, uncertainty and in a complex decision-making environment. Even more, often airports and their wider socio-economic systems are limited in their capacity (resources, people, etc.) due to the disruptions caused by a disaster. Airports are multidisciplinary systems, involving aspects from passenger handling,

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international exchange of passenger and goods (international law), aviation-specific issues, logistics, safety and security. Especially during a sudden on-set disaster, the aviation industry and humanitarian field need, and are even 'forced', to work closely together. However, both these disciplines are complex systems in their own right, introducing even more complex coordination challenges when they meet in challenging operational circumstances. To analyse how we can bring both disciplines closer together, this paper concentrates on methods to facilitate interactions and knowledge exchange between different expert groups. Therefore, the paper is structured as follows: First, we give an overview on how the aviation and humanitarian system are linked with each other and what the current challenges are. This is followed by a description of three different methods that can be used to bring both groups together. The sessions themselves as well as the used methods and results will be presented after this. Finally, we discuss the results and give suggestions for future work.

2 Theoretical Background

2.1 Humanitarian Response

Changes in climate and the growing population have not only led to an increase in the occurrence of disastrous natural events but have also increased the impact of these events on the population, as illustrated by the Red Cross World Disaster Report [1]. These disruptive events and their impact can be characterized in several ways [2]. First, a disruptive event *overwhelms the local response* capacity of a community to deal with the effects. The demand for (emergency) resources and capacities exceeds the available capacity. Second, there are *significant disruptions*; these disruptions also affect the locally available coping capacity, i.e. the needed resources can reach those who need them. Third, there is a factor of *time pressure*. A timely response plays a critical role in reducing the negative effects of such an event on a community. These combined factors make a community facing a large-scale disaster vulnerable and depend on the support of external agencies and organizations to supplement their response capacity and mitigate the effects on their community.

The circumstances in disasters present several challenges to humanitarian agencies like identifying and understanding the needs and size of the affected population, the complex coordination with other NGOs and governmental agencies [3, 4] and international and local logistical challenges under time pressure and uncertainty. For effective delivery of aid, the corporations and integration of logistical organizations, transportation companies and especially airports for access are critical success factors [5].

2.2 Airport Management

Air traffic is nowadays pressured by high demands on economy and safety. To guarantee most efficient air traffic, all resources at an airport should be used in a most efficient way. Airports in general are complex systems where different stakeholders (e.g. airlines, air navigation service provider, airport authority, ground handler and security) have to interact with each other not only in their own operational centres but also work together with other stakeholders. Analyses have shown that there is a growing amount of air traffic [6]. Furthermore, there are also new challenges regarding economic and environmental issues [7]. Because of these aspects, the process of sharing information becomes more and more important. To support an optimized information process during normal operations, the concept of Airport Collaborative Decision-Making (A-CDM) [8] has been developed. A-CDM focuses on how different stakeholders can use a common database. Studies have already shown that this lead to an increase of efficient operations [8–10].

An inadequate information sharing among different stakeholders during normal operations can lead to negative consequences like delays; during humanitarian disasters, this can lead to delays in the delivery of crucial aid, reduced availability of response capacity, etc. This is just one example which shows the relevance of information sharing, knowledge exchange and working collaboratively with each other. There are various studies which have already focused on the role of collaboration between different stakeholder groups in aviation as well as collaborative management [11], but no studies exist about the best way to analyse and facilitate these interactions and cooperation, especially with an additional complex system such as humanitarian aid.

2.3 Research Question

Airports are the 'lifeline' for an affected country (receiving incoming aid, both assistance and relief items) and the linking pin between the aviation and the humanitarian system. Stakeholders of both systems must cooperate to guarantee the most efficient way of handling things in challenging circumstances. This is not always easy to realize because the aviation and humanitarian fields are complex systems and characterized by different stakeholders with divergent goals and different interests.

Hence, further research is needed on best practices for creating a mutual understanding. A shared understanding paves the way for a meaningful dialog, a prerequisite for exploring dependencies and interactions and necessary conditions to jointly improve the efficiency of operational procedures.

Fig. 1 Overview of different methods to facilitate interactions (Adopted from [12, 13])

Various methods exist to facilitate these interactions, ranging from 'simple' meetings with presentations to more elaborate interactive activities. To analyse which method is best studied to bring both disciplines together, this paper concentrates on different methods (see Fig. 1) to facilitate interaction and knowledge exchange between different expert groups. These methods are different from each other regarding the degree of complexity and reality. On the left axis, you can see high complex and more realistic methods (e.g. field exercises); on the right axis, you see low complex methods (light on resources) including a higher abstracted degree of reality (discussion rounds with experts) [12, 13]. While several approaches are available, the question still exists: which method works best in which situation to create a mutual understanding.

3 Methods

To answer this research question, three methods for facilitating interactions have been examined: (1) open discussion rounds with experts (no in-depth discussion), (2) gaming-related method (explore the connections of issues) and (3) simulation game (understand the connections of issues, knowledge of the subject is necessary, role play, storytelling). These different forms of the facilitation of interactions represent different levels of (a) the ease of implementation vs. more elaborate set-ups and (b) the incentives and options for participants to explore cross-cutting issues in a more constraint, realistic setting vs. a more free-form setting. In the different methods, we examine the scope of issues covered and the depth of the issues explored. We are specifically interested in an in-depth discussion regarding cross-cutting issues as an indicator of a mutual understanding.

In each session participants were asked about current challenges due to the topic of airports during a humanitarian disaster, identify gaps, barriers, best practices and next steps to improve the coordination between the aviation industry and the humanitarian sector.

These sessions have been conducted over the course of a year and have been aligned with planned events where both the humanitarian community and the aviation sector were in attendance. In each of these events, the session has been facilitated using a different method. Across the different events, there was a small retention of participants; however most attendees had not participated before. The facilitators introducing the different methods were the same. For each method the set-up has been described and the outcomes analysed to determine the depth and range of topics and issues covered.

3.1 Discussion Rounds with Experts

3.1.1 Sample and Set-Up

The annual Humanitarian Networks and Partnerships Week (HNPW) brings together experts in crisis preparedness and response from a diversity of organizations and countries. The objective of the HNPW is to provide a platform where discussions focus on identifying solutions to humanitarian challenges. These challenges cover a wide range of topics, including information management, safety, coordination and improving the logistical agility of the humanitarian response.

The attendees of this event included members of the United Nations including Office for the Coordination of Humanitarian Affairs, the World Food Programme and the logistics cluster, the United Nations Development Programme. Furthermore members from the international logistics and aviation industry, including Deutsche Post DHL (logistics partner), and International Civil Aviation Organization also attended. Finally, different (international) NGOs and government representatives were attending the sessions. Throughout the session, around 20 participants attended.

One session was part of the Inter-Network Day; in a rotating fashion, different groups of HNPW participants would visit different topics, including the 'Changing airports from humanitarian response bottlenecks to effective logistics hubs' session. In a total of 5 rounds, around 40 participants provided their input on issues, challenges, best practices and potential solutions to strengthen the role of airports in disaster response.

3.1.2 Results

The open session allowed participants from different backgrounds to join the discussion and provide their input. As many of them have had experience with the challenges at airports in disasters, the open session provided a low threshold to provide their input. At the same it allowed them to learn about the underlying causes for these issues, for example, specific constraints in the aviation industry such as

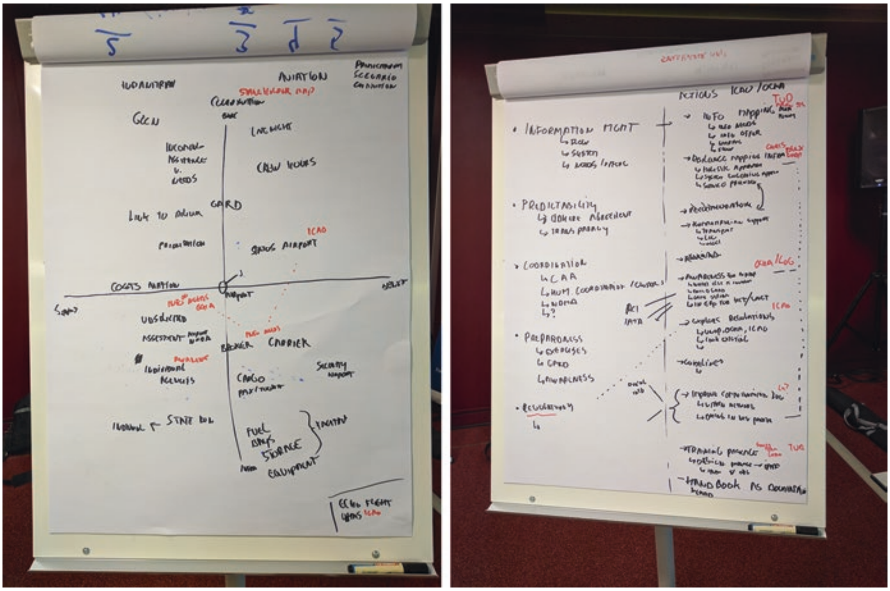

Fig. 2 Results from the discussions at the Humanitarian Networks and Partnerships Week 2018

regulations. Furthermore, the sessions at HNPW also provided valuable insight in the topic itself. It enabled humanitarians and aviation experts to express their challenges and constraints to each other. A specific example that was explored in depth was the information exchange between the aviation industry and the humanitarian community. As one of the results of the HNPW, various key issues have been listed (see Fig. 2).

There are several advantages to the approach used at the HNPW to bring together people and organizations from different disciplines. First, there is a low need for resources and preparation of specific materials. While some experts provided their experience and real-world examples to the discussion, from a facilitator perspective, no additional materials needed to be prepared in advance. It also allowed a more flexible approach to the discussion. The open discussion approach also worked well for the explorative nature of the sessions, in which humanitarian participants may not be familiar with aviation specifics and vice versa. Most importantly, the open approach makes the discussion and sessions open to a wide range of (potential) participants with different experiences, expertise and backgrounds. The open nature allowed the discussions and interactions to adapt the participants' level and interests.

The disadvantage to this method is that because of the wide range of participants, it is difficult to come to a deeper and more analytical understanding of the topic. There was limited in-depth discussion on the issues and the underlying root causes. Towards the end of the HNPW, participants mentioned that a more structured approach would be needed to understand how the different issues are connected in order to formulate next steps forward.

3.2 Gaming-Related Method

3.2.1 Sample and Set-Up

Thirty-four international stakeholders from the field of aviation, humanitarian organizations, industry and academia attended this 2-day workshop. Driven by real-world challenges in humanitarian logistics, information management and coordination as well as simulation and training, the group worked within smaller working groups on identifying challenges in these areas. Therefore, they used the formula method [14] which consists of two main steps: (1) brainstorming, referring to a certain question, where all participants discuss main elements derived from a question and write them on cards, and (2) developing a formula within smaller working groups, where people can use all aspects which were mentioned during the brainstorming session as well as all the mathematical symbols they know (+, −, =, ≠, etc.). After this, the formula of every group as well as the results will be presented and discussed.

3.2.2 Results

In Fig. 3, three examples of a formula are presented. The focus is less on the correctness of all mathematical symbols than on the structure and interdependencies of the main topics. The participants themselves enjoyed this new way of thinking and structuring their ideas. This method is easy to handle and recommendable if you want to analyse differences between groups. It is also well suited to identify gaps. Disadvantages are the less complexity and reduced degree of reality. Because of these two things, it might be challenging to transfer the results of the formulas into the real working life. Therefore, an intensive debriefing is necessary.

3.3 Simulation Game

3.3.1 Sample and Set-Up

A third workshop was conducted with several participants from the Netherlands working either in the field of aviation or humanitarian aid. This workshop consisted of three parts. First, during the briefing, the people had the chance to get to know

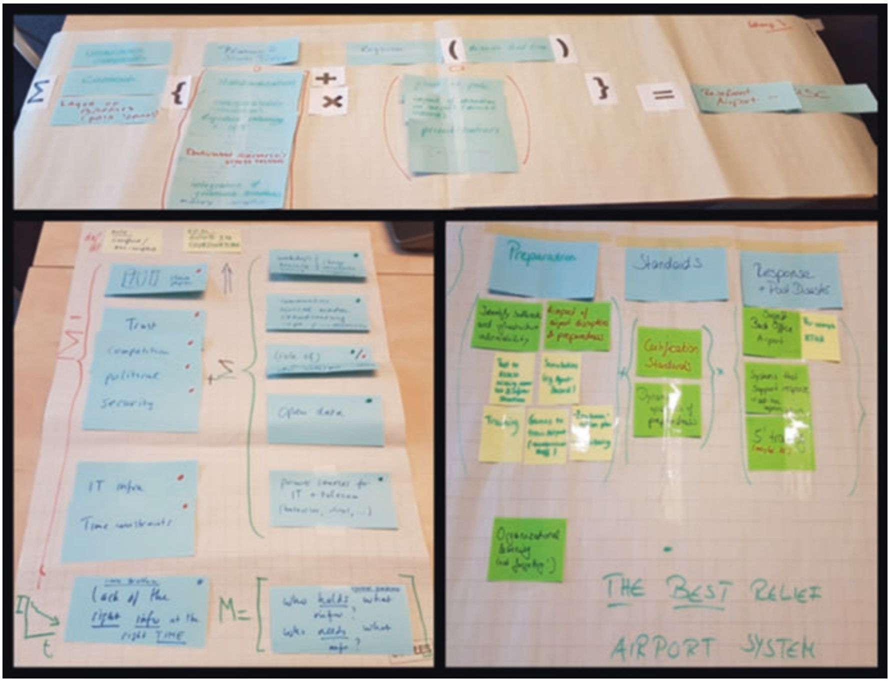

Fig. 3 Examples of formulas

with each other. This was followed by an introduction about the structure of the session as well as presentations about the humanitarian and aviation context. Second, the simulation game was played (see below for detailed description). During this, also observations were made. Third, in the discussion phase, the participants were asked about transferring results from the workshop into their real working life.

To understand these complex systems including the behaviour of stakeholders, it is relevant to model aspects of decision-making. This is difficult to analyse in real life [15]. Therefore, a simulation game scenario was used which consisted of four steps, following the disaster management cycle [16, 17] (see Fig. 4).

The scenario was based on a recent event that occurred during the 2017 hurricane season in the Caribbean. The participants themselves took on the role of airport managers (St Maarten airport) and the humanitarian coordination (United Nations Disaster Assessment and Coordination team). Each of the elements of the disaster management cycle has been translated into a specific 'challenge' in the game (see Fig. 5 for the timeline) which has been defined as follows:

1. Preparation: The players received a notification (a so-called prewarning) about an incoming hurricane. They were asked to prepare the airport for this event.
2. Response: Following the hurricane landfall, participants were asked to assess the damage, take measure to reopen the airport and accommodate the initial humanitarian assistance.

Fig. 4 Disaster management cycle [16, 17]

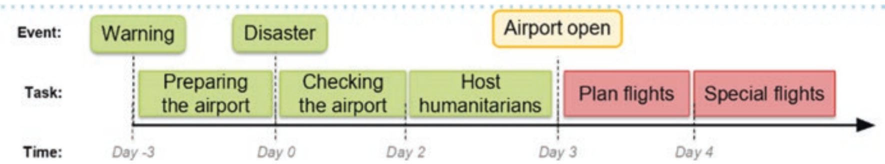

Fig. 5 Timeline for simulation game scenario

3. Recovery: At this stage, the airport is functional again (at limited capacity), and participants need to handle and support the incoming relief and outgoing passengers, as well as deal with specific cases (medicine, VIP, etc.).
4. Mitigation: The participants were asked to reflect on the past stages and propose improvements to reduce the impact in future events.

3.3.2 Results

The results have shown that the participants emphasized the commonalities between their fields. This led to a better understanding of the constraints and challenges that their counterpart was operating in. Moreover, the game helped to illustrate the interdependencies between the various elements within and between their lines of work. In addition to the two complex systems benefitting from an improved awareness and understanding of each other, the game session also provided valuable insights for research. The game session demonstrated directions for improving the synergy between the humanitarian and aviation sectors for more efficient aid delivery and coordination in disaster responses.

4 Discussion and Conclusions

An increasing number of people are facing the consequences of volatile events around the globe, whether due to natural causes or man-made crisis. The mounting frequency and intensity of these events require the international humanitarian community to become more agile in responding to these events. In order to ensure an effective delivery of aid, a strong cooperation between different actors is needed. In the logistical domain, airports play a critical role to ensure that aid reaches those in need. To strengthen the role of airport in disaster, experts from both the humanitarian and aviation industry need to create a better understanding of their mutual dependencies and contribution towards each other.

The present paper analysed three methods (discussion rounds with experts, gaming-related method, simulation game), to determine the best approach to bring experts from different complex disciplines together (i.e. aviation and humanitarian aid) to (1) create a mutual understanding of and learn actively from each other, (2) identify gaps and issues and (3) develop solutions and new approaches. All methods can be used as a platform to facilitate these discussions. Based on our analyses of the methods, we found that the choice for a method depends on different aspects: (a) the focus of the (research) question, (b) the target group, (c) the desired outcome and (d) the availability of resources (e.g. time, materials). Most importantly we found that the method of interaction also contributes to the level of engagement of the participants and as a result the depth of the discussion and its outcome.

5 Outlook and Future Work

In the present paper, the focus was on analysing different methods to facilitate interactions and knowledge exchange between different groups of experts. Therefore, three approaches (discussion rounds with experts, gaming-related method, simulation game) were successfully tested. Those methods are not only limited to the area of airports in a humanitarian disaster. They can also be used in any other area where different stakeholders need to work together. During the debriefing, participants mentioned that the conduction of a role change would be also interesting for them. This means that people do not react in their role as an expert but have the unique chance to 'play' another role with the goal to understand the perspective and responsibilities of the other stakeholders.

A specific focus for future research is to further understand and quantify the relationship between the variables that factor into the facilitation of a session, as those explored in this paper, in relation to the objective of a session. As currently a wide range of methods exists to facilitate (explorative) sessions between two disparate groups across a broad spectrum from group discussions to elaborate role playing set-ups, such an understanding would support facilitators in making an (better) informed choice in the method of delivery of explorative sessions. The work presented in this paper presents first steps towards exploring these relationships, trade-offs and choices for facilitation methods.

References

1. Terry C, Schipper L (2015) World disasters report 2015: focus on local actors, the key to humanitarian effectiveness. International Federation of Red Cross and Red Crescent Societies, Geneva
2. Rodríguez H, Quarantelli EL, Dynes RR (2007) Handbook of disaster research. Springer, New York
3. Van den Homberg M, Meesters K, Van de Walle B (2014) Coordination and information Management in the Haiyan Response: observations from the field. Procedia Eng 78:49–51
4. Comes T, Meesters K, Torjesen S (2017) Making sense of crises: the implications of information asymmetries for resilience and social justice in disaster-ridden communities. Sustain Resilient Infrastructure: 1–13
5. Gyöngyi K, Spens KM (2007) Humanitarian logistics in disaster relief operations. Int J Phys Distrib Logist Manag 37(2):99–114
6. Mensen H (2013) Handbook of aviation. Springer, Berlin/Heidelberg
7. Advisory Council for Aviation Research and Innovation in Europe (ACARE) (2011) Flightpath 2050 – Europe's vision for aviation: maintaining global leadership & serving society's needs. Publications Office of the European Union, Luxembourg
8. EUROCONTROL (2017) Airport CDM operational concept document. Available at http://www.euro-cdm.org/library/cdm_ocd.pdf. Accessed 13 Apr 2018
9. Ball MO, Hoffman RL, Knorr D, Wetherly J, Wambsganss M (2000) Assessing the benefits of collaborative decision making in air traffic management. 3rd USA/Europe air traffic management R & D seminar, Napoli, Italy
10. Günther Y, Inard A, Werther B, Bonnier M, Spies G, Marsden A, Temme, M, Bohme, D, Lane R, Niederstrasser H (2006) Total airport management. Available at http://www.bs.dlr.de/tam/Dokuments/TAM-OCD-public.pdf. Accessed 11 Apr 2018
11. Freese M (2016) Game-based learning – an approach for improving collaborative airport management. 10th European conference on games based learning, Paisley, Scotland
12. Meesters K, Van de Walle B (2014) Serious gaming for user centered innovation and adoption of disaster response information systems. Int J Inf Syst Crisis Response Manage 6(2):1–15
13. Alexander D (2000) Scenario methodology for teaching principles of emergency management. Disaster Prev Manag 9(2):89–97
14. Leigh E, Kinder J (1999) Learning through fun & games: 40 games and simulations for trainers, facilitators, and managers, Sydney. McGraw-Hill Co. Inc, New York
15. Klabbers J (2006) The magic circle. Sense Publishers, Rotterdam
16. Khan H, Vasilescu LG, Khan A (2008) Disaster management cycle-a theoretical approach. J Manag Mark 6(1):43–50
17. Van de Walle B, Turoff M, Hiltz SR (2010) Information systems for emergency management. Routledge, London

3D Periodic-Sugoroku Game for Active Learning of the Periodic Table

Takeshi Shibata, Masami Ido, Shinichi Ito, and Kazuhiko Sato

Abstract The periodic table is an important set of scientific symbols that are not commonly used in everyday life but which may cause science phobia in youngsters. Many types of educational tools for learning the periodic table do not provide an opportunity to discover the relationships between chemical elements. In this study, we propose a NEO Game of *sugoroku* involving a 3D periodic chart (i.e., *periodic-sugoroku*) for use as an educational tool. *Sugoroku* is a Japanese board game similar to *Parcheesi* or *Monopoly*. Using this proposed tool, students can actively learn the periodic chart while enjoying a *sugoroku* game.

Keywords Sugoroku · 3D Periodic chart · Active learning

1 Introduction

A segment of the young population in Japan exhibits a lack of interest in scientific knowledge or methodology. This phenomenon of science phobia is an important problem. Some scientific symbols induce this science phobia. However, scientific symbols assist in logical thinking. Many youngsters find these symbols difficult to understand since they are not used on a daily basis. An interactive educational tool designed for learning science may be useful in resolving this problem [1–3].

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The periodic table is an important set of scientific symbols for scientific understanding, not commonly used in everyday life. The periodic table not only lists the symbols but also describes the relationships between chemical elements. The table is sequenced by atomic number, and membership of a group indicates the distribution of electrons for each atom. The periodic table appears in a variety of scholastic materials such as textbooks being used in junior high schools in Japan. Many types of educational tool for learning the periodic table have been proposed [4, 5]. These previous tools encouraged students to independently memorize the symbol of each chemical element. These tools did not provide the opportunity to discover the relationships between chemical elements. For an educational tool, we focus on a 3D periodic chart that is a type of periodic table. A 3D periodic chart maps the chemical elements onto the 3D space. As the 3D periodic chart can be scanned from any viewpoint, a student is encouraged to actively learn the relationships between chemical elements.

In this study, we propose a NEO Game involving a *sugoroku* and a 3D periodic chart (i.e., *periodic-sugoroku*) as an appropriate educational tool. *Sugoroku* is a Japanese board game similar to *Parcheesi* or *Monopoly*. In Japan, educational tools based on the *sugoroku* game have already been proposed [6, 7]. Through the use of such a proposed tool, students can actively learn the periodic table while enjoying a *sugoroku* game.

2 Periodic-Sugoroku

2.1 *Overview of* Periodic-Sugoroku

Learning the periodic table requires remembering both the names and values of the chemical elements. It is also important to understand the relationship between each chemical element. The educational tool should encourage students to perform three activities, as follows:

1. Observe the periodic table.
2. Understand the value of each chemical element.
3. Understand the position of each chemical element.

In this study, we focused on *sugoroku* game in order to provide these educational effects. In *sugoroku* game, players are required to place a game-piece onto a board containing many panels. Players then move these game-pieces according to a set of rules. Generally, the rule for moving a game-piece requires players to roll a die toward a goal panel on the game board.

In order to encourage students to observe and understand each chemical element, we employed a 3D periodic chart of Elemen-touch [8]. Elemen-touch is one of periodic table, which places each chemical element along a spiral line on the 3D space. In contrast to the traditional 2D layout, Elemen-touch places each chemical element continuously around a 3D board. This enables students to effectively describe the relationship between each chemical element.

In this study's proposed *periodic-sugoroku*, each panel on the Elemen-touch game board represents a chemical element. Players are able to move game-pieces by using playing cards instead of dice. Furthermore, the board does not contain a goal panel. Thus, players are able to move game-pieces to obtain scores when selecting chemical elements.

2.2 Periodic-Sugoroku *Rules*

Figure 1 shows the tools involved in this study's proposed *periodic-sugoroku*. Players use a tablet board (Fig. 1a), playing cards (Fig. 1b), element-cards (Fig. 1c), and assistant-tablets (Fig. 1d). One tablet board is shared among all players. The tablet board displays a 3D periodic chart as a gaming board through the use of computer graphics in addition to the position of each player's game-piece. Each player also has an assistant-tablet. The assistant-tablet shows all panels that the player is able to reach with their game-piece according to the combination of playing cards they possess.

Table 1 shows the *periodic-sugoroku* rules. In this game, each chemical element panel is associated with points matching the value of the chemical element. A noble-metal element contains 8 points, while rare-earth elements contain 4 points, rare-metal elements contain 2 points, and other common elements contain 1 point.

At the beginning of each game, five element-cards and three playing cards are dealt to each player. Player game-pieces are then placed on the hydrogen panel, which contains the atomic number 1. Players are able to move game-pieces according to the sum of their playing cards by playing one element-card. When the color of the playing card is black, it is calculated as a positive number. Otherwise, the color of the playing card is red, which is calculated as a negative number. When the player reaches a panel and is in possession of an element-card matching that panel,

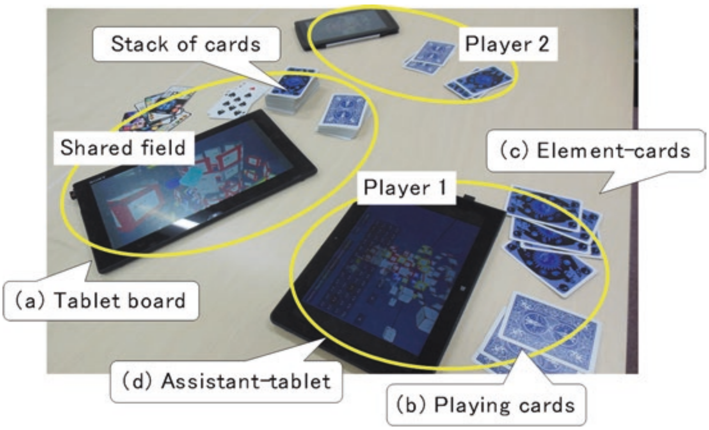

Fig. 1 *Periodic-sugoroku* game tools

Table 1 *Periodic-sugoroku* rules

Tools	Periodic table, game-pieces, playing card, element-card
Initializing	Deal 5 element-cards and 3 playing cards. All game-pieces are placed on the Hydrogen panel
(1). Point of element	Noble metal elements contain 8 points. Rare-earth elements contain 4 points. Rare-metal elements contain 2 points. Other common elements contain 1 point
(2). Score	When a player reaches a panel and is in possession of an element-card matching the panel, they obtain the points associated with the element
(3). Cost to move	Pay 1 element-card
(4). Destination	Move a game-piece according to the sum of the playing cards
(5). Move to same group	If a player plays an element-card as an extra cost, the player can move a piece to another element panel of the same group
(6). Exchange element-cards	When the player obtains a point, they are able to draw 2 element cards
(7). Extra-element-card	When a player reaches a panel that is occupied by another player's game-piece, these players exchange all element cards
(8). Winner	At the end of the game, the player with the highest score is the winner

they obtain the points associated with that chemical element. When a player obtains a point, they are able to draw two element-cards.

In addition, if a player plays an element-card as an extra cost, they are able to move their game-piece to another element belonging to the same group. When a player reaches a panel that is occupied by another player's game-piece, these players exchange all element-cards. When the stack of element-cards is depleted, the game is finished. At the end of the game, the player with the highest score is the winner.

According to these rules, since players are able to move game-pieces through a combination of playing cards, they must strategically decide on its destination. This rule encourages players to observe the position of the chemical elements while understanding their values.

2.3 Periodic-Sugoroku *Software*

Elemen-touch is a 3D periodic chart on which the chemical elements are spirally positioned in a 3D space. In order to play *sugoroku* using this 3D periodic chart, each player much share information regarding all game-pieces. Players must also observe the 3D periodic chart from their own viewpoints. We therefore developed software for *periodic-sugoroku* using virtual reality and networking technology.

Figures 2 and 3 show the three software devices used in *periodic-sugoroku*. The first device involves a board-app that is utilized on a tablet board (Fig. 2a). This board-app provides a 3D periodic chart that is used as a *sugoroku* board. The board-app can also display all game-pieces. Players share the board-app to move their game-pieces.

A viewer-app (Fig. 2b) works on each assistant-tablet. Each player can observe the 3D periodic chart using their own viewer-app. The board-app and viewer-app are

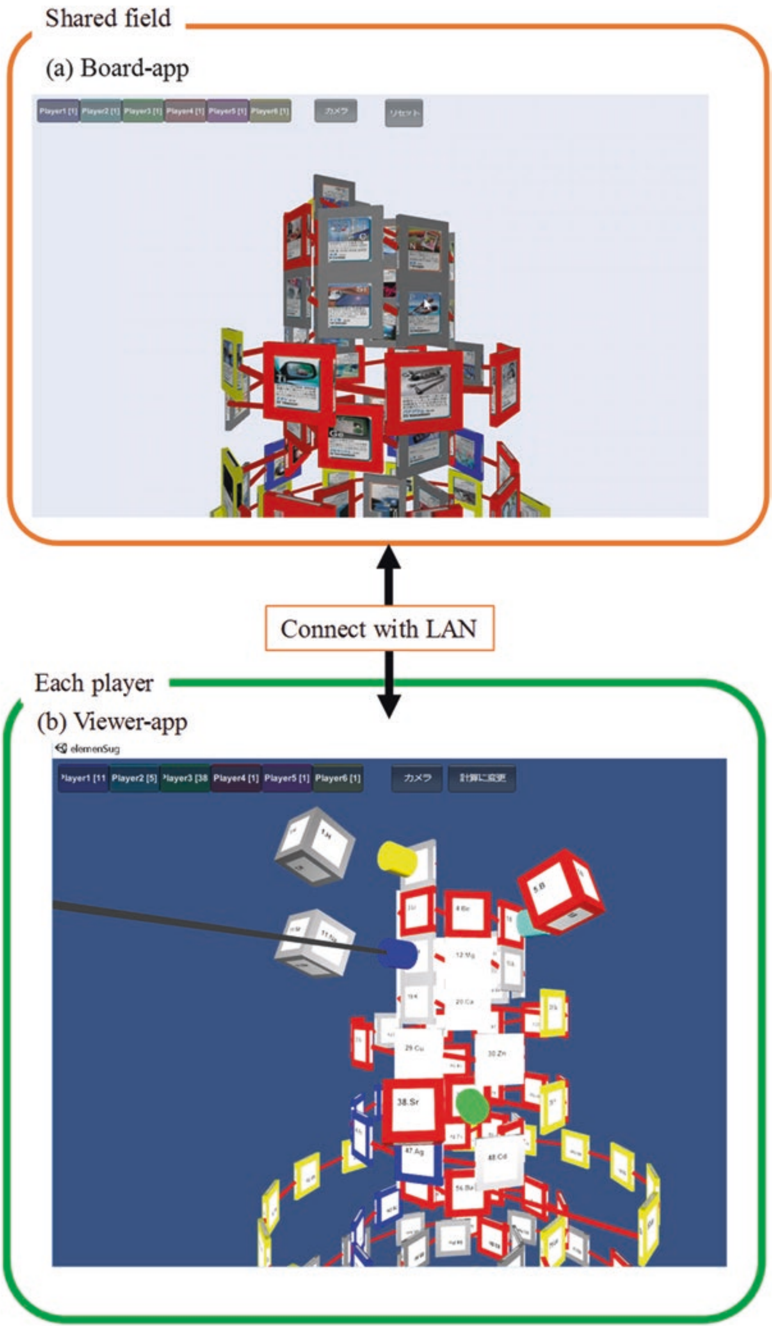

Fig. 2 Board-app and viewer-app of *periodic-sugoroku* software

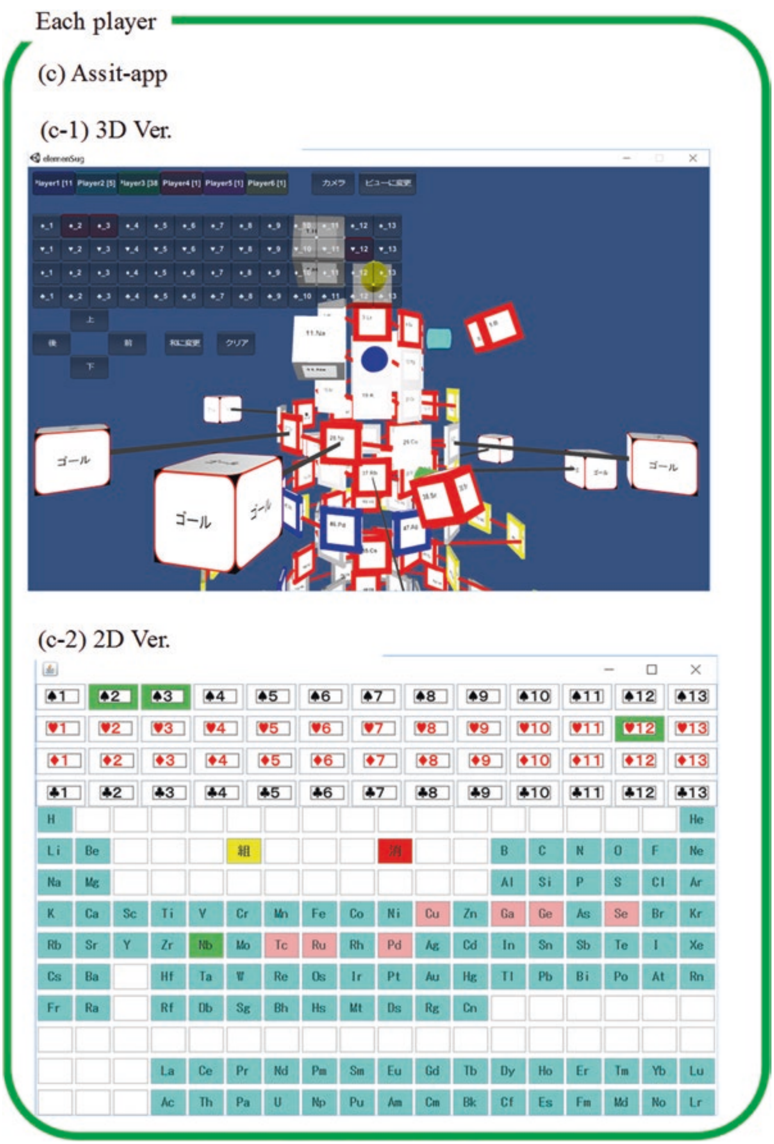

Fig. 3 Assist-app of *periodic-sugoroku* software

connected through a local area network (LAN). The movement of a game-piece on the board-app is sent to the viewer-app; each viewer-app shows all game-pieces.

By using both the board-app and viewer-app, players are able to share the position of all game-pieces and observe the 3D periodic chart from a free viewpoint. These functions enable players to strategically plan.

An assist-app (Fig. 3) works on the assistant-tablet. Two versions of assist-app, 3D version (c-1) and 2D version (c-2), were developed. The assist-app can obtain all destinations from all playing card combinations. The assist-app reduces the time taken to calculate destinations. Players are therefore able to concentrate on observing the 3D periodic chart while developing strategies to obtain high scores.

3 Experiment

In order to evaluate this study's *periodic-sugoroku*, a total of 16 participants played the game. After playing the game, the participants answered a questionnaire. In this experiment, we used one Windows laptop PC as a tablet board in addition to three Windows laptop PCs and one Android tablet PC that served as assistant-tablets. This experiment proceeded according to the following four steps:

1. Providing instructions on using the tablet board and assistant-tablets
2. Providing the rules for *periodic-sugoroku*
   - Overview of rules
   - Tutorial
   - Practice play (10 min.)
3. Playing *periodic-sugoroku*
4. Answering the questionnaire

Table 2 shows the questionnaire. Questions Q1 to Q6 concerned participant-characteristics, while questions Q7 to Q19 were about *periodic-sugoroku*, and Q20 was a general open-ended question.

This experiment was conducted three times. Different participants played *periodic-sugoroku* in each experiment. In the third round, participants played *periodic-sugoroku* in groups of two. We also provided "how to play" information, so all participants were able to understand the rules.

4 Results and Discussion

The average play time was 40 min. At the beginning of the game, we received inquiries about the rules from some participants. Almost all players understood the rules and were able to play smoothly. Figure 4 shows the results of the questionnaire. The horizontal line indicates question number, while the vertical line indicates score.

The results for Q7 (i.e., Were you interested in the periodic table before playing *periodic-sugoroku*?) indicated that not all participants were interested in the periodic table prior to playing the game. However, each median for Q8 to Q10 (i.e., questions about interest in the periodic table after playing *periodic-sugoroku*) was either 3 or 4 points. These results indicate that *periodic-sugoroku* can attract participants to the periodic table.

Table 2 Questionnaire

Questionair of Periodic-sugoroku game Day: Month:
About your property
Ql. SEX Age : ( )
Q3. Have you ever taken a chemistry class? [YES/NO]
Q4. How many times did you play periodic-sugorokou?
About 3D periodic chart
Q5. Do you know that there are many kinds of periodic tables?
Q6. Do you want to use or learn about 3d periodic charts?
About your awareness after playing a game of periodic-sugoroku
Q7. Were you interested in the periodic table before playing periodic-sugoroku?
QS. Did you gain interest in the periodic table?
Q9. Do you think that you want to use or learn the periodic table?
Q10. Did you gain interest in rare-earth or rare-metals?
Ql 1. Did you learn about elements you did not know about before?
Q12. Did you consider the relationship between each element?
Q13. Do you think you can learn the periodic table by playing periodic-sugoroku?
About periodic-sugoroku
Q14. Is it easy to remember the rules of periodic-sugoroku?
Q15. How was the usability of the board-app?
Q16. How was the usability of the viewer-app?
Q17.How was the usability of the assist-app?
Q18. Doyen want to play periodic-sugoroku again?
Q19. Did you enjoy the game?
Q20. Free comment

Note: In the experiment, the questionnaire was written in Japanese.
Note: Participants were required to mark 1 to 5 to answer each Q5 to Q19. (1. Strongly disagree. 2. Disagree. 3. Neither agree nor disagree. 4. Agree. 5. Strongly agree)

The median of Q11 (i.e., Did you feel that you gained knowledge about the periodic table?) indicated a high score (5 points). On the other hand, the median of Q12 (i.e., Did you consider the relationship between each element?) was not high (2.5 points).

Each median for Q13, Q18, and Q19 (i.e., questions about *periodic-sugoroku* impressions) indicated high scores. These results indicate that many participants gave positive answers and wished to play *periodic-sugoroku* again.

In order to discuss the educational effect of the *periodic-sugoroku*, we obtained a correlation matrix of answers. Table 3 shows the correlation scores between each question, and it also shows the results of the test for no correlation. There was a significant correlation ($p < 0.05$) between Q12 through Q16 and Q15 through Q17, and the correlation scores were high (they are indicated by rectangular areas on the table). Q12 to Q13 involved interest in and understanding of the periodic table. Q14 to Q17 were questions regarding the operation of the *periodic-sugoroku* game.

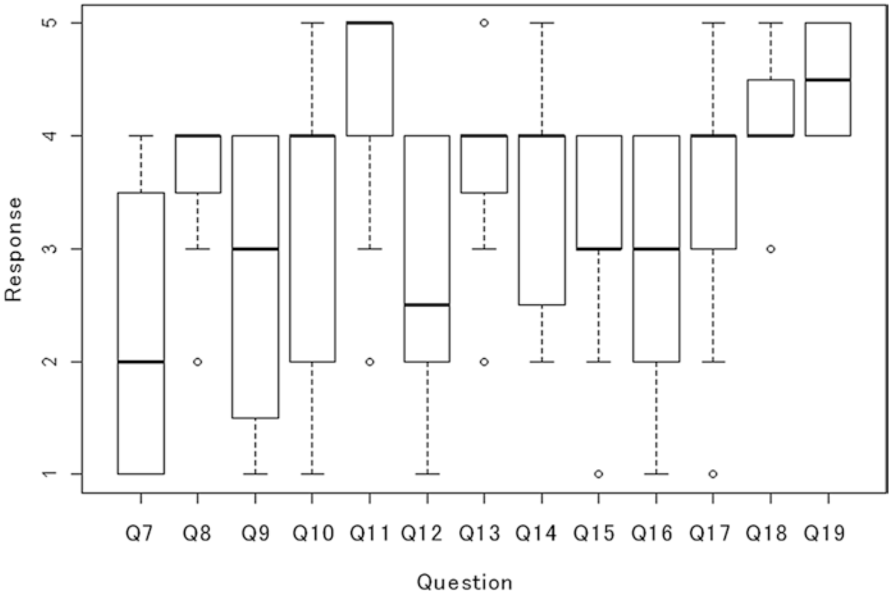

Fig. 4 Experimental results

Table 3 Correlation score

(* p<0.05, ** p<0.01)

	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19
Q7	1.00												
Q8	0.33	1.00											
Q9	**0.68****	0.32	1.00										
Q10	0.33	-0.15	**0.44**	1.00									
Q11	**-0.50**	-0.02	-0.13	-0.15	1.00								
Q12	-0.03	**0.42**	-0.15	-0.29	-0.09	1.00							
Q13	-0.03	0.33	0.10	-0.35	0.16	**0.70****	1.00						
Q14	0.39	-0.02	0.26	0.29	-0.25	-0.30	-0.15	1.00					
Q15	-0.02	0.17	0.15	-0.32	-0.03	**0.58***	**0.59***	-0.27	1.00				
Q16	0.13	0.52 *	0.09	**-0.45**	0.03	**0.63****	**0.57***	-0.22	**0.79****	1.00			
Q17	0.26	0.13	0.23	-0.09	0.03	0.40	**0.55***	-0.44	**0.42**	**0.42**	1.00		
Q18	-0.15	-0.07	0.15	-0.04	0.27	-0.04	0.17	0.30	-0.14	0.01	-0.09	1.00	
Q19	-0.16	0.32	-0.05	-0.10	**0.44**	-0.10	0.00	**0.44**	0.08	0.19	**-0.44**	0.00	1.00

The answer of Q11 shows that the proposed *periodic-sugoroku* can provide an opportunity to study a chemical element which the player has not known. The obtained correlation matrix indicates that participants who were able to proficiently use the assistant-tablet tended to be attracted to the periodic table through *periodic-sugoroku*.

5 Conclusions

In this study, we proposed a *periodic-sugoroku* game for learning the chemical elements. During the game, each player was required to move their game-piece by summing playing cards. The winner was the player with the highest score at the end of the game. In order to play the game, we developed a board-app, view-app, and assist-app.

A total of 16 players answered a questionnaire after playing so that we could assess the game. According to the questionnaire results, many participants positively evaluated the game and wished to play it again. Participants who were able to proficiently use the assistant-tablet tended to be attracted to the periodic table through *periodic-sugoroku*.

Future study requires improving the educational functions of the game, including the addition of a debriefing feature for the playing log.

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References

1. Nakayama T, Izuishi K, Kusunoki F, Yoshida R, Adachi T, Ogitsu T, Takemura H, Mizoguchi H, Inagaki S (2014) Learning support system for paleontological environment based on body experience and sense of immersion. Proceedings of the 6th International Conference on Computer Supported Education 2:252–257
2. Ido M, Itho S, Kuboyama R, Shibata T, Takeda R, Inoue H (2017) Utilization of the gaming simulation in the active learning no. 3. Proceedings of JASAG National Conference Autumn 2017:78–87, in Japanese
3. Ido M, Shibata T, Kuboyama R, Ito S, Kasahara D, Watanabe I, Abe N, Ishige A, Kamada T, Takeishi R (2016) Utilization of the gaming simulation in the active learning no. 2. Proceedings of JASAG National Conference Autumn 2016:66–77, in Japanese
4. Noguchi T, Kamata M (2012) Particle model expressing “weight” and “size” of atoms: development and trial use in junior high school science. Jpn Soc Sci Educ 36(1):38–43, in Japanese
5. Franco-Mariscal AJ, Oliva-Martínez JM, Almoraima GM (2014) Students’ perceptions about the use of educational games as a tool for teaching the periodic table of elements at the high school level. J Chem Educ 92(2):278–285
6. Deguchi A, Sekiguchi A, Ohkubo T (2015) SATOYAMA-life admins: development and experimental evaluation of the Sugroku game for environmental learning. J Chem Educ Jpn Soc Sci Educ Res Rep 30(3):113–116, in Japanese
7. Deguchi A, Inagaki S, Kusunoki F, Yamaguchi E, Takeda Y, Sugimoto M (2010) Vegetation interaction game: digital SUGOROKU of vegetation succession for children. International Conference on Entertainment Computing:493–495
8. Maeno Y Elementouch, http://www.ss.scphys.kyoto-u.ac.jp/elementouch/, in Japanese

Part II
S&G to Learn Business

A Business-Simulation Game to Teach How to Comprehend Financial Statements

Yuichiro Gomi and Yudai Tanino

Abstract A learning method is needed to teach university students how to read financial statements. Using a business game incorporating the need to comprehend financial statements and a paper examination, 16 students who were not studying accounting participated in an examination to see whether the game fostered reading comprehension of financial statements. The results could not clarify whether the developed business game can foster reading comprehension of financial statements. In the future, a business game should be developed in which the reading of the financial statements greatly affects the outcome.

Keywords Business game · Financial statements · YBG · BSel

1 Introduction

As globalization of corporate activities progresses and business models become more complex, businesspeople need to grasp the actual financial condition of a business (such as a company and its business partners); consequently, businesspeople increasingly need to be able to read financial statements [1]. Since working people might not be able to find adequate time to learn, university students should develop the ability to comprehend financial statements before joining the workforce. However, few undergraduate departments and faculties have opportunities to give lectures on accounting. Accordingly, we believe that a learning method must be devised that is easy to implement and understand even for students who do not study accounting.

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Even students without knowledge of accounting thought that business-simulation games (hereafter referred to as “business games”), which simulate various business scenarios, can effectively teach accounting skills.

A business game simulates a situation in which the participants, who compete for corporate profits in a virtual business environment that models a real business environment, must make business decisions. Participants aim to learn how to deal with figures and make decisions while playing games.

Business games have two advantages over lectures: they can (1) motivate learning through characteristics of games such as competition and entertainment and (2) simulate a business by simulating an actual business model. In this study, we developed a business game that utilizes competitive edge and examined whether it can cultivate the skills needed for reading financial statements.

2 Prior Research and Its Problems

The target players of business games are often students studying business administration and accounting [2]. Ishii et al. previously developed a business game to teach students who had not studied accounting how to read financial statements [3]. The results revealed that their business game was easier to implement than other learning methods. On the other hand, they did not verify whether their business game effectively cultivates the skills needed for reading financial statements. Moreover, their game did not involve financial analysis of companies; consequently, the reading ability needed for understanding financial statements may not have been fostered during the game. Therefore, a business game needs to be developed that incorporates verification of the game’s learning effect and necessitates comprehension of financial statements. Therefore, this research is intended to reveal a method for students who do not study accounting to learn how to read a financial statement.

Learning effects of business games are often evaluated by questionnaires. However, such questionnaires have a problem of low objectivity [4]. Therefore, in this research, we also evaluated using the scores obtained in a public qualification exam.

3 Experimental Methods

The flow of the experiment carried out in this study is listed as follows:

1. All subjects receive lectures on accounting terminology.
2. All subjects take the first paper test.
3. On the basis of the results of the first paper test, a t-test is conducted, and to avoid bias in accounting knowledge, the subjects are classified into two groups: one that will play a business game (intervention group) and the other that will not (control group). After that, the intervention group plays the business game.
4. All subjects take the second paper test.

5. All subjects take the questionnaire survey.
6. The results of the paper test and the questionnaire survey are analyzed.

4 Explanation of Business Game

In the work we report here, BSel (business simulation for e-Learning) was used as a tool for developing and conducting business games. BSel is a multiuser e-Learning system developed, operated, and maintained by the Research Center for Business Simulation, Yokohama National University [5]. The advantages of using BSel are that it makes development of business games easy, enables simultaneous decision making via a network, and reduces the waiting times of game participants.

As for the content of the business game developed in this study, the player plays the role of a store manager who purchases apples, manufactures apple juice from them, and sells it. The players in the developed business game enter the necessary items in accordance with the following procedure.

1. The player chooses the source of funds used for purchasing the apples. Players can procure "short-term borrowings from banks" or "capital from shareholders."
2. The player produces apple juice with the apples purchased. At this time, the player sets the price and quality of the apple juice, the number of units of apple juice to be produced, and so on.
3. The game supervisor executes the model calculation and reflects on the results of the first round of the game.
4. The player prepares financial statements on the basis of the results and determines the best strategy for the next round of the game.
5. The player repeats steps 1 to 4 until the game ends.

A conceptual model of the developed business game is shown in Fig. 1.

5 Evaluation Methods

5.1 Paper Test

The paper tests were prepared by extracting past problems from "Business Accounting Certification Grade 3," which is an examination conducted by the Osaka Chamber of Commerce and Industry [1]. The Business Accounting Certification is a certification examination created with an emphasis on understanding numerical values expressed in financial statements and making them useful for business. On the basis of the results of the first and second paper tests, a t-test was conducted to determine whether significant differences between the test results of the intervention group and the control group existed before and after the business game was

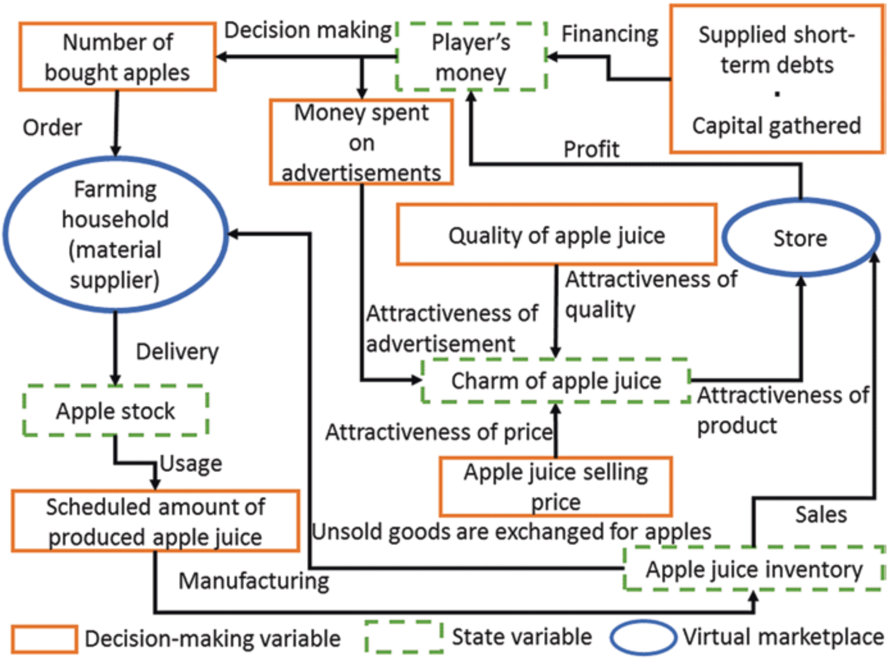

Fig. 1 Conceptual model of a business game

Table 1 Contents of paper test

Number of questions	10
Answer format	Multiple choice (4 or 5 choices)
Number of implementations	2
Score distribution	1 correct answer = 1 point (10 out of 10)
Range of second test	About the same
Content of second test	Different from first test
Difficulty of second test	About the same
Expected value	2.3

played. The paper test contents are listed in Table 1. Further, the expectation value of Table 1 is the mean obtained when a subject answered at random.

5.2 *Questionnaire Survey*

The questionnaire results were analyzed using a paired comparison method. The questionnaire questions are listed in Table 2. Questions with "∗" asked for written answers. Results for Q1~Q4 were estimated using an average and a standard deviation. Results for Q5~Q6 were estimated using variance analysis.

Table 2 Questionnaire contents (abstract)

Question number	Questionnaire	Choices number	Minimum scale	Maximum scale
Q1–2	"Profit and loss statement," "balance sheet," "cash flow statement," and "the numerical value that is the value of the enterprise" were taught in a lecture. How was the scope of lectures on accounting terms in 40 minutes?	5	Little	Much
Q2	About business game (intervention group members only)			
Q2–1	This game simulated managing a business by making decisions about expenditure. Do you think the game gave you a realistic experience?	4	I don't think so	I think so
Q2–3∗	How do you think you could have won the first game? (If you were the winner, what did you do to win?)			
Q2–4∗	How do you think you could have won the second game? (If you were the winner, what did you do to win?)			
Q2–10	Was a financial statement form used to meet the "achievement condition" (for the current ratio the first time and the gross capital turnover rate the second time)?	5	No, it wasn't	Yes, it was
Q3	About making of a financial statement (intervention group members only)			
Q3–1	This game simulated doing accounting for a business by reading a financial statement. Do you think you the game gave you a realistic experience of accounting?	4	No, I don't think so	Yes, I think so
Q4	About a paper test			
Q5	Learning method and understanding (intervention group members only)			
Q5–1	Which is more effective: business game or lectures on accounting terms	5	Business game	Lectures on accounting terms
Q5–2	Which is more effective: business game or self-study using a textbook	5	Business game	Own learning using a textbook
Q5–3	Which is more effective: lectures on accounting terms or self-study using a textbook	5	Lectures on accounting terms	Own learning using a textbook
Q6	Learning method and volition (intervention group members only)			
Q6–1	Which is more effective: business game or lectures on accounting terms	5	Business game	Lectures on accounting terms

(continued)

Table 2 (continued)

Question number	Questionnaire	Choices number	Minimum scale	Maximum scale
Q6–2	Which is more effective: business game or self-study using a textbook	5	Business game	Own learning using a textbook
Q6–3	Which is more effective: lectures on accounting terms or self-study using a textbook	5	Lectures on accounting terms	Own learning using a textbook

Table 3 Paper test results

	Intervention group (N = 10)		Control group (N = 10)	
Test number	Average	Standard deviation	Average	Standard deviation
First test	2.90	1.76	2.90	1.30
Second test	3.00	1.61	2.60	1.50

6 Results

6.1 Paper Test Results

The average value and standard deviation of the results of the paper tests taken by the intervention group and the control group are listed in Table 3.

Comparing the average values of the results of the first and second tests for the intervention group did not reveal a significant difference between the results [$t(20) = 0.89$, $p > 0.05$]. Similarly, comparing the average values of the results of the first and second tests for the control group did not reveal a significant difference between the results either [$t(20) = 0.63$, $p > 0.05$]. Ultimately, comparing the average value of the results of the second tests for the intervention and control group also did not reveal a significant difference between the results [$t(20) = 0.68$, $p > 0.05$].

6.2 Questionnaire Survey Results

The average value and standard deviation of the questionnaire results are listed in Table 4. The answer percentages for Q2–1 and Q3–1 are listed in Table 5. The analysis of variance results is listed in Table 6. Excerpts of answers for Q2–3 and Q2–4 are listed in Table 7.

Table 4 Average and standard deviation of Q1–2 and Q2–10

Question number	Average	Standard deviation
Q1–2 (N = 20)	3.83	0.69
Q2–10 (N = 10)	3.67	1.33

Table 5 Answers for Q2–1 and Q3–1

Question number	I think so (3~4)	I don't think so (1~2)
Q2–1 (N = 10)	70%	30%
Q3–1 (N = 10)	90%	10%

Table 6 Analysis of variance table for Q5 and Q6

Factor of Q5	Sum of squared	Degrees of freedom	Unbiased variance	Variance ratio	P value	Judgment (p < 0.05)
Totality	65	54				
Main effect	16.778	2	8.839	17.896	0.000	[∗]
Effect between individuals	39.222	34	1.154	2.461	0.029	[∗]
Combination effect	1.5	2	0.75	1.6	0.233	[ ]
Error	7.5	16	0.469			

Factor of Q6	Sum of squared	Degrees of freedom	Unbiased variance	Variance ratio	P value	Judgment (p < 0.05)
Totality	103	54				
Main effect	52.481	2	26.241	42.537	0.000	[∗]
Effect between individuals	40.185	34	1.182	1.916	0.083	[ ]
Combination effect	0.463	2	0.231	0.375	0.693	[ ]
Error	9.87	16	0.617			

"∗" of judgment is "$p < 0.05$". In other words, there is a significant difference

7 Discussion

7.1 Paper Test Results

As shown in Table 3, comparing the average and expected values of the first tests for the intervention group did not reveal a significant difference between the results [t(20) = 0.319]. Examining the findings did not seem to show that the lectures on accounting terminology provided any learning effect.

Table 7 Descriptive answers (abstract)

Question number	Answer
Q2–3	The advertising expenses are made expensive
Q2–3	I quickly determined which item to raise
Q2–3	The cost of goods sold is considered, and the selling price is established
Q2–4	The advertising expenses are made expensive
Q2–4	I quickly determined which item to raise
Q2–4	I decided not to earn money at the beginning

The results obtained for Q4 in Table 4 indicate that subjects considered the learning content of accounting terminology lectures is very wide. However, from the answers to the questions in the paper test, we were unable to clearly learn what the subjects obtained in lectures on accounting terminology because there are too many terms.

The players played the game even though they could not understand the vocabulary of financial statements in the lectures on accounting terminology. Therefore, comparing the average values of the results of the first and second tests for the intervention group did not reveal a significant difference between the results. It is necessary to develop a business game for comprehending not only financial statements but also profit and loss statements, balance sheets, and cash flow statements.

7.2 *Questionnaire Survey Results*

We analyzed the correlation between the scores for Q2–10 and the paper test results using Pearson's correlation coefficient [$r = 0.679$, $p < 0.05$]. The correlation was a very positive 0.679. This information indicated that making reading and comprehending a financial statement part of the game may enable players to become better able to prepare financial statements.

Q 2–1 and Q 3–1 asked whether the business game could simulate the experiences of business management and accounting. In Ishii et al.'s study, 89% and 100% of subjects answered "yes," respectively [3]. Table 5 shows that only 70% and 90% of subjects thought so for our game, so it may not be as good at providing realistic experiences of management and accounting as the business game developed by Ishii et al. However, their experiment had only 9 subjects, whereas ours had 10. Thus, the increase in the number of subjects may have caused the difference in the results.

The answers to Q5 are survey results about the learning method and the understanding of it. The answers to the question given in Table 6 indicate the combination effect did not reveal a significant difference. However, there was a significant difference between the main effect and the effect among the individuals. From this we conclude that our business game is easier to understand than lectures on accounting terms and learning by using a textbook.

The answers to Q6 are survey results about the learning method and volition. The answers to the question given in Table 6 show there was no significant difference between the individual and the combination effect. However, there was a significant difference for the main effect. From this we conclude that our business game is more an ambitious learning method than lectures on accounting terms and learning by using a textbook.

The answers "The advertising expenses are made expensive" and "I quickly determined which item to raise" in Table 7 make it evident that there were players who assumed that understanding the structure of the game system was necessary to achieve victory in the game.

Considering the results, we can conclude that the players were able to learn how to read financial statements by reading and comprehending one during the game. However, they were not able to read and comprehend the financial statement sufficiently, which might be because the game was badly designed. Accordingly, the game should be redesigned so that players will be able to read and comprehend financial statements to develop winning strategies.

8 Concluding Remarks

The paper test results we obtained showed that our business game does not effectively teach students how to read and comprehend financial statements. On the other hand, the questionnaire results we obtained suggest that an improved business game may be able to do so.

In the future, we will need to reduce the lecture contents and develop corresponding games. We believe that this will enable us to develop business games that encourage understanding of financial statements and establish objective evaluation methods.

Acknowledgment We thank Shintaro Hori for his help and encouragement in this study.

References

1. Osaka Chamber of Commerce and Industry (2014) Business accounting certification test official text grade 2, 3rd edn. Chuokeizai-sha Holdings Inc, Japan, p 221
2. Federico P, Hélène G (2011) The impact of a simulation game on operations management education. Comput Educ 57(1):1240–1254
3. Ishii K, Watana K, Gomi Y (2016) Development and Proposition of a Business Game that Enables Students without Accounting Knowledge to Learn Effectively. 2016 IEICE society conference on proceedings, Sapporo, Japan, September 29–30
4. Lynn V (2015) Simulation games in business and marketing education: how educators assess student learning from simulations. Int J Manag Educ 13(1):57–74
5. Tanabu M (2017) On the future direction of YBG gaming. In: Yokohama National University research Center for Business Simulation 15th YBG user conference on proceedings, Yokohama, Japan, p 18

Co-creating Prototype Improvement Using Participatory Design on the Development of a Serious Game in Financial Literacy Skills

Arry Rahmawan Destyanto, Akhmad Hidayatno, Armand Omar Moeis, and Mohammad Rizky Nur Iman

Abstract Financial literacy is an essential part of youth education, not only for making better financial decisions but also to minimize the threat of becoming investment fraud victims. A well-designed serious game can enhance financial literacy skills for the players. This paper explains the results of a co-creation process to improve the game effectiveness of an early-stage board-game-based prototype used for financial literacy education for youths. This research generated and selected the improvement ideas using participatory design (PD), which involves two primary activities, the nominal group technique (NGT) and an ideas selection session, to gain as many improvement ideas for the co-creation process as possible. A comparison between improvement ideas generated from the participants as game evaluators and as co-creators is presented in this paper to discover the differences. This research highlights the fact that participants as co-creators tend to suggest improvements of the prototype in the fundamental concept of the game, while as game evaluators, the participants tend to suggest functional improvements in game mechanism aspects to improve the game's effectiveness.

Keywords Serious simulation game · Game-based learning · Financial literacy education · Co-creation game development

1 Introduction

The knowledge of and skills for determining effective decisions to manage personal finance and wealth in life is essential. Governments around the world have embraced the essential need for having those skill sets to enhance economic development

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within a country [1]. The common term to describe an individual's ability to possess the set of skills and knowledge to make effective decisions with their financial resources is 'financial literacy' [2]. Berry et al. [3] argued that children and youths who acquire financial literacy education may have better financial decision-making skills later in their lives and positively influence their behavior [4]. The importance of financial literacy becomes more significant nowadays because of the growing complexity of financial decision-making. Inadequate financial literacy can lead to mismanagement, wealth loss, or susceptibility to becoming an investment fraud victim.

As the necessity of financial literacy education emerges, the effectiveness of existing financial literacy education globally is questioned [5]. In the context of high-school students, Peng et al. [6] reported no significant difference between those who experienced financial education and their investment decisions. Another report by Mandell and Klein [7] found that students who finished financial literacy courses were not guaranteed to have better results in financial decision-making. As the education methods of financial literacy education had been questioned, Totenhagen [8] investigated several promising methods in financial literacy education by performing a systematic literature review. One of the favorable delivery methods that emerged is using interactive learning experiences. Interactive learning can increase youth motivation in deepening learning material about money because of its fun and real feedback experience [9].

Examples of interactive learning programs for financial literacy education of youths are available, such as cooperative extension and credit unions partnerships [10] or the simulation of different economic contexts [11]. The more common innovative approach is using simulation games, such as the Stock Market Game. The Stock Market Game is a simulation game that emphasizes saving and investing knowledge for improving the player's financial literacy skills. From an observation result by Hinojosa et al. [12], they show that individuals using the game for interactive learning results in significant differences in financial knowledge, outperforming those who did not play it. Using games for financial literacy education can be an interesting solution because simulation games can imitate the real learning environment but without the real risk of consequences from learning process mistakes.

However, due to the growing complexity in determining financial decisions, the actual context needs to be reconsidered when developing a serious game for financial literacy education. There is an urgent need to tackle challenges in making financial decisions, not only in terms of savings and investing, but also the value of money, risk diversification, inflation, and the concept of compound interest. Although Hinojosa et al. [12] show that using simulation games like the Stock Market Game is useful for educating youths in financial literacy, its effectiveness is questioned for answering today's challenge in financial literacy education because the concept of financial complexity is growing.

There are some arguments that serious games effectiveness is based on what the learning outcomes that game player should achieve. However, developing effective serious games from scratch and involving more complex learning outcomes also bring about a hefty risk investment. Why don't we try to improve the existing games in order to be in a better position to tackle more complex challenges?

This paper is written based on the research objective of improving the effectiveness of an older version of a serious game for tackling more relevant challenges today. The case study of developing a game called Invest-Man is presented in this paper, using the participatory design (PD) approach for generating and co-creating various improvement ideas to improve the existing serious game in order to answer more relevant challenges and involve more complex learning outcomes.

2 Participatory Design and Co-creation in Serious Games Development

Different from the common design process, PD is a creation and development process in which the end-users make essential contributions to products and services [13]. These essential contributions can start from collective creative ideation, proceeding to generating improvement ideas, to collaborative creation to implement those ideas, which is also called co-creation [14]. The term 'collaborative' refers to a condition in which the activity is undertaken by two or more people. When developing serious games, the PD approach can increase 'ordinary' user engagement, facilitate more in-depth learning about the subjects, and, the most important thing, remove the subjectivity when it involves only the designer's perspective [15, 16].

However, in spite of the advantages of using the PD approach, there are issues that can emerge when it is applied in practice. One of the issues that should be anticipated is that the designer should be selective when choosing the participants involved in the development process. At the least, the co-creator should fulfill one of two aspects: familiarity with the domain content and have experience in serious game design [13]. Scaife et al. [17] argued that not all of the end-users are fit to be a co-creator in serious game development. For example, children are better as informants rather than co-creators because of their limited knowledge in the domain area and serious game design.

Although finding users that fit in with the PD approach is a challenge, it still has benefits in improving design objectivity and, at the same time, strengthening the domain and game design knowledge from the users as a result of design collaboration. The authors argue that it is crucial to strengthen the understanding of the application of PD in serious game design, especially for supporting innovation processes with the purpose of improving game effectiveness. As PD is more often used in developing serious games from the early stages of development, the authors expect that this paper can bring a novel contribution in the literature for using PD in existing serious game prototypes to improve game effectiveness.

3 Invest-Man: A Serious Game for Teaching Financial Literacy Skills

Due to the growing complexity in financial decision-making today, the use of serious games has become a promising method to teach financial literacy skills. Based on prior serious games that focused on teaching saving and investing lessons, in this case study, the authors developed a serious game prototype to teach additional concepts that users must consider when making financial decisions, as described by Lusardi and Mitchell [18]: risk diversification, compound interest, and the concept of inflation rates.

Before the co-creation process begins, the authors, alongside the game designer, created an initial prototype as the basis for users or participants to co-create an improved prototype for better game effectiveness. In short, Invest-Man is a serious game that has the primary purpose of teaching the knowledge and skills about personal financial decision-making in the modern era. Invest-Man has been designed to be played in classrooms under the supervision of an instructor, trainer, or facilitator. Several instruments used in this game are stocks, credits, loans, insurance, foreign exchange, deposits, and taxation. Invest-Man is a four-player game, with other roles involving bankers and a facilitator as support for the main players. The players are assigned various different roles or jobs, which are determined based on the pre-test scores. Players with higher pre-test scores would be assigned to the jobs with higher monthly incomes. The authors used basic financial literacy knowledge as the basis of the pre-test for the players. After being assigned their jobs, the players needed to define a monthly lifestyle that they wanted, for example, marriage and the number of children they would have, using insurance for avoiding potential financial loss in the future, taking out loans for financing, and other financial habits that have effects on their monthly free cash flow for the players to invest or make savings.

The goal for each player is to increase their free cash flow until the end of the game. To keep the game fair, the winner of this game is not calculated based on their nominal cash flow, but, instead, the growth ratio is used, which is the result of current cash flow divided by their free cash flow. The player should be dealing with several uncertain scenarios, such as disasters, accidents, bonuses, price fluctuations, and risk of becoming investment fraud victims. Figure 1 illustrates the basic operational aspects of Invest-Man.

4 Co-creation Process to Improve an Existing Serious Game Prototype's Effectiveness: A Case Study of the Invest-Man Game

In this paper, the authors present the use of the PD approach for generating collective creative improvement ideas and co-creating the improved prototype based on these ideas generated in the prior session. This co-creation process starts after the

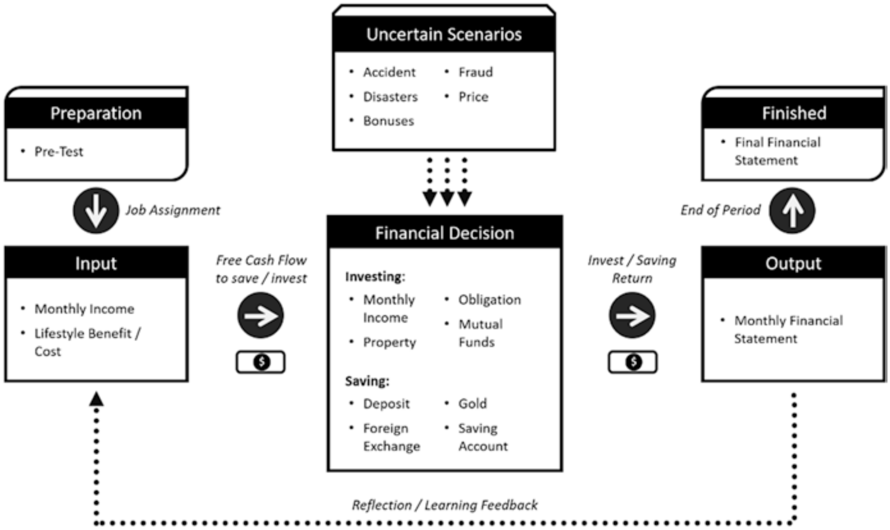

Fig. 1 Conceptual model of the Invest-Man game

improvement ideas had been generated, tabulated, and selected to be implemented in the co-creation process. The PD process will focus on how all of the participants can be actively involved in generating a significant number of ideas to improve the previous game prototype's effectiveness.

4.1 Participants

As the definition of youth in Indonesia refers to young people with ages ranging from 16 to 30 years, there is an urgent need to classify youths in order to find the users that fit into the co-creation process. The authors classified Indonesian youths into three categories, as defined by Adisoetomo et al. [19]: (1) transitional youth, (2) establishing youth, and (3) established youth. This case study focuses on inviting participants that belong to the establishing youth and established youth groups to co-create the game.

Establishing youth refers to people in the age-range 20–24 years, having completed post-school education, become financially semi-independent, and are semi-autonomous decision-makers in their lives. Meanwhile, established youth refers to young people in the age range 25–29 years, having completed higher or extended education, become financially independent, and are fully autonomous decision-makers. The majority of established youth have income security, while the establishing youth group members still face a struggle in job-search challenges. The participants from each category were selected based on their familiarity with the topic or having at least a little knowledge of games design. All participants reported familiarity with the game mechanism and the majority of participants are former regular games players.

4.2 Procedure and Method

The PD workshop was held in the Systems Engineering, Modelling, and Simulation Lab, Universitas Indonesia. The primary purpose of the workshop was to obtain improvement ideas for the game design, which, in the participant's opinion, have better effectiveness for transferring knowledge and skills in financial literacy. In this workshop, one of the authors was a lead facilitator to guide the designer and users in contributing improvement values through the existing prototype. The facilitator split the workshop into two primary activities: nominal group technique (NGT) and ideas selection after all of the participants played the first prototype of Invest-Man.

In the first activity, the NGT is chosen as an alternative to brainstorming so as to minimize premature judgment for each improvement idea generated by the participants. The NGT is similar to small group discussion with structured variation. It can prevent domination of the discussion because each participant would spend several minutes in silence jotting ideas down based on the open-ended questions given by the facilitator. This method can be a practical approach to encouraging passive group members to contribute and prevent brainstorming domination by a single person. The NGT was developed by Delbecq and Van de Ven [20], and the sequential process of the NGT conducted in this workshop is based on the explanation by Sample [21]. The result of the NGT is many ideas from participants that were jotted down on paper which would be presented later.

In the NGT session, there is no limitation on the number of improvement ideas generated by the participants. The NGT session is automatically ended after no more ideas are generated.

Next, a lead facilitator introduced the second activity to the participants, ideas selection. First, all of the ideas generated from the NGT session would be categorized based on their similarity. An affinity diagram was chosen to help the participants categorize similar co-creation result ideas and make it more structured, as described in Figs. 2 and 3.

Based on the affinity diagram as shown in Fig. 3, the authors highlight seven essential categories of improvement ideas that emerged as the major themes during the NGT session. The seven categories of improvement are: (1) basic rules of the game, (2) technology integration, (3) case study, (4) game visuals, such as mobile internet and social media, (5) game property, (6) game purpose, and (7) an others category to summarize minor improvement ideas generated by the participants.

The ideas in each category would be selected further and prioritized based on the feasibilities of time and budget resources. Based on those considerations, the second category, technology integration, was excluded because of limitations in the budget and time resources for conducting collaborative game creation.

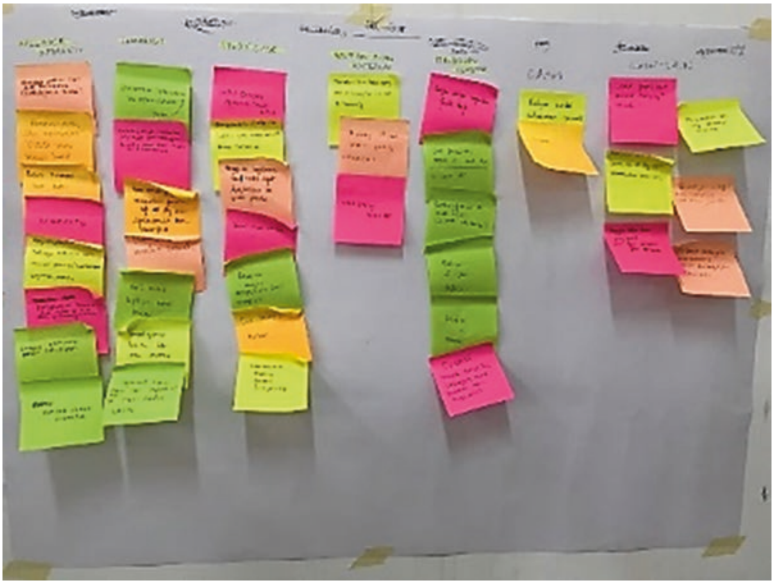

Fig. 2 Original categorized nominal group technique (NGT) result from the participants using an affinity diagram in Bahasa Indonesia

Rules of the Game	Technology	Case Study	Game Visuals	Game Property	Game Purpose	Others
Collaboration	Internet connection usage	Real Case Study*	Changing Layout	Using "Real Money"	Social Impact	Certified instructor
Teamwork	Social media integration	Based on Real Problem	Improving contrast	Electronic Transaction	Beyond Profit	Clear clarification
Considering player risk profile	Social media integration	Actual number and risk profile	Changing font	Electronic Money	Considering impact to others	Additional materials
Group decision making	Tutorial in form of video	Same case study & real	Higher resolution printing	Real Money Design		Dynamic / Attractive instructor
Family decision making	Real-time simulation using mobile apps	Competition-Level Case Study		Real Currency Rate		Game mechanism simplification
	Integrating with existing mobile apps	Practical Case Study				

Fig. 3 Clear, tabulated English translation of the categorized nominal group technique (NGT) result

Table 1 List of changes between the first iteration and co-creation prototype of the Invest-Man game

Category	List of changes First iteration prototype	Co-creation result prototype
Basic rules of the game	*Competition*: Each board consists of four players that compete for the highest growth in the free cash flow ratio	*Collaboration*: Each board consists of four players and they collaborate to get the highest accumulated return between other boards (teams)
Case study	*Pre-test*: Use the pre-test to determine the kind of job and monthly income for the players. Each player is more likely to get different monthly incomes and, also, different contextual problems	*Case study*: Each player would be given a real case study on financial decision-making. All of the participants received a similar or the same case
Game visuals	*Game Visual 1.0*: Use the default game visuals	*Game Visual 2.0*: Use improved game visuals (fonts, colors, board) and change the board game layout to fit with other improvements
Game property	*Paper money*: Use imitation paper money for carrying out transactions in the game	*Electronic money*: Use simulated electronic cards to emphasize the experience of using real money for conducting transactions in the game
Game purpose	*Profit oriented*: The goal of the game is set based on the growth of personal wealth	*Beyond profit oriented*: The goal of the game is set based on the growth of collective wealth, so the players should consider ethical decisions which bring about positive impact to others
Others	*No supplementary materials*: Players do not have supplementary materials to improve the understanding of the lessons learned	*Supplementary materials included*: Players have supplementary materials, such as a report to read or videos to watch, to improve their understanding of the lessons learned

4.3 List of Changes Resulting from the Co-creation Process

The collaborative creation is the next activity conducted to improve the existing prototype using many improvement ideas obtained in a prior workshop session. The creation activity progressed through a series of weekly monitorings of remote working and online task assignments which are distributed between the researcher, designer, and game participants. As the final output of this collaborative creation session, there are several significant changes implemented in the new version of the game. These changes are listed in Table 1.

The final prototype was tested at a concluding user workshop to validate the implementation of the ideas generated from the prior ideation phase result. Overall, the participants were very excited about the new concept, design, and game mechanism, as shown in Fig. 4.

Fig. 4 Final user workshop for testing the co-creation result prototype

4.4 Results and Discussion

Here, the authors focus on the quantity of improvement ideas generated from the participants as co-creators to address the growing complexity of financial literacy education. The NGT seems to be adequate for generating a large quantity of ideas and encourages every participant to actively contribute to the discussion to bring many ideas to the table.

During the NGT activity, the participants' ideas seem to be grounded in the value, game concept, and experience they had encountered previously in financial decision-making. Although the lead facilitator did not give a limitation for determining the scope of ideas, none of the ideas was novel or breakthrough compared to each other. However, the improvement ideas generated from the NGT session are applicable and seem promising for increasing the game's effectiveness.

It was quite interesting when the authors compared the improvement ideas generated by the participants as game evaluators and as game co-creators. As shown in Table 1, the improvement ideas generated from PD mostly suggest improvement in the fundamental concept of the game. For example, the suggestion to use a real case study in the game can change the structure of the game itself, extending its duration, and require systemic changes in the existing game's mechanism to embed the real case study within it. The suggestion to change the game's goals from competition to collaboration also challenges the game's fundamental assumption and brings about a systemic change to the gameplay.

In contrast, based on the feedback questionnaire responses obtained from the participants as game players and evaluators only (not as co-creators), the ideas for improvement were less of suggestions to the concept and, yet, more in the effective game mechanism. There were several suggestions obtained from players after finishing the first game iteration: (1) add checks as an additional way of carrying out financial transactions, (2) add one to two additional currencies for foreign exchange transactions, (3) add one more facilitators to make the game easier to understand for all players, and (4) improve the game visuals. Three of the four suggestions mentioned concerned functional improvement, especially in the gameplay mechanics. Only one suggestion (game visuals) is similar to the feedback from the participants as co-creators.

5 Conclusion and Future Suggestions

PD introduces an alternative method for improving the existing serious game which can produce various improvement ideas to implement and enable co-creating between the researcher, game designer, and participants. The common practice of serious game improvement involves using the participants' feedback after finishing the game. Meanwhile, PD generated an entirely different improvement ideas result compared with when the participants were only game evaluators. When the participants had been permitted to criticize, redesign, and improve the existing serious game as co-creators, they tended to contribute to the fundamental concept area of game development. In contrast, the participants as game evaluators tended to focus on contributing in more practical ways to improve game effectiveness, especially in the game mechanics.

Although using PD seems to be more promising for improving the existing serious game prototype, this method did not trigger breakthrough or novel ideas generated by the participants. Further investigation is needed to discover the influential factors that determine the novelty of ideas generated in PD.

In this paper, the authors also have not yet ensured that the improvement result from PD is more effective for teaching financial literacy, because the evaluation process has yet not finished. To evaluate the effectiveness of the game as a future research suggestion, the authors propose to use four-level evaluation, as explained by Kirkpatrick [22]. Four-level evaluation has been the standard method to use because it does not measure only the level of reaction but it also measures the level of learning transfer.

However, given its potential benefit of improving existing serious games in financial literacy education, PD can be a powerful approach to improving existing serious game prototypes in many domains.

References

1. The Organisation for Economic Co-operation and Development (OECD) (2013) OECD/INFE set of criteria, principles, guidelines, and policy guidance to improve financial education. OECD website. https://www.oecd.org/daf/fin/financial-education/TrustFund2013_OECD_INFE_Framework_Fin_Ed.pdf. Last accessed 20 Sept 2018
2. Mandell L (2012) The financial literacy of young American adults. UCLA Anderson School of Management, Fink Center Bull 1(1):7–8
3. Berry J, Karlan D, Pradhan M (2018) The impact of financial education for youth in Ghana. World Dev 102:71–89
4. Hilgert MA, Hogarth JM, Vitt LA, Anderson C (2003) Household financial management: the connection between knowledge and behavior. Fed Reserv Bull 106
5. Willis LE (2011) The financial education fallacy. Am Econ Rev Pap Proc 101(3):429–434
6. Peng TM, Bartholomae S, Fox JJ, Cravener G (2007) The impact of personal finance education delivered in high school and college courses. J Fam Econ Iss 28(2):265–284
7. Totenhagen CJ, Casper DM, Faber KM, Bosch LA, Wiggs CB, Borden LM (2015) Youth financial literacy: a review of key considerations and promising delivery methods. J Fam Econ Iss 36(2):167–191
8. Mandell L, Klein LS (2009) The impact of financial literacy education on subsequent financial behavior. J Financ Couns Plan 20(1):15–24
9. Varcoe KP, Peterson SS, Swanson PW, Johns MC (2010) What do teens want to know about money—a comparison of 1998 and 2008. Fam Consum Sci Res J 38(4):360–371
10. Tobe EA (2005) Successful state collaborations. Credit Union Mag:16A–17A
11. Lucey TA (2007) The art of relating moral education to financial education: an equity imperative. Soc Stud Res Pract 2(3):486–500
12. Hinojosa T, Miller S, O'Brien B, Swanlund A, Hallberg K, Brown M (2009) The Stock Market Game TM study final report. Stock Market Game website. https://www.stockmarketgame.org/assets/pdf/2009%20Learning%20Point%20Study%20Full%20Report.pdf. Last accessed 20 Jan 2019
13. Khaled R, Vasalou A (2014) Bridging serious games and participatory design. Int J Child-Comput Interact 2(2):93–100. https://doi.org/10.1016/j.ijcci.2014.03.001. Last accessed 22 Jan 2019
14. Sanders EB-N, Stappers PJ (2008) Co-creation and the new landscapes of design. CoDesign 4(1):5–18
15. Muller MJ, Druin A (2003) Participatory design: the third space in HCI. In: The human-computer interaction handbook. Lawrence Erlbaum, Hillsdale, pp 1–70
16. Vines J, Clarke R, Wright P, Mccarthy J, Olivier P (2013) Configuring participation: on how we involve people in design Republic of Ireland. In: Proceedings of the SIGCHI conference on human factors in computing systems CHI'13, pp 429–438
17. Scaife M, Rogers Y, Aldrich F, Davies M (1997) Designing for or designing with? Informant design for interactive learning environments. In: Proceedings of the ACM SIGCHI conference on human factors in computing systems CHI'97, pp 343–350
18. Lusardi A, Mitchell OS (2005) Financial literacy and planning: implications for retirement wellbeing. National Bureau of Economic Research website. http://nber.org/papers/w17078. Last accessed 20 Jan 2019
19. Adioetomo SM, Posselt H, Utomo A (2014) Youth in Indonesia. United Nations Fund for Population Activities (UNFPA). Indonesia Monogr Ser 2:5–6. UNFPA Indonesia website, https://indonesia.unfpa.org/sites/default/files/pub-pdf/BUKU_Monograph_No2_Youth_in_Indonesia_ENG_05_Low-res.pdf. Last accessed 20 Jan 2019

20. Delbecq AL, Van De Ven AH (1971) A group process model for problem identification and program planning. J Appl Behav Sci 7(4):466–492
21. Sample AJ (1984) Nominal group technique: an alternative to brainstorming. J Ext 22(2). https://www.joe.org/joe/1984march/iw2.php. Last accessed 10 Feb 2019
22. Kirkpatrick DL, Kirkpatrick JD (2006) Evaluating training programs: the four levels, 3rd edn. Berrett-Koehler Publishers, San Francisco

Augmented Reality in Finance Learning Games

Blazej Podgorski

Abstract This article is a part of the author's work about innovation in learning processes due to generation changes. The presented project focuses on augmented reality learning game design as a new way of teaching financial indicators, such as return on investment (ROI). This indicator shows the efficiency at capital allocation in the process of operating profit generation. The scenario of the business to analyze depends on the player's location at that moment. In each scenario, the player has to make 15 decisions about the most important aspects of the business.

Keywords Learning games · Augmented reality · Return on investment

1 Introduction

This article focuses on augmented reality learning game design as a new way of teaching financial indicators, such as return on investment (ROI). The choice of this indicator is very important, because it shows the efficiency at capital allocation in the process of operating profit generation. Mobile phones are used as the platform for this game. There are three reasons behind this, as follows: the changes in generations, market growth of mobile phones and effectiveness of learning. During the period 2003–2013, the mobile games market showed the highest rate of increase in the entire segment of educational games [1] and the forecasts for the next years are similar. The effectiveness of mobile learning games is higher than textbook learning [2].

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2 Literature Review

Primarily, digital games have been mainly used for leisure purposes. Nowadays, they are used for a wider range of reasons [3]. They can have positive impacts on physical health, the speed of movement, intense interaction [4] and motivation [5]. The most important of these is the engagement of players with a virtual environment [6]. However, all of these features make games the perfect learning tool.

The idea of the creation of mobile education games is based on generational and technological changes. The current education system focuses on traditional methods that are suited to the X generation, in which success is oriented through knowledge [7]. The Y generation enlarges that aim with leisure and pleasure. The most important difference between those two groups is in their approach to technology. The Y generation adopts new technology very quickly [8] and social surveys show that over 85% of this generation uses a smartphone [9]. The Z generation, the wave of current students, is even more addicted to technological devices.

The digital environment in learning processes gives the opportunity to allow dynamic feedback on a player's actions as a set of rules and outcomes with correlation of an appropriate challenge level for a better sense of self-efficacy and a gradual, learning-oriented outcome [10]. A similar but shorter description of digital learning was presented by Prensky [11], who describes it as a combination of learning and digital entertainment.

The link between the real world and virtual reality is developing very quickly [12]. For example, the game Pokémon GO was hailed by the media as “the biggest mobile game in U.S. history” [13]. This type of game creates a deeper interaction between the player and the game, which gives a huge scope for learning potential. A Goldman Sachs report (2016) [14] on augmented reality from 2016 argues that it has the potential to “become the next big computing platform, and as we saw with the PC and smartphone, we expect new markets to be created and existing markets to be disrupted”.

3 Education Background of the Game

The main aim of this project was to present the concept of using augmented reality as a new way of teaching, for example financial indicators like ROI. ROI is a performance measure used to evaluate the efficiency of an investment or compare the efficiencies of a number of different investments [15].

The choice of this indicator is very important because it shows the efficiency at capital allocation in the process of operating profit generation. In a modern company, there is an option to increase value via revenues. This may happen by cutting costs, improving the usage of fixed assets and rotating of working capital. Basically, all management decisions made by the company have an impact on this indicator. Students and younger managers usually have a problem with analysing this indicator

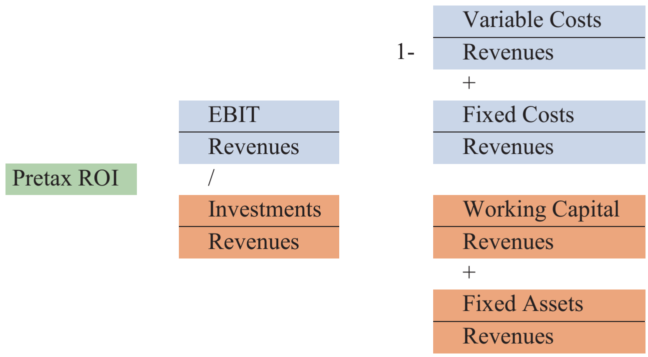

Fig. 1 The first two levels of return on invested capital (ROIC) decomposition

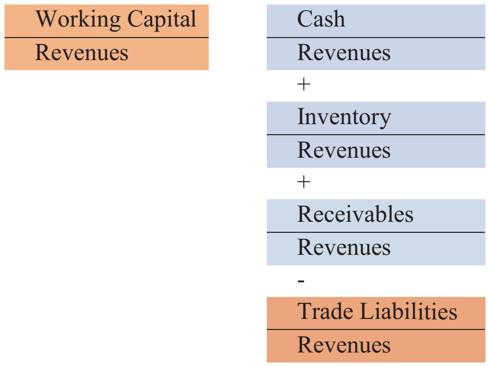

Fig. 2 The third level of return on invested capital (ROIC) decomposition/ working capital decomposition

thoroughly. They understand the relations between making management decisions and generating cash flow, but they very often have problems with making profits for the business.

The game is based on the decomposition of this indicator. A player has to make decisions which will have an impact on the indicator value and the profitability of the project. The example of ROI decomposition is presented below.

The calculation of tax expenses is the first level of decomposition. The second level is the relation between the value of the counter (earnings before interest and tax, EBIT) and the denominator (investments as a percentage of revenues). The next step is to analyse the relations between all company costs and revenues separately (Fig. 1). In the denominator case, for example, it can be split into investments, working capital and fixed assets. The last point of decomposition is to calculate each part of the working capital (Fig. 2).

4 The Game

The very important problem is how can this indicator be represented graphically? The Earth has been chosen as the best allegory of every step of ROI decomposition. The closed ecosystem that is Earth is suited perfectly to illustrating each business, and its construction can be easily used to represent every level of analysis of the ROI indicator. Revenues and operating costs will be presented as the atmosphere. Working capital, property and plants, and intangible assets will be described as land and mountains. The player's main goal will be the maximisation of land surface. In order to do this, the player will have to make 15 decisions randomly, choosing from 45 options for eight types of businesses. The range of decisions starts with or from simple inventory, receivables, liabilities and cash management, through product advertisement to capital expenditure. The game should take around 5 min to complete, which is normally spent in a queue.

In order to select a proper scenario for the business, the augmented reality factor in the game will be based on the usage of video cameras, GPS and phone integration with maps, similar to the system used in the Pokémon GO game. The scenarios for playing the game are planned as follows:

- Restaurants (food court)
  - Fast food (like McDonalds, Pizza Hut)
  - Brunch/lunch restaurants
- Food shops
  - Groceries
  - Discount
- Clothing shops
  - Chain shops (Zara, H&M, Uniqlo)
  - Boutiques
- Hairdressers
- Petrol stations

The game will choose the environment according to the player's location when they start it. This should help in understanding the particular business. The businesses were not chosen without a reason because they are the places where the client is waiting in a queue. This should increase the customer's level of interest in the game and help them indirectly understand the mechanisms involved in the specific branch.

5 Summary

This article is a part of the author's work about innovation in learning processes due to generation changes and technology development. The presented project focuses on augmented reality learning game design as a new way of teaching financial indicators like the ROI. The expected results are as follows: a better understanding of the indicator and the influence of individual decisions on its value and the business in general. Thanks to the more intense interaction between the chosen scenario that depends on the gamer's location, it will be possible to use their attention and enlarge the gamification effect. Thanks to the awareness of the factors that create value in a particular business, the gamer will be able to better understand the existing scenarios within its mechanisms.

References

1. Takahashi D (2013) With a mobile boom, learning games are a $1.5B market headed toward $2.3B by 2017. venturebeat.com. http://venturebeat.com/2013/08/16/with-a-mobile-boom-learning-games-are-a-1-5b-market-headed-toward-2-3b-by-2017-exclusive/. Last accessed 2018/03/01
2. Podgorski B, Wardaszko M (2017) Mobile learning game effectiveness in cognitive learning by adults: a comparative study. Simul Gaming Interdisicipl J Theory Pract Res 3:1–20
3. Boyle E, Connoly T, Hainey T, Boyle J (2012) Review: engagement in digital entertainment games: a systematic review. Comput Hum Behav 28:771–780
4. Ijsselsteijn W, Nap H, de Kort Y, Poels K (2007) Digital game design for elderly users. In: Proceedings of the 2007 conference on future play (future play '07). ACM, New York, pp 17–22
5. Tamborini R, Bowman ND, Eden A, Grizzard M, Organ A (2010) Defining media enjoyment as the satisfaction of intrinsic needs. J Commun 60(4):758–777
6. Carvalho R, Ishitani L (2018) Motivational factors for mobile serious games for elderly users. http://www.academia.edu/15764911/Motivational_Factors_for_Mobile_Serious_Games_for_Elderly_Users. Last accessed 2018/03/01
7. Podgorski B, Wardaszko M (2015) Mobile educational game – smart Leo W: "hybrid simulation & gaming in the networked society". Hidehiko Kanegae, Ritsumeikan University, Kyoto, pp 367–390
8. Freestone O, Mitchell V (2004) Generation Y attitudes towards e-ethics and internet-related misbehaviours. J Bus Ethics 54(2):121–127
9. Nielsen (2014) Mobile millennials: over 85% of Generation Y owns smartphones. http://www.nielsen.com/us/en/insights/news/2014/mobile-millennials-over-85-percent-of-generation-y-owns-smartphones.html. Last accessed 2018/03/01
10. Mayer RE, Johnson CI (2010) Adding instructional features that promote learning in a game-like environment. J Educ Comput Res 42(3):241–265

11. Prensky M (2001) Digital game-based learning. McGraw Hill, New York, pp 1–19
12. Rauschnabel PA, Brem A, Ivens BS (2015) Who will buy smart glasses? Empirical results of two pre-market-entry studies on the role of personality in individual awareness and intended adoption of Google Glass wearables. Comput Hum Behav 49:635–647
13. Lovelace B (2016) 'Pokemon Go' now the biggest mobile game in US history. CNBC. Retrieved January 10, 2017, from https://www.cnbc.com/2016/07/13/pokemon-go-now-the-biggest-mobile-game-in-us-history.html. Last accessed 2018/03/01
14. Goldman Sachs (2016) Virtual & augmented reality. Retrieved March 31, 2016, from http://goldmansachs.com/our-thinking/pages/technology-driving-innovationfolder/virtual-and-augmented-reality/report.pdf
15. Investopedia (2018) https://www.investopedia.com/terms/r/returnoninvestment.asp. Last accessed 2018/03/01

Learning Efficacy Among Executives and Students of an Organizational Growth Game

Jessica Weber-Sabil, Harald Warmelink, Alessandro Martinisi, Thomas Buijtenweg, Kevin Hutchinson, and Igor Stefan Mayer

Abstract Business games are used for organizational performance interventions as well as for educational purposes. To what extent can games be designed for intervention and used for educational purposes (and vice versa)? The authors study the learning efficacy of a game originally designed to support the implementation of the growth strategy for a client organization, a Dutch SME operating on the global market. Data was collected systematically through surveys before and after the game, 1 session with 25 executives from the client company and 2 sessions with 39 students of entrepreneurship. The findings indicate that although the learning efficacy, game quality and enjoyment among both groups are good or average, the differences are significant. The conclusion is that although business games in general are an effective intervention and active learning tool, the influence of contextual factors on learning among students may be more pronounced than it is among the executives for which the game has originally been designed.

Keywords Organizational growth · Simulation gaming · Executive learning · Educational game · Business game · Learning efficacy

1 Introduction

Business games are one of the most well-established genres of simulation gaming (SG) [4]. They are used either as intervention methods to increase business performance or educational purposes, teaching students the principles of business and management [5]. At the time of writing, there are a great many application areas for business games: marketing, finance, entrepreneurship [2, 3], business leadership [6]

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and strategic management [4], to only name a few. Entrepreneurship games challenge players to explore the relationships between company strategy, marketing, sales and operations while getting a new venture off the ground. An increasing number of business games focus on the early stages of business, i.e. the startup phase [see, e.g. 1 or 2].

A scan of the relevant literature, however, does not give a great many business games that focus on organizational growth after the startup phase, such as through product innovation, market expansion or acquisition. Whereas markets are becoming more competitive and global, it is increasingly important for executive managers as well as students to understand the dynamics of growth strategies. In this paper, the authors study the learning efficacy of a business game originally designed as an intervention method to increase the business performance of a client company, but later used for more generic learning purposes in game sessions with executive managers and students.

2 Materials and Methods

In 2016, the authors were requested by a client organization [anonymized for confidentiality reasons] to develop and moderate a tailor-made company strategy game to support the implementation of its global growth strategy. Having its roots and headquarter in the Netherlands, the client company is a family-owned SME with around 3000 employees operating in a global market producing a specific type of food ingredients. The company had recently redefined its growth strategy, but this strategy still needed to trickle down to the various regional and country units and management levels. Furthermore, central management wanted to see the growth plans 'in action' in a simulation, and use the shared experience for joint reflection on possible consequences and refinements. The resulting game was first played in 2017, with 35 senior managers of the company in a global strategy meeting. For obvious reasons, the insights and impact of this session cannot be shared here. However, the game play highlighted several tensions in the implementation and influenced the subsequent course of action.

In a second game session, a slightly revised version of the game was played for more generic learning purposes with the middle management of a regional business unit of the client company. Furthermore, the game was played with two groups of students of the minor entrepreneurship in the institution of the author's affiliation (November 2017).

Many business games are used either as interventions to improve organizational performance, or for educational purposes. The question, however, is to what extent are games originally designed for executive managers as an intervention in organizational performance, equally effective when played with students for educational purposes? Since the motivation, the expectations and the context or content knowledge of students and executives on the game are different, they may also respond differently to the game-based learning process. The authors therefore study the learning efficacy among managing executives and students in response to the same game that has originally been designed to support the implementation of the growth strategy of the client organization where the executives are employed.

The game is a tailor-made and simplified representation of an international player in the professional food business. The five to seven rounds in the game, with instruction and debriefing, take around 5–7 h. The game has been designed to accommodate around 35 players.

The game is tailored to represent the organizational structure, operational processes and strategy of the company (see Fig. 1). Corporate is responsible for the companies' strategy and oversees the operations and performance in three areas: Europe, Asia and South America. Area directors are leading and coordinating the areas' operations, cross-area trade and product portfolio management. Each area consists of three countries, each with a managing director. Managing directors are responsible for the strategy, operations and performance of their country. Game facilitators manage the market where the country directors buy raw materials and sell their products. The challenge for the players is to achieve strong company growth measured against indicators such as sales, profitability and revenues. An Excel-based simulation model calculates key performance indicators per country such as revenue, profit, return on sales, asset (production line) utilization and innovation level (number of new products produced) per country. A pricing model calculates product prices and thus revenue per round based on each country's supply of and demand for said products. At the end of each round, updates on each country's KPIs are provided with which the counties can ascertain the effects of their chosen strategy and decisions and determine how to proceed in the next round.

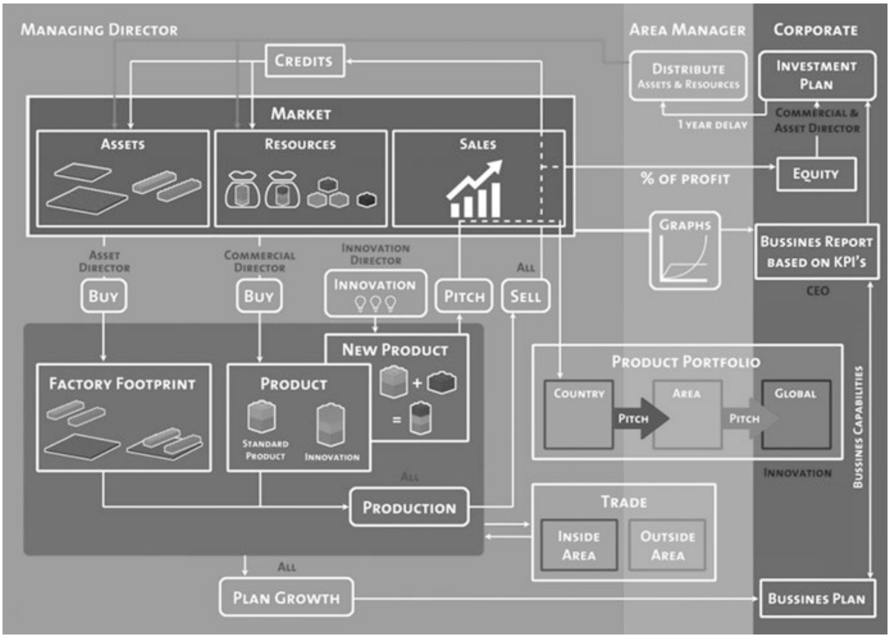

Fig. 1 Organization of the activities in the SG rounds per role

At the start of the game, each country has two production lines and some virtual credits to buy raw materials or, later in the game, buy new production lines or factories. Product sheets explain which products can be made with which raw materials using LEGO® bricks of different colours that can be bought at the marketplace. At the start of the game, production lines can only produce one type of product: either rolls, bread or cake. However, the managing directors can soon innovate their product line by creating new colour combinations of bricks and create efficiency by pooling resources or sharing production capacity. In this fashion, the game steadily increases in complexity. Through actions like product innovation, marketing, market expansion, internal partnerships like pooling of resources or sharing production and acquisition of other companies, players can and should develop a coherent growth strategy. They should learn about the different levers that can be used to create growth, how these levers fit, or do not fit together, and how well to align the actions among the different internal actors.

The study design is based on the game evaluation model by Mayer et al. [7, 8]. Participants were asked to fill out surveys before and after the game. Questions were single items and multiple-item constructs that measure background variables (age, gender, etc.), possible mediating factors such as previous game experience, learning expectations and motivation. Table 1 lists the variables measured in the survey. The quality of the game was measured through several constructs for the game design,

Table 1 Correlating mediating factors

	Total		Students	Executives	Mann-Whitney sig.
Component	Mean (SD)	Median	Median	Median	
Organizational growth knowledge (α = 0.87)	3.9 (0.8)	4.0	3.3	4.3	0.000
Enjoyment (α = 0.78)	4.1 (0.8)	4.3	3.7	4.7	0.000
Game design quality (α = 0.9)	3.9 (0.6)	3.9	3.7	4.5	0.000
Facilitation quality (α = 0.81)	4.1 (0.7)	4.0	4.0	5.0	0.000
Gameplay quality (α = 0.87)	4.0 (0.8)	4.2	3.8	4.6	0.000
Attitude towards game-based learning (α = 0.88)	3.9 (0.8)	4.0	4.0	4.0	0.030
Intrinsic motivation (α = 0.68)	3.7 (0.8)	3.5	3.5	4.3	0.001
Expected communication and social skills (α = 0.9)	3.8 (0.8)	4.0	3.5	4.3	0.000
Expected expert knowledge (α = 0.77)	3.7 (0.7)	3.7	3.3	4.3	0.000
Expected professional skills (α = 0.91)	3.8 (0.8)	3.8	3.2	4.8	0.000
Learning style preference for individual study (α = 0.81)	2.3 (0.9)	2.5	2.0	2.5	0.113
Learning style preference for group work (α = 0.75)	4.0 (0.7)	4.0	3.5	4.5	0.000

One-tailed Kendall's tau; $p < 0.05$

the facilitation and the game play. The learning efficacy was measured through three Likert statements assessing the perception of participants learning about organizational growth. Enjoyment of the game is taken as an indicator for a precondition of learning. The growth strategies were observed and discussed during the debriefing after the game sessions of which data was used for interpreting the statistics and not reported systematically here for reasons of space. Applicable statistical analyses were descriptive analyses, Mann-Whitney independent condition tests and Kendall's tau correlation analyses.

Players of the original game were 90% male, with an average age of 55+, having 25 different nationalities and working in high management positions. The data set used for the statistical analysis consists of 61 player-participants, of which 36 are students and 25 executives. The student group has 11 females and 25 male participants and an average age of 21 years. The majority of students are Dutch (86%), followed by 11% Germans and 3% Italian. Students have already played one or two simulation games before. The average executive manager is around 36 years and has played none or one simulation game before. In executive sessions there were 15 female and 10 male participants.

3 Findings

Table 1 presents the results of a mean comparison between students and executives on the learning efficacy construct 'learning about organization growth' and mediating variables, such as learning expectations, motivation, game quality and enjoyment. The findings indicate that both groups are appreciative of the game quality, the enjoyment as well as the learning effect. The results however also show a noticeable difference between the students and executives, with regard to all factors except for the preference for individual learning. In other words, the context factors among the students and executives, as well as the learning effect after having played the game, vary noticeably between the two groups. Students were positive, but significantly lower in appreciation of the game and learning about organizational growth compared to the executive group.

Table 2 represents the results of a more refined correlation analysis between learning efficacy and mediating factors, separated for the student and executive management groups. The results show that learning in the executive group is significantly and quite strongly correlated with the enjoyment of the players. If and when the executive players enjoyed the game more, they also report a higher learning effect. Other factors such as game quality, motivation, learning style preference or expectations are not related to the learning effect of the executives. However, for the students, there are more influential factors on learning, such as the game design quality, the quality of the facilitation and the learning style. Enjoyment of the game also correlates with learning, but less pronounced than in the executive group. Students, who have a preference for individual learning, report a significantly lower level of learning in the game.

Table 2 Correlating mediating factors

Sign. corr. factors	Organizational growth *stud.*	Organizational growth *Exec*
Game design quality	0.57	
Game facilitation quality	0.41	
Enjoyment	0.33	0.67
Learning expectations: communicative and social skills	0.46	
Learning expectations: professional skills	0.55	
Learning style: individual study	0.47	

One-tailed Kendall's tau; $p < 0.05$

4 Discussion

The results indicate that the learning due to the game is significantly different between the students and executive managers.

The learning processes of students in the game seemed influenced by various contextual factors such as game quality, quality of facilitation, the learning style and enjoyment of the game. Students who believed that the game was well designed and moderated indicated a higher learning effect. Conditional factors influence the learning of the students more, than among the executives. But how come that the learning of the students diverged and was less self-evident compared to the executives? Given the fact that the students related less clearly to the content and context of the game, it might have resulted in divergent learning effects and greater differences in appreciation of the game quality. Students had a tougher time understanding the usefulness of the game, if only for the obvious reason that they have little experience with business and management in general, or organizational growth in particular.

In contrast, the majority of senior executives of the first game session and of the later game session with the middle management found the game responded positively towards understanding organizational growth in their company. Although a few respondents were quite sceptic towards the enjoyment and expected impact, a strong aspect of understanding organizational growth is showing leadership skills. The business game was an opportunity for executives to position themselves and their role in the overall organization. During the course of the game, area managers turned out to have a central role in horizontal and vertical planning, coordination and communication. Both students and executives showed different managerial styles which ranged from very open and participative to leading and controlling. In all game sessions, corporate remained largely invisible for advice or guidance. However, some natural leaders took initiative to manage the complexity of organizational growth by orchestrating intensified cooperation with a few players. Thus, the majority of students and executives found the open, ambiguous style of the game quite challenging to adapt to; a mixture of strong leadership and improvisation is a highly desired skill in leadership, which only a few players showed.

In terms of player strategies, student and executive groups discovered different means of communication. Decision-making processes in and outside the game certainly played a role in the executive gameplay. Though, it was not observed that middle management would particularly consult upper management before making decisions. Instead executives and students preferred a direct communication style between all teams.

Despite the statistically proven differences between the groups, it can be stated that for students and executives, the business game was a respectable experience to train teamwork. Observations revealed that participants would first focus on their own country and determine how they could make the most profit, so that the next round they could extend their production capacity and growth. What they would then observe is that their individual choices would hamper the growth of another country. Particularly the student group needed the time to collectively understand that organizational growth depends on collaboration. Despite being one company, the participants were actually competing with each other because of their chosen strategy. This realization typically led to increased collaboration between the countries. During game advancement, cooperation, sharing and communication even increased among students and executives groups, recognizing that these elements are essential for an organizational growth strategy. Thus, collaboration strategies were soon implemented and executed with the result that countries that collaborated performed better than those working alone. One executive player described the beginning of gameplay as '[…] we behaved as a group of individuals with an opportunity to act more as one company [at the end of gameplay]'. Players in the executive group were at all times equally engaged in the game activity, while student players withdrew after centralization became the dominant playing mode due to a lack of available tasks. Observations in the executive group revealed that although a high level of collaboration was recognized, centralization to increase organizational growth was not an option for the middle management group. Social responsibility to full employment is a strong principle in the company's corporate culture.

The game was found to be an 'interesting metaphor of our own situation', as stated by an executive player. The game created a constructive discussion on important aspects and consequences of the new strategy concerning organizational growth strategies.

5 Conclusion

Although business games in general are effective as intervention and active learning method, the influence of contextual factors on learning among students may be more pronounced than it is among the executives for which the game has originally been designed. Mediating factors such as game quality, facilitation but also the motivation and expectations have a significant relation on learning effects, in our case to organizational growth. The analysis combined with the observations shows how (some) students find it more difficult to contextualize the purpose, content and context of the game. Our results also reaffirm that active game-based learning is simply not for everyone nor at any time. Some players in the first executive session responded quite similar as the students; this is with low expectations before and scepticism after. Aspects like culture and position in the organization seemed to play a role why people are reluctant or not in favour of active learning techniques. Similarly, some students found the game ineffective within their entrepreneurship education because they found it difficult to conceptualize the context and purpose. For an active learning platform to be effective, it is important to be aware and accept the variety in responses of players to game-based learning and understand much better the factors that influence them.

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References

1. Almeida F (2017) Learning entrepreneurship with serious games – a classroom approach. Int Educ Appl Sci Res J 2(1):1–4. Retrieved from http://arxiv.org/abs/1710.04118
2. Hauge JB et al (2013) Field assessment of serious games for entrepreneurship in higher education. J Converg Inf Technol 8(13):1–12. http://www.globalcis.org/jcit/ppl/JCIT3944PPL.pdf
3. Jerman Blažič A, Džonova Jerman Blazic B (2015) Exploring and upgrading the educational business-game taxonomy. J Educ Comput Res 52(3):303–340. https://doi.org/10.1177/0735633115572959
4. Keys JB (1997) Strategic management games: a review. Simul Gaming 28(4):395–422. https://doi.org/10.1177/1046878197284005
5. Kriz WC (2017) Historical roots and new fruits of gaming and simulation. Simul Gaming 48(5):583–587. https://doi.org/10.1177/1046878117732845
6. Lopes MC, Fialho FAP, Cunha CJCA, Niveiros SI (2013) Business games for leadership development: a systematic review. Simul Gaming 44(4):523–543. https://doi.org/10.1177/1046878112471509
7. Mayer I et al (2014) The research and evaluation of serious games: toward a comprehensive methodology. Br J Educ Technol 45(3):502–527. https://doi.org/10.1111/bjet.12067
8. Mayer I, Warmelink H, Bekebrede G (2013) Learning in a game-based virtual environment: a comparative evaluation in higher education. Eur J Eng Educ 38(1):85–106. https://doi.org/10.1080/03043797.2012.742872

Business Game Promoting Supply Chain Collaboration Education at Universities

Tomomi Kaneko, Ryoju Hamada, and Masahiro Hiji

Abstract Most engineering students have less motivation to learn business management skills and knowledge because they have never learned them and might imagine that they are difficult. To resolve the two difficulties above simultaneously, the authors have been developing original analogue business games since 2007: BASE business games. The authors created the BASE Supply Chain Collaboration Games (BASE-SCC), which are specified for learning supply chain collaboration. These business games require that students form teams and manage simulated companies as smartphone assemblers. The authors applied the games for students at Sirindhorn International Institute of Technology (SIIT), Thammasat University. The results of questionnaire analysis demonstrate that the participants enjoyed the games and acquired necessary management skills through the game experiences. Furthermore, the authors confirmed that the games have reproducibility as educational materials.

Keywords Analogue business game · Game-based learning · Simplified management skill · Supply chain collaboration

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1 Introduction

In countries such as Japan facing a low birth rate and aging population, the supply of young people as laborers has decreased considerably. Consequently, because there is no time to train new employees, it is expected that students must be "reliable colleagues" as soon as they graduate from a university, which implies demands especially from engineering education. The skills that they must acquire are not only "professional knowledge" and "fundamental skills in society" acquired through life as a student but also "business management skills and knowledge", which include total skills and knowledge for actual cooperative activity. The first two can be learned through lectures in higher education. However, students who are not specializing in the study of economics have no time or opportunity to learn business management skills such as basic accounting, finance, human resource management, and supply chain management. Although they might study hard with great personal effort, their knowledge cannot be assimilated or related meaningfully because they have no business experience. To resolve those two difficulties above simultaneously, the authors have been developing original analogue business games called BASE business games since 2007 [1].

A unique feature of BASE business games is that they are physical board games. The basic concepts of BASE business games are presented below.

- Within a limited time, they teach only important business management skills and knowledge to target students.
- Playing the games is fundamentally enjoyable.
- The game play is as brief as possible.
- The games motivate studies of business management skills and knowledge for future careers.

The authors organized the games for a lecture of "Entrepreneurship for IT Business Development" at Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand. This lecture used the applied BASE business games. Results of questionnaire analyses demonstrate that the participants enjoyed the games and acquired important management skills and knowledge and that they were motivated to do so through the game experiences. Furthermore, the authors confirmed that the games hold reproducibility as educational materials.

2 Literature Review

Gaming is an effective method for considering various difficulties of daily life. In fact, business games and simulations have a long history. In the 1980s, a computer-assisted game simulating international manufacturing and trade was used for the Master of Economics program at American University. The Carnegie Mellon Tepper School of Business has used a business game called the Carnegie Management

Game for over 30 years since its establishment. This game, which is accessible from all over the world, can be participated in easily. In fact, the authors have joined the game from Japan. The game can incorporate numerous parameters, some of which are difficult for non-economics students such as the author. Furthermore, many games related to supply chains have been reported. Zhou et al. [2] examined the Beer Game and developed a four-step Internet-based Supply Chain Simulation Game. Kiekintveld et al. [3] created a Supply Chain Management Game related to an event called the Trade Agent Competition. The four games above are good educational materials, but students studying economics for the first time face too much difficulty to join business games used in economics courses. The authors strove to produce games that allow easy participation. Furthermore, the authors assume that understanding cooperative works related to supply chains is fundamentally important in the real world but also assume that no opportunities exist to learn them simply in a short time. Supply chain collaboration (SCC) games can teach cooperation skills that are almost equal to real-world collaboration skills.

3 Introduction to SCC and SCC2 Games

The authors created BASE business games of two types: "Supply Chain Collaboration Game (SCC game)" and "Supply Chain Collaboration 2 Game (SCC2 game)." Supply chain collaboration is an extended concept of supply chain management. These business games require that students form teams and manage a simulated company. To do so, they must manage strategy, risks, cash accounts, fixed costs, and inventory control with supply chain collaboration.

Figure 1 presents an SCC game outline. The SCC game purpose is to learn supply chain operations. Players operate smartphone manufacturers and create smart-

Fig. 1 Outline of the SCC game

phones comprising a motherboard and a display: each component has six levels of quality. The price of each motherboard and display is fixed with the level of quality. Therefore, players must devote careful consideration to which combination represents the best choice for the market situation and other companies' strategies. Profits are earned after purchasing motherboards and displays from suppliers with appropriate timing, assembly at the factory, and sale of the finished smartphones. The inventories of motherboards, displays, and smartphones are checked with a handwritten inventory control sheet. Regarding accounting, participants make payments using the cash flow sheet for every game's month. At the end of the game year, they create a basic income statement and balance sheet. In SCC games, all sheets are scored manually.

The most interesting action of the games is "sales." Every game month, participants can sell smartphones in four markets that have different market characteristics. The four markets, designated as Premium, Deluxe, Standard, and Basic, are defined as "Acceptable Quality," "Price Cap," and "Market Volume." These conditions change annually. Participants must choose a market based on a comparison between their smartphone's quality and the market's acceptable quality. When the total sales volume does not exceed the market volume, participants obtain the maximum sales revenue, which is equal to the market price cap. However, open bidding begins when the total sales volume exceeds the market volume. Open bidding is face-to-face bidding: a remarkable activity. The mechanism entertains participants. They come out to the market board, by which they wanted to sell smartphones. Then they put a smartphone, which is simulated by dodecahedron dice, on the market. At the signal of the facilitator, they show the price to other companies with a calculator. They can receive the sales revenue of their sales price if participants win the bid. Through game play, students devise how to maximize the profits of their companies and to develop their companies while managing cash flow.

Figure 2 presents the SCC2 game outline, which is more complicated than the SCC game. The purpose of the SCC2 game is to learn cooperation in the supply chain. In the SCC2 game, players separate and form companies of three types: Motherboard Vendors, Display Vendors, and Smartphone Manufacturers. Each company assembles motherboards, displays, and smartphones, as in the SCC game. A significant difference between the SCC2 game and the SCC game is that Motherboard Vendors and Display Vendors are subcontractors of Smartphone Manufacturers. Thereby, Smartphone Manufacturers must negotiate Motherboard Vendors and Display Vendors on price and many motherboards and displays. All companies must negotiate with awareness of their own company's cash flow. The authors assume that the experience of negotiation with others helps students to interpret cooperation in the supply chain. This action is the outstanding feature of the SCC2 game.

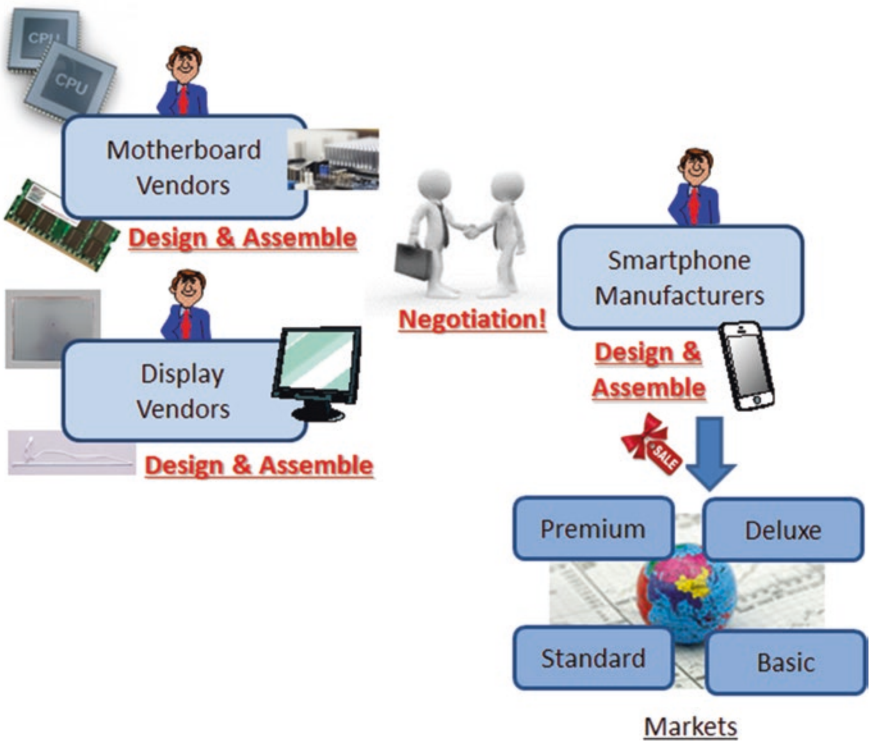

Fig. 2 Outline of the SCC2 game

4 Educational Practices at SIIT Thammasat University

The authors conducted a lecture on "Entrepreneurship for IT Business Development" as visiting teachers during 2010–2016 at the School of Information and Communication Technology (ICT) and Management Technology (MT) at Sirindhorn International Institute of Technology (SIIT), Thammasat University. During this process, SIIT asked the authors to develop a Supply Chain Collaboration Game, which became the origin of SCC and SCC2. The authors applied the SCC game and SCC2 game for most lectures held during 2014 and 2015.

To verify the game's effectiveness, the authors conducted questionnaire research as self-evaluation using a Likert scale. The averages of responses to respective questions can be compared because the respondents were the same students. Before and after the lectures, students replied to the questionnaire presented in Table 1. The responses to these questions were given on a five-point scale. Figure 3 presents average results obtained for 2014 and 2015.

Table 1 Questions related to management knowledge games

1.	What would a company do when cash becomes short?
2.	Why does a good company sometimes become bankrupt suddenly?
3.	Why do most companies borrow money from a bank?
4.	How does a company reduce manufacturing costs?
5.	What would happen to a company if they produced too many goods?
6.	Why is risk management important?
7.	How is a break-even point calculated?
8.	What factors does supply chain collaboration include other than price?
9.	Why is a continuous relationship with suppliers important to sustain the company?
10.	Why do companies establish a business strategy?
11.	Concept of inventory control
12.	Concept of production planning
13.	Concept of human resource development

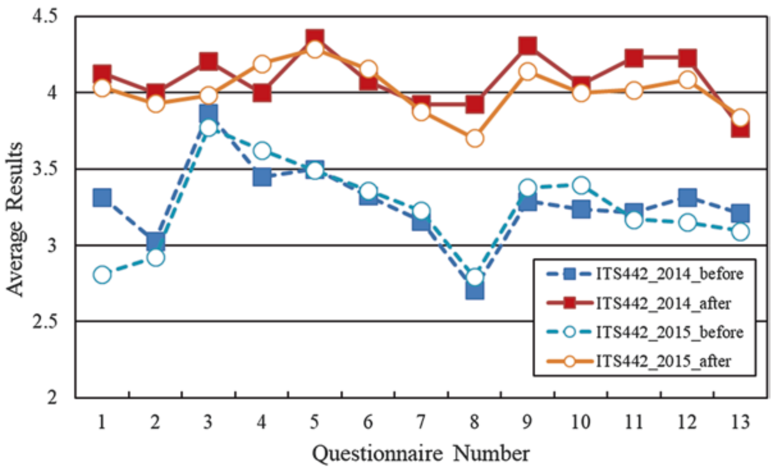

Fig. 3 Results obtained for 2014 and 2015

Table 2 presents the students' reported degrees of connection between knowledge and skills horizontally. The average values of the response to the question increased 0.92 in 2014 and 0.96 in 2015, indicating that their reported knowledge and skills are connected well horizontally. The authors confirm that this teaching method is useful for connecting their knowledge and skills horizontally in a short time.

Table 3 presents the results of "Was your motivation increased?" Results show that many students increased their motivation, meaning motivation to participate in

Table 2 Degree of connection of their knowledge and skills horizontally in your mind

2014 ($n = 39$)		2015 ($n = 57$)		
Before	After	Before	After	
0	0	1	0	1. Strongly no
6	0	9	0	2. No
13	2	24	5	3. Neutral
15	19	18	32	4. Yes
5	18	5	20	5. Strongly yes
3.49	4.41	3.30	4.26	Average

Table 3 Is your motivation increased?

2014 ($n = 39$)	2015 ($n = 57$)	
0	0	1. Strongly no
1	1	2. No
6	9	3. Neutral
19	28	4. Yes
13	19	5. Strongly yes
4.13	4.14	Average

this lecture. One can infer that increased motivation to participate in this lecture might be equal to increased willingness to learn business management skills and knowledge.

Table 4 presents the results of "Do you recommend the lecture using SCC games to younger students?" The authors assume that responses to this question are representative as a summary of student satisfaction. In both years, many students might recommend lectures that include SCC games to younger students. Results show that students generally enjoyed this lecture and that they were satisfied with it.

Overall results show improved management knowledge comprehension. Also, the results of both years exhibit similar tendencies, even for responses of different student groups. This result demonstrates that these games yield reproducible results as educational materials. The authors assume that the responses of both are comparable.

The authors assessed the attraction of SCC games for students. Table 5 presents answers to questions about interesting actions for the SCC game and SCC2 game. Results demonstrate that the most interesting action was "Bid/Sales" in both years. Because the authors tried to study "Bid/Sales" deeply, they attempted to apply open and closed bidding. Open bidding is already described in chapter "HalluciFear: Educational Game About Drug Addiction". Closed bidding is not face-to-face bidding. Students discussed prices with team members and voted using a bid paper in a market box. After all companies had bid, the facilitator opened the market box and projected the bidding results on the screen for all students. Closed bidding was applied at the middle stage of the SCC game because they understood the rules of the SCC game and became conscious of proper bidding prices at that time.

Table 4 Do you recommend the lecture using SCC games to younger students?

2014 ($n = 39$)	2015 ($n = 57$)	
1	0	1. Strongly no
1	1	2. No
3	4	3. Neutral
10	22	4. Yes
24	30	5. Strongly yes
4.41	4.42	Average

Table 5 What are interesting actions in SCC and SCC2? (multiple responses accepted)

Year	2014 ($n = 39$)		2015 ($n = 57$)	
Options	Frequency	Ranking	Frequency	Ranking
General operation → Cash	17	5	17	8
General operation → Inventory	20	4	17	8
General operation → Sales	24	2	21	5
My decision will appear in actual practice	17	5	18	7
Bid/sales	31	1	42	1
Beat out competitors	7	9	31	3
Talk together	17	5	31	3
Talk with members	9	8	38	2
Calculation	21	3	20	6

Table 6 Which bidding was interesting?

	2014 ($n = 36$)	2015 ($n = 38$)
Open bidding	5	25
Closed bidding	31	13

After closed bidding, the questionnaires were administered. Responses to the first question are shown in Table 6.

The results of both years were divergent. Although the authors conducted free explanation along with the question, the answers diverged and did not lend themselves to interpretation. The authors did not examine the reasons for students' favorite bidding methods, but asked for the favorite parts of both bidding types, whether or not they were interested. This approach revealed interesting aspects of open bidding and closed bidding. Therefore, in 2015, the authors posed the following two questions, to which there were 58 respondents. It counted the number of each of the four choices.

Knowing the competitors was the most valuable reason for preferring open bidding as shown in Table 7. The authors assume that because the competitors were also friends, they were able to enjoy their friendship and human relationships. However, regarding raising profits as a company, the mechanism by which no company can see a competitor's bid information ahead of the bidding round was the most popular reason for the closed bidding as shown in Table 8.

Table 7 Why do you like open bidding? (multiple-choice question)

Know competitors	34
Decide your bidding price as you wish	25
Competition with other companies	25
Get high revenues	17

Table 8 Why do you like closed bidding? (multiple-choice question)

No company can see a competitor's price a priori	39
No faulty play, corruption, or collusion	21
Do not know competitors	17
Decide your bidding as you wish	14

Table 9 Did your bid price change if the months of closed bidding were open bidding instead?

	Open bidding	Closed bidding	Total
Yes. They became higher	7	0	7
No. They did not change	0	3	3
Yes. They became lower	10	6	16
No answer	8	4	12

(n = 38)

The overall result of Table 9 demonstrated that open bidding tends to produce a bid price that is lower than that of closed bidding. It is apparent that the decision-making process of bidding prices during open bidding interfered with the competitors to a greater or lesser degree. The SCC games usually use open bidding because the authors hope that students learn to know the price competitors well and then decide a price. That hypothesis is supported by the results shown in Table 7.

5 Conclusions

The authors have developed BASE business games and applied SCC games to students at SIIT Thammasat University in Thailand.

1. Responses of different student groups obtained in 2014 and 2015 exhibit similar tendencies, which demonstrates that these games hold reproducibility as educational materials.
2. Overall results demonstrate that the participants enjoyed the games and acquired important business management skills and knowledge and motivation of learning them through the game experiences.
3. The most exciting action of these games is "Bid/Sales." This item was evaluated most highly because it is possible to experience the reality of affecting information related to price determination through competition. Results demonstrated that learning real-world aspects of bidding attracts student interest.

References

1. Hamada R, Hiji M, Kaneko T (2016) Development of BASE manufacture game in Thai. Thaisim J Learn Dev 1(1):1–17
2. Zhou L, Xie Y, Wild N, Hunt C (2008) Learning and practicing supply chain management strategies from a business simulation game: a comprehensive supply chain simulation. Proceedings of the 2008 Winter simulation conference, Miami, FL, USA, pp 2534–2542
3. Kiekintveld C, Wellman M, Singh S, Estella J, Vorobeychik Y, Soni V, Rudary M (2004) Distributed feedback control for decision making on supply chains. ICAPS-04 Proceedings, Whistler, BC, Canada, pp 384–392

How Can We Ensure Middle School Students Acquire Economic Thinking? Developing and Evaluating an Analog Game Involving Smartphones Simulated with LEGO® Blocks

Shigeto Kobayashi and Masayuki Yoshida

Abstract In economic education, it has become increasingly important for middle school students to acquire economic thinking. We developed an analog game using LEGO® blocks for students to gain perspective on economic issues. In this game, we treated combined LEGO® blocks as smartphones, and the students "produced" and "traded" LEGO® blocks to engage in economic activities. Using this game, we conducted economic education classes in two middle schools. We clarified whether students were able to master economic viewpoints through the lesson. To achieve this objective, we conducted a questionnaire survey on opportunity costs before and after the lesson and used the Financial Fitness for Life Theme tests. Students could make decisions after comparing profits and losses resulting from the consequences of their choices. More than half of the students selected the correct answer for applied questions using the opportunity cost concept. However, about three-fourths of the students could not define opportunity cost.

Keywords Active learning · Economic education · Gaming · Opportunity cost

1 Introduction

Uncertainty surrounding individuals' decision-making ability is growing due to changes in social structure; simultaneously, instances where individuals are compelled to make decisions are also increasing. Under these circumstances, economic

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education has become even more important for middle and high school students. Economic thinking is a conceptual framework for understanding economic phenomena and grasping their essence, but the notion has two meanings: the "general meaning of things" and "universal knowledge." An example of the former is knowledge of "economic activity, economic systems, and their functions," while the latter refers to "a way of thinking unique to economics, reflecting economic theory" [1]. According to the teaching guidelines for Japanese middle schools, students should come to understand that "in the market economy, individuals and companies select how much to produce and consume while considering prices" [2]. As a method of dealing with content, students learn that in specific cases, "the economic activities of individuals and companies are carried out by selection under various conditions" [2]. Conversely, textbooks are focused on facts and institutions, and it is difficult for students to acquire economic thinking reflecting economic theory. Kanou [3] asserted that it is possible to acquire economic thinking from textbooks by asking "why" questions, but students find such questions challenging because, with the exception of making purchases, they lack economic experiences. To overcome this challenge, students need to conduct activities in the market economy and reflect on such tasks through gaming. The effectiveness of gaming in economic education, in relation to traditional lecturing, has been assessed as a means of conveying economic insights and principles [4]. However, since most studies on gaming for economic education have only been targeted at undergraduate students, it is difficult to put economic education reflecting economic theory into practice for middle school students.

2 Research Goal and Methodology

We developed an analog game using LEGO® blocks to help middle school students gain economic thinking, especially focusing on opportunity cost[1], a key concept in economics. The reason for this focus is because, although opportunity cost is arguably the most fundamental concept in economic reasoning, even economists who hold PhDs find it difficult to completely understand [6].

We treated combined LEGO® blocks as if they were smartphones, and the students produced and traded the blocks to engage in economic activities. Since learners' decision-making and the outcomes of most games are self-explanatory, they are usually only able to acquire one decision criterion [7]. However, in the game we developed, since the economic environment changes dynamically (in terms of interactions) as players trade with each other, the participants gradually came to understand the decision-making criteria according to fluctuating circumstances. We asked students to describe the thought processes that accompanied their decisions, as well as to contrast their own thoughts with economic thinking reflecting economic theory, facilitating enhanced learning.

[1] Opportunity cost is the next best alternative that is given up when a choice is made. It is an essential concept for rational decision-making because it is a correct measure of the costs of everything we do [5].

The goal of this study was to clarify whether students were able to master economic viewpoints, in particular the concept of opportunity cost, by playing this game, and whether they could make rational decisions in a changing environment using fundamental concepts of economics.

Using this game, we gave classes on economic education at two middle schools (teaching a total of 57 students). To achieve these objectives, we conducted a questionnaire survey on opportunity costs before and after the lesson and used the Financial Fitness for Life Theme (FFFL) tests developed by the National Council on Economic Education [8]. In the questionnaire survey, we asked the respondents about kinds of costs they value in daily selection both before and after the lesson. In the context of cooking curry, we asked the participants which factors they emphasized when they decided to cook themselves, rather than buying naan (an Indian bread that is eaten with curry). We also asked about sunk costs spent on making curry, as well as material expenses, direct costs (the material expense of naan), and opportunity costs (the time spent making naan). In addition, we asked the respondents about their views on the economy via a questionnaire survey. The survey aimed to explore how their perspectives on the economy changed before and after the lesson.

3 Analog Game Involving Smartphones Simulated with LEGO® Blocks

3.1 Outline of the Game

In this game, the value of a smartphone made from LEGO® blocks depends on the colors of the combined blocks. The combination of the most valuable colors consists of four points, while the blend with the lowest value is one point. The team with the highest total score wins. We divided the participants into eight teams, with each one representing a different color; we gave each team 14 blocks with which they could obtain the highest score. The maximum number of points that can be obtained using the blocks given at the beginning is eight points. This condition was the same for every team.

Each team can choose either "trade" or "production" as a way to get a new block. Trade means that teams exchange blocks, while production means that a team increases the number of blocks in its stockpile by adding a block of the color that the team represents. Each team can select whether to trade or produce while referring to the number or color of the blocks in their stockpile. By setting this rule, we offered participants the opportunity to learn rational decision-making, especially the concept of opportunity cost.

This game consists of three phases (Fig. 1), and teams can choose to either trade or produce five times in each phase. In the first phase, it is only possible to trade within a group of four teams, but in the second phase, trade is possible between all

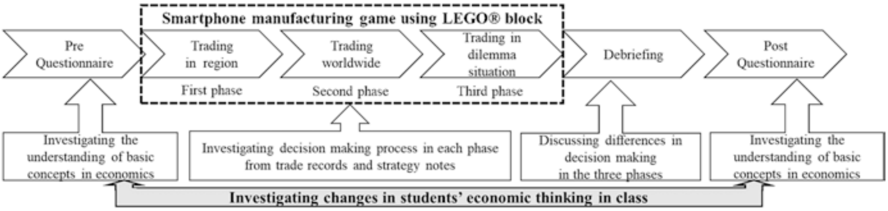

Fig. 1 Outline of the game whereby a smartphone is simulated with LEGO® blocks

eight teams. Since a group that can trade during the second phase possesses blocks for making highly valuable smartphones (that each other group can acquire), it is advantageous to trade with teams belonging to different groups. However, we did not explain this fact to the participants, expecting them to discover it themselves while observing others and negotiating.

In the third phase, if a team makes a smartphone worth four points that has the same color combination as another team's smartphone, the score is reduced according to the number of overlapping colors. Given this rule, when making a smartphone worth four points, a team has to decide whether to consider the blend of colors of smartphones produced by other teams. This situation creates a social dilemma. If individual teams behave selfishly, not only will their scores fall, but all of the teams' scores will also decrease. Thus, we provided opportunities for the participants to make decisions under fluctuating circumstances while adding rules to simulate real economics in each phase.

3.2 Implementing the Game

We conducted the game in A school in July 2017 and B school in August 2017 without regard for the regular curriculum. The participants in A school consisted of 36 students (9 first year students, 16 second year students, and 11 third year students[2]), while the participants in B school comprised 21 students (all third year students). None of the participants were informed about economics or the content of the game in advance. Before playing the game, we administered a questionnaire survey on opportunity costs and impressions of the economy. Subsequently, we explained the rules of the game for approximately 15 minutes. Four college students in total who were familiar with the rules of the game assisted each team. Each phase lasted about 15–20 min. We asked each team to record the kind of trade it conducted with other teams. At the end of each phase, we asked each team to describe the strategy it had adopted and to give reasons for why their score increased.

[2] In Japan, a first year middle school student is 13 years old.

3.3 *Outcomes of the Game*

3.3.1 Changes in Cognition of the Concept of Opportunity Cost Before and After Lesson

Based on the changes in cost that participants considered in terms of daily decisions before and after the lesson (Table 1), at A school, the items of opportunity cost (the time spent making naan) and direct cost (the material cost of naan) increased significantly after the lesson. Conversely, in B school, no significant difference was confirmed before or after any of the items. Regarding the reason for this, about half of the participants chose "agree" and "partially agree" for the items of opportunity and

Table 1 Changes in perceptions of cost before and after the lesson (A school)

Item	Option	Before	After	Statistics
It is important to think about the price of naan being sold at supermarkets	Agree	20	24	*n.s.*
	Partially agree	15	10	
	Partially disagree	5	2	
	Disagree	0	0	
It is important to think about the material cost spent making curry	Agree	18	23	*n.s.*
	Partially agree	11	10	
	Partially disagree	6	3	
	Disagree	0	0	
It is important to think about the time spent making curry	Agree	11	20	$p < 0.05$
	Partially agree	13	11	
	Partially disagree	10	5	
	Disagree	1	0	
It is important to think about the material cost when you make naan yourself	Agree	15	21	$p < 0.05$
	Partially agree	15	14	
	Partially disagree	5	1	
	Disagree	0	0	
It is important to think about the time when you make naan yourself	Agree	12	23	$p < 0.05$
	Partially agree	13	8	
	Partially disagree	10	5	
	Disagree	0	0	

The numbers indicate the number of respondents for each item. Statistics are p values measured using the Wilcoxon signed-rank test direct cost, both before and after the lesson; thus, we assume that the participants were already considering these ideas. We believe that the two schools experienced different results due to the composition of the participants.

While all the participants at B school were in the third year, the participants of A school ranged from first year to third year. Although children in middle school classes rarely deal with opportunity costs, the economic thought of first and second year students with fewer economic experiences than third year students may have influenced the game.

3.3.2 Understanding the Concept of Opportunity Cost

Table 2 shows the results of the question asking participants to define opportunity cost. The correct definition is the "value of the next best alternative not chosen." The percentage of correct responses at A school was 22.2%, while the percentage of correct responses for B school was 9.5%. According to an earlier survey by Yamaoka [9], the proportion of correct responses among middle school students (n = 187) in Japan is 16.9%. In a survey targeting middle school students (n = 362) in the USA, the correct response rate was 17.0% [8].

Based on our game, it is hard to determine whether participants correctly understood the definition of opportunity cost. In the debriefing, we taught them that "opportunity cost" means "other choices you have to give up by making a certain choice" according to the situation in the game; thus, we believe that it was difficult for the participants to select the correct answer. Meanwhile, 61.9% of the respondents at B school defined opportunity cost as "total benefits expected from all forgone opportunities." Since they could choose "production" or "trade" in the game, we think it highly probable that they misunderstood the phrase "all forgone opportunities."

Conversely, a higher number of participants chose the correct answer for the question about the concept of opportunity cost than the question about its definition. Table 3 shows the answers to the question: "What is the opportunity cost of dropping out before you graduate from high school?" The correct answer is "higher wages in the future." The percentage of correct responses for A school was 47.2%,

Table 2 Which is the definition of opportunity cost of a decision?

	A school (%)	B school (%)
Money spent making the decision	33.3	4.8
Worst choice that could have been made	19.4	23.8
Value of the next best alternative not chosen	**22.2**	**9.5**
Total benefits expected from all forgone opportunities	22.2	61.9
NA	2.8	0.0
Sum	100.0	100.0

The correct definition is indicated in bold

Table 3 What is the opportunity cost of dropping out before you graduate from high school?

	A school (%)	B school (%)
Higher wages in the future	**47.2**	**81.0**
Freedom to do what you want right now	25.0	4.8
What you earn working after you drop out	13.9	9.5
No expenses for textbooks and school supplies	13.9	4.8
Sum	100.0	100.0

The correct answer is indicated in bold

Table 4 What is the opportunity cost of saving money?

	A school (%)	B school (%)
The value of the interest on the savings	8.3	0.0
The products that could be purchased now	**50.0**	**52.4**
The possible loss of the savings in case of theft	22.2	19.0
Taxes that will have to be paid on the savings and earned interest	16.7	28.6
NA	2.8	0.0
sum	100.0	100.0

The correct answer is indicated in bold

while that figure was 80.1% for B school. The proportion of correct responses for middle school students in an earlier survey was 65.8% [9], higher than in A school. However, all the subjects of the earlier survey were third year middle school students, and it cannot be said that the correct answer rate is remarkably low, considering that more than half the participants in our survey were middle school first and second year students. The correct answer rate for B school was much greater than that of the earlier survey for third graders only.

The answer to the question in Table 4 is also an application question using the concept of opportunity cost. We asked: "What is the opportunity cost of saving money?" The correct answer is "the products that could be purchased now." The percentage of correct responses for A school was 50.0%, while B school was 52.4%. Since the correct answer rate for this question in the earlier survey was 27.3%, both schools' percentages of correct responses were higher than those of the earlier survey [9].

3.3.3 Changes in Perceptions of the Economy Before and After the Lesson

Figure 2 shows changes in participants' perceptions of the economy before and after the lesson. We asked them to freely describe their views, classifying the text data into multiple categories using SPSS Text Analytics for Surveys. In both schools,

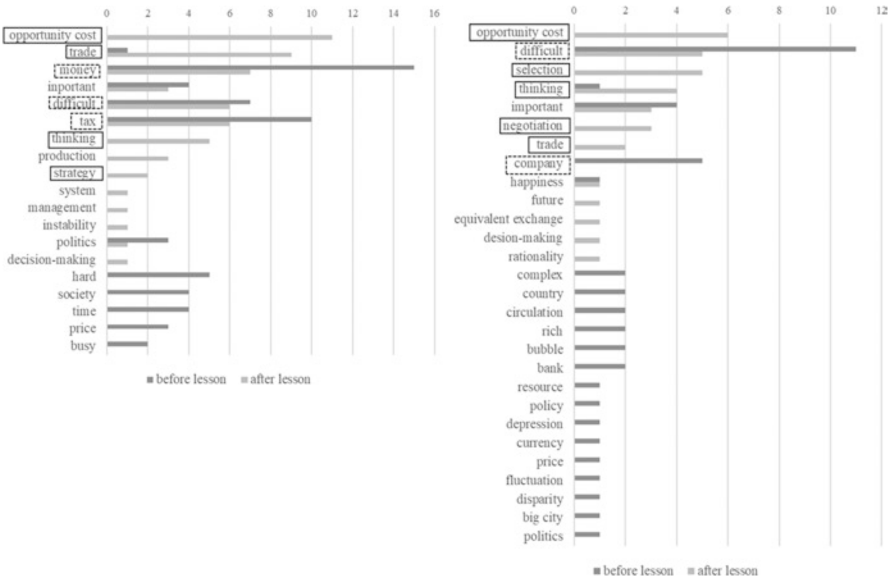

Fig. 2 Changes in participants' perception of the economy before and after the lesson. Left, A school; right, B school

categories such as "money" and "difficult" were dominant in thoughts on the economy before the lesson (Fig. 2, dashed line boxes), but the category of "opportunity cost" that we dealt with in the debriefing prevailed the most after the lesson (Fig. 2, solid line box). In both schools, categories related to the social system such as "tax" and "company" appeared before the lesson (Fig. 2, dashed line boxes). However, after the lesson, categories of actions and thinking levels not described before the lesson such as "trading," "thinking," "strategy," "negotiation," and "selection" appeared (Fig. 2, solid line boxes).

3.3.4 Participants' Actions and Strategies in the Game

We considered the relationship between participants' actions and strategies in the game based on the "strategy sheet" and "trade record" described by the teams at the end of each phase. Comparing both schools, at A school, the average amount of production was 7.1, while that of trade was 7.6 at A school, and at B school, the average amount of production was 6.5, while that of trade was 8.5. In both schools, the quantity of trade was slightly higher than the amount of production, on average. Trade was most frequent in the second phase, followed by trade in the order of the first and third phases.

By analyzing the "strategy sheet" regarding a team's reasons for taking such actions, each team could recognize that others that could trade in the second phase possessed blocks for making high-value smartphones. Through such recognition, each team chose to actively trade. Essentially, participants could see that the profit obtained from trade was greater than the profit obtained from production due to changes in the trading environment.

From the analysis of B school's strategy sheet, in the first phase, most teams only traded for their own benefit. Yet in the second phase, they could trade with the recognition that all teams that traded would benefit each other. In fact, in the second phase, the total score of all the teams increased. Based on this outcome, participants chose to trade after understanding that doing so not only benefited them but others as well.

One team made smartphones using the same color in order to reduce the scores of other teams while observing the color combinations of the smartphones other teams produced. Another team collected a large number of specific colored blocks through trade so as not to duplicate the color of the smartphone. Both strategies are techniques for outmaneuvering other teams by taking advantage of the rules introduced during the third phase.

However, in the third phase, in order to avoid losses due to overlapping colors, the number of groups making smartphones worth three points (by producing the color of the block representing their teams) increased. Through these strategies, in the third phase, some teams increased their scores, and others reduced their scores. Even at both middle schools, we did not observe behaviors coordinated with other teams to avoid losses; thus, the final score for all teams as an average was significantly lower than in the second phase.

4 Conclusions

The participants recognized the importance of opportunity cost, which is a fundamental concept of economics. They did so by reflecting on the implications of their actions according to environmental changes; they described their trade records, their strategies, and experienced debriefing during the game. More than half of the students selected the correct answer for applied questions using the opportunity cost concept. However, approximately three-fourths of the students could not derive the definition of opportunity cost themselves since the number of action choices in the game was limited to two.

Conversely, using a questionnaire survey on a free description form, students could make decisions after comparing profits and losses resulting from the consequences of their choices; we found that they could rationally state the reasons for their decisions. Perhaps in this game, participants understood some aspects of rational decision-making, but we think that factors that affect decision-making in the three phases are isolated from each other and that some participants had "partial understanding of the economic system" that is not completely integrated [10]. In order to integrate various factors, it is necessary to advance the students' cognitive framework. Encountering an imbalance that causes perturbation of the cognitive framework is important for cognitive development. Regarding this point, initially, the students perceived the economy as a social system unrelated to them. However, by producing and trading blocks in the game, they realized that the economy is an important activity related to their decisions. They internalized the economic system through this game. We were able to provide the first step to help them acquire economic thinking.

Future work includes developing lessons that focus on opportunity cost and reflections during the debriefing. In the third phase, we assumed that a Pareto improvement would improve resource allocation without lowering any team's score. In this game, since the three-phase situation became complicated, we could not contend with Pareto improvements adequately. It will be necessary to reconsider the contents of the strategy confirmation sheet and debriefing at that point in time.

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References

1. Inose T (2016) Economic viewpoint and thinking (in Japanese). In: Japanese Association for the Social Studies (ed) Social studies dictionary. Gyosei, Tokyo, pp 184–185
2. Ministry of Education, Culture, Sports, Science and Technology (2008) Course of study for junior high schools (in Japanese). http://www.mext.go.jp/a_menu/shotou/new-cs/youryou/chu/sya.htm. Accessed 28 Nov 2018
3. Kanou M (2012) Economic education in faculty of education (in Japanese). In: Iwata T, Mizuno H (eds) Problems and prospects of economic education in teacher training. Sankeisya, Nagoya, pp 37–51
4. Gremmen H, Potters J (1997) Assessing the efficacy of gaming in economic education. J Econ Educ 28(4):291–303
5. Stiglitz JE, Walsh CE (2002) Economics, 3rd edn. Norton, New York
6. Ferraro PJ, Taylor LO (2005) Do economists recognize an opportunity cost when they see one? A dismal performance from the dismal science. Contrib Econ Anal Policy 4(1):1–14
7. Fukuda M (2014) Development and practice of simulation-game for inquiring multiple society (in Japanese). Report of the grant-in-aid for scientific research (no. 23531260) by MEXT. https://kaken.nii.ac.jp/ja/file/KAKENHI-PROJECT-23531260/23531260seika.pdf
8. Walstad WB, Rebeck K (2005) Financial fitness for life: middle school test examiner's manual (grades 6–8). Council for Economic Education, New York
9. Yamaoka M (2008) Japan-U.S. comparison of personal financial literacy: a preliminary analysis of results of FFFL theme tests for middle school (in Japanese). J Asia-Pacific Stud 10:59–83
10. Furth HG (1980) The world of grown-ups: children's conceptions of society. Elsevier, North Holland/New York

Simulation Games to Foster Innovation: Insights from the Transport and Logistics Sector

Anastasia Roukouni, Heide Lukosch, and Alexander Verbraeck

Abstract There is an indisputable gap between the conceptualization and introduction of innovation and the actual and effective implementation of innovations in the complex sociotechnical system of transport and logistics throughout Europe. With our research we investigate the role of simulation games as an instrument to understand the dynamics around innovation processes in this system, by the means of literature review and in-depth interviews with key stakeholders of selected innovation cases within the Port of Rotterdam. The aim of our study is to gather valuable insights into how simulation games can be used to handle the extremely critical issue of effectively implementing innovation in the transport and logistics sector. It is thus expected to stimulate and enhance interaction among actors on policy level, by highlighting the potential advantages of using the approach of simulation games when the implementation of innovation is in discuss.

Keywords Innovation · Innovation ecosystem · Simulation games · Transport and logistics · Port of Rotterdam · Actors

1 Introduction

There is an indisputable gap between the conceptualization and introduction of innovation and the actual and effective implementation of innovations in the transport and logistics sector throughout Europe [1, 2]. The ecosystem of transport and logistics is one with a large number of interconnected actors, being highly dynamic, which makes it a so-called complex sociotechnical system [3]. Key questions related to innovations in this domain are why so much time is needed to move from theory to practice and why, as a result, many innovations in the sector remain in a pilot phase. Moreover, there is a growing need to better understand the roles several

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ecosystem actors play in the innovation process [4–6]. Our research focuses on the Port of Rotterdam, which is a very representative example of the aforementioned situation, as several innovations are created there every year, but very few are successfully implemented and actually used in the sector; only recently this situation has started to change [7, 8].

The main objective of the present paper is to investigate the role of simulation games as an instrument to understand the dynamics around innovation processes in the complex system of transport and logistics. We examine several aspects of simulation games, e.g. their potential to reveal interactions and tensions between multiple actors involved (with very diverse backgrounds, different and often conflicting perspectives, goals and aspirations) and to contribute to the interpretation of their behaviour and of the negotiations taking place among them. In order to achieve the research's objectives, a comprehensive literature review is performed, in combination with the conduction of in-depth interviews with some key actors who are actively involved in projects related to innovation.

2 Towards an Innovation Ecosystem Approach in Transport and Logistics

There are numerous different definitions of the concept of innovation, across different scientific fields and among researchers even within the same field. The Oslo Manual, which provides guidelines for collecting and interpreting innovation data [9], distinguishes two forms of innovation: technological product innovation and technological process innovation. In the research presented herein, we approach both these aspects of innovation, considering it as a continuous and evolving procedure in a complex system in which many actors are actively involved and can influence this procedure.

The decision-making process related to transportation and logistics issues – and particularly innovation issues – is intrinsically complex due to the fact that, in addition to the large number of factors involved, there are usually many alternative scenarios to be examined. Moreover, a large number of actors are involved in the decision-making process; these actors usually come from different backgrounds and have different objectives, interests and aspirations [10].

In [1], two key factors that determine whether an innovation will be successfully implemented or not in the freight transport and logistics sector are identified: firstly, the perceived characteristics of it and secondly, the innovation system itself. The former refers to the quality and complexity of the innovation, while the latter refers to the process and social context, such as the composition and diversity of actors involved, the role of the government or the degree of market competition.

Before actors decide whether or not to engage in the adoption of an innovation, they tend to evaluate reasons for and against such decision. In addition to that, they are more likely to assume that the potential costs of adopting the innovation would be way higher than its associated potential benefits [11]. The human resistance to innovation can be met in three forms: direct rejection, postponement or opposition. The factors that may influence this resistance can be divided in four groups: perception of innovation characteristics, consumer characteristics, characteristics of the propagation mechanisms and influence of opinion leaders [12]. According to [13], in the transport industry, early adopters of an innovation can be considered as drivers of the innovation, which is capable of decreasing the risk of human resistance. The authors use the case of the introduction of e-cargo bikes in the city of Herne, Germany, as an example. A pilot study was conducted by [14], addressed to transportation professionals; it showed that among the most significant innovation barriers are resistance to change and lack of political will.

The concept of "ecosystem" has recently evolved as a new way to approach and promote innovation. An ecosystem is a system in which continuous and dynamic interactions among different actors occur and therefore innovations are not realized as a result of individual efforts or through a chain evolving process; they are seen as the result of multifaceted communication and synergies among various stakeholders [15]. Urban technology innovation ecosystems are described in [16] as a number of stakeholders, assets and the interaction among them in city environments, resulting in new technology and ideas. Moreover, an innovation ecosystem stimulates synergies among people and firms in a given geographical space, enhancing this way the development of new ideas and the commercialization of them [17] as well as creating and capturing value [18].

3 Simulation Games: Role and Potential in Fostering Innovation

Simulation games are increasingly gaining momentum as a way to support learning processes while at the same time creating a deeply engaging environment for collaboration among different stakeholders [19]. The application of gamified tools has the potential to improve the quality of the ideas developed to address innovation challenges. In addition to that, it can contribute to enhancing the innovation and entrepreneurship skills of the game participants [20]. According to [21], simulation games can be used as a promising tool to raise awareness regarding shared resources in the field of supply chain management. Moreover, they are considered very efficient in providing useful insights into the impact of collaborative applications, which make use of ICT or ITS technology in the freight and logistics sector [22]. Simulation games can be also used as boundary objects (intermediaries) in order to help in the adaptation to future situations that are associated with a high level of uncertainty, as in the case of climate change, for instance [23].

Simulation gaming can be thus considered as a robust approach in the direction of comprehending large-scale systems with a high degree of integration and with numerous actors dealing with significant uncertainties [24], by examining these systems through different perspectives [25].

4 Analysis of Selected Innovation Case Studies Within the Port of Rotterdam

4.1 Case Descriptions

Ports, as being part of the complex system of transportation, usually operate in uncertain logistics environments [26]. The Port of Rotterdam (from now on PoR in this paper) is the largest seaport in Europe and one of the largest in the world, having a huge scale of container transshipment and state-of-the-art container terminals. As already mentioned earlier in this paper, innovation in the PoR has been rather limited so far, although this situation has started to change during the last years, with some innovative initiatives.

Among these initiatives, three promising innovation case studies related to the PoR were selected; all of them are currently in the forefront of the dynamic innovation ecosystem of the port. These case studies are called PortXL, Truck Platooning and the Navigate digital tool. A short description of each one of them is as follows:

PortXL It represents a so-called World Port Accelerator. It partners with leading companies, organizations and individuals around the world. Its aim is to accelerate innovative companies and start-ups in ports worldwide, in a short time frame with an intense mentorship-driven programme. Its ecosystem consists of founders, investors and corporate partners.

Truck Platooning This initiative explores the concept of trucks driving automatically in small convoys, a short distance apart, resulting in a smoother traffic flow, higher traffic safety, fuel savings and a reduction in CO_2 emissions.

Navigate This digital tool provides a complete overview of the most efficient routes via the PoR. It includes among others, information about transit times and logistics companies that can be used for potential partnerships and an empty depot planner for the reposition of empty containers. Navigate makes use of different types of data (deep sea, short sea, rail or barge), with only direct solutions available in the system at the moment, but plans to extend the services. Launched in May 2017 as a beta version, it incorporates willingness to co-create most of it together with different target groups, supporting transparency of data and asking for feedback to improve the tool.

4.2 Case Analysis: Interviews' Results

In-depth interviews were conducted with three key representatives for each one of the aforementioned cases (all having manager-related positions), in order to obtain a better understanding of their goals, inspirations and ideas for future development and also to reveal their perspectives towards the potential of using simulation games. Two experienced researchers conducted the interviews in a semi-structured manner. The interviews were audio-taped and analysed afterwards. The most important take-aways of these interviews in relation to innovation in transport and logistics and simulation games are summarized below.

The *PortXL* project, according to the first interviewee, focuses on practical and efficient ideas, not necessarily highly disruptive or very new ones. An idea that has been successfully used in another sector for many years, but has never been tested in transport and logistics so far, can be as well considered an innovation for them. It is noteworthy that it would be really interesting for them if a game was played by start-ups and potential clients, contributing this way in enhancing mutual understanding and eventually leading to a deal/contact among the different parties involved. PortXL envisions a simulation game to be useful and interesting if people from different functions were brought on the table; not only innovation managers but also, e.g. financial managers, procurement managers, etc. A really important factor for PortXL, when it comes to the successful implementation of an innovation, is the synthesis of the (start-up) team. A great idea that is supported by a "problematic" group of people (who cannot really cooperate smoothly nor work effectively together) will not go far, according to their opinion. On the contrary, they have seen innovations which started based on not what first seemed to be a not-too-bright idea but which were supported by very smart people who succeeded in working efficiently together; these innovations finally evolved much more successfully than the former ones, and they survived competition. Therefore, if we take into account what [20] states, the use of a simulation game can play a positive role also in improving the aforementioned situation, by strengthening the innovation and entrepreneurship skills of the game participants and hence hopefully reduce conflict among them and stimulate more efficient collaboration. In PortXL, they expect that a game could support the collaboration process between different actors in the innovation ecosystem, which is one of the expected outcomes of such a game also based on the literature (e.g. see [19]).

Although the technology regarding the *Truck Platooning* concept has been evolving a lot during the last years, there is still way to go according to the representative of the next case. Certain technological barriers exist, in addition to a conservative attitude of some people within the different companies involved in the logistics field. In this case, emphasis is put on the fact that the decision-making regarding this case is a very complex process and there are a lot of stakeholders that have to come together in order for the final decisions to be taken. In the PoR, they are willing to stimulate and accelerate the Truck Platooning innovation, create a favourable environment, help to "make it happen" (as the slogan of the PoR states), but they believe that other parties should also support the innovation processes. It is often observed that other parties would like to use the new environment-friendly technology, but at no additional cost. This observation is in line with the "human resistance to innovation" concept derived from the literature and analysed in Sect. 2 of the present paper (e.g. see [12, 14] etc.). Some of the actors involved in the Truck Platooning case tend to believe that the costs associated with introducing this innovation could outperform the associated benefits, as also suggested by [11]. PoR would like to be the frontrunner in Truck Platooning, because in case they do not, they are afraid that competitive ports might start first and attract more shippers. A game in this case could help to explore measurements towards the introduction of this technology.

The aim of the case project *Navigate*, as stated during the interview, is to create a widely used platform for more efficient and sustainable transport. Three mega trends are identified: digitisation, disintermediation and disruption. Large companies/shippers want to be able to show their clients that they have chosen the most sustainable route; therefore, in Navigate they believe that a game around this objective has the potential to be really useful. They would be interested in a game that aims at developing awareness to different parties involved in the transportation chain regarding the CO_2 emissions of each one of the potential transport options available. As mentioned earlier in Sect. 2, simulation games can be very suitable for investigating collaborative applications, which make use of ICT or ITS technology in the freight and logistics sector [22], which is exactly the case of the Navigate platform.

The three cases presented are good examples of what has been identified in the literature as the "innovation ecosystem" concept (see Refs. [15–18]) because continuous and dynamic interactions among different actors take place in all of them and innovation is the outcome of a collective rather than an individual process. Moreover, all of them have the ambition to be early adopters of innovation. The Truck Platooning representative, for instance, has said unequivocally that they would like to be the frontrunners and not let competitive ports be one step ahead of them; this outcome is in line with [13], in which it is claimed that, in the transport industry, the first to use and implement an innovation tends to be considered as the "driver" of that innovation.

5 Simulation Game Development

As this paper is part of an ongoing research, the selected innovation cases will be used by means of organizing tailored workshops to collect data and observations, with the intention to develop a realistic, meaningful and engaging board game, to provide valuable insights into the extremely critical issue of effectively implementing innovation in the sector and also to stimulate and enhance interaction between actors on policy level in the PoR ecosystem and beyond. The game should be easily adaptable to serve the needs of different cases related to innovation.

Taking into account the fact that the case studies do not have exactly the same characteristics and degree of maturity, we will try to develop a flexible game in order to allow us drawing general conclusions, and then, based on their specific needs, to offer a tailored version of the game for each one of the examined cases. The game will ideally being able to be played by all categories of stakeholders related to the PoR. External factors such as costs, politics, policies, technology, barriers that hinder the innovation adoption, etc. will be also included in the game in a controlled way.

We aim at creating a game that could act as a trigger to make the multiple actors involved aware of the existing challenges, as well as of the critical role that they can play in the innovation process. Based on the innovation ecosystem concept, the game will focus on the dilemma between competition and consensus of actors, in the search of finding a balanced trade-off that could lead to an optimum result, regarding factors such as the implementation time and the quality of innovation.

In order to fulfil the aforementioned game requirements, the Triadic Game Design (TGD) philosophy [27] was selected to be used for the game development. The TGD philosophy states that there are three game components, which are considered to be of equal importance: reality, meaning and play. The first component, reality, refers to the representation of the actual system and the existing relationships and tensions among the actors involved. It also includes the validity check of the game. The meaning component refers to ensuring that the game will serve its goal and support knowledge transfer. The last one, play, incorporates elements such as fantasy and fun, as well as the rules of the game [28].

6 Conclusions – Perspectives

To the best of our knowledge, no simulation games have been developed yet attempting to address the challenging topic of examining the reasons behind the problems identified in innovation adoption and diffusion in the transport and logistics sector, under an ecosystem perspective. The research presented herein provides valuable insights into how simulation games can be used to handle the extremely critical issue of effectively implementing innovation in the sector. It is thus expected to stimulate and enhance interaction between actors on policy level, by highlighting the potential advantages of using the gaming approach when the effective implementation of innovation is in discuss. Ideas for future research include testing the game in different environments, in addition to the three selected cases, and with a variety of actors, in order to validate its usefulness and practicality and enhance its general character. Moreover, the information collected by the conducted interviews could be analysed further using more sophisticated qualitative analysis techniques, such as content analysis. Another idea we are currently working on is to develop an educational version of the game, which can be very useful as a strategy to enhance active learning in university departments which focus on transport and logistics and/or innovation studies.

The use of all these different versions of our simulation game is expected to not only contribute to the improvement of understanding of the complex trade-offs that take place within an innovation ecosystem; it is also expected to offer the possibility of creating awareness among the actors who have crucial roles in the long-term success of innovations in the transport and logistics sector.

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References

1. Van Binsbergen A, Konings R, Tavasszy LA, Van Duin JHR (2014) Innovations in intermodal freight transport: lessons from Europe. Paper presented at the 93th annual meeting of the Transportation Research Board, Washington, DC, USA, 12–16 January 2014
2. Ciprés D, Polo L, Capella A (2016) Innovation in transport logistics-best practices from the EU project LOGINN. In: Kotzab H, Pannek J, Thoben KD (eds) Dynamics in logistics, Lecture Notes in Logistics. Springer, Cham
3. De Bruijn H, Herder PM (2009) System and actor perspectives on sociotechnical systems. IEEE Trans Syst Man Cybern A Syst Hum 39(5):981–992
4. Tushman ML (1977) Special boundary roles in the innovation process. Adm Sci Q 22(4):587–605
5. Bessant J, Ramanlingham, B, Rush H, Marshall N, Hoffman K, Gray B (2014) Innovation management, innovation ecosystems and humanitarian innovation: literature review for the humanitarian innovation ecosystem research project, CENTRIM, University of Brighton, Brighton, UK
6. Warnke P, Koschatzky K, Dönitz E, Zenker A, Stahlecker T, Som O, Cuhls K, Güth S (2016) Opening up the innovation system framework towards new actors and institutions. Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis (49) Karlsruhe
7. Nijdam M (2010) Leader firms, the value of companies for the competitiveness of the Rotterdam seaport cluster. PhD thesis, Erasmus Research Institute of Management, Erasmus University Rotterdam, Rotterdam, The Netherlands
8. Witte P, Slack B, Keesman M, Jugie J-H, Wiegmans B (2018) Facilitating start-ups in port-city innovation ecosystems: a case study of Montreal and Rotterdam. J Transp Geogr 71:224–234
9. OECD (2005) Oslo manual: guidelines for collecting and interpreting innovation data, 3rd edn. OECD, Paris
10. Macharis C, Bernardini A (2015) Reviewing the use of multi-criteria analysis for the evaluation of transport projects: time for a multi-actor approach. Transp Policy 37:177–186
11. Claudy MC, Garcia R, O'Driscoll A (2015) Consumer resistance to innovation – a behavioral reasoning perspective. J Acad Mark Sci 43(4):528–544
12. Cornescu V, Adam CR (2013) The consumer resistance behavior towards innovation. Procedia Econ Financ 6:457–465
13. Heinrich L, Schulz WH, Geis I (2016) The impact of product failure on innovation diffusion: the example of the cargo bike as alternative vehicle for urban transport. Transp Res Procedia 19:269–271
14. Orcutt, L, Alkadri MY (2009) Barriers and enablers of innovation: a pilot survey of transportation professionals. TRB Manuscript, Compendium of Papers

15. Kono T, Kagami K (2015) An institutional approach to the creation of innovation ecosystems and the role of law. Penn State J Law Int Aff 4(1):166–185
16. Mulas V, Minges M, Applebaum H (2016) Boosting tech innovation. Ecosystems in cities: a framework for growth and sustainability of urban tech innovation ecosystems. Innov Technol Gov Glob 11(1/2):98–125
17. Katz B, Wagner J (2015) The rise of innovation districts: a new geography of innovation in America. Report, Metropolitan Policy Program, Brookings Institute
18. Dattee B, Alexy O, Autio E (2017) Maneuvering in poor visibility: how firms play the ecosystem game when uncertainty is high. Acad Manag J 61(2):1–67
19. Agogué M, Levillain K, Hooge S (2015) Gamification of creativity: exploring the usefulness of serious games for ideation. Creat Innov Manag 24(3):415–429
20. Patricio R (2017) A gamified approach for engaging teams in corporate innovation and entrepreneurship. World J Sci Technol Sustain Dev 14(2/3):254–262
21. Baalsrud HJ, Kalverkamp M, Forcolin M, Westerheim H, Franke M, Thoben MF (2014) Collaborative serious games for awareness on shared resources in supply chain management. In: IFIP international conference on advances in production management systems (APMS), Ajaccio, France, IFIP advances in information and communication technology, AICT-439 (Part II). Springer, Berlin, pp 491–499
22. Oonk M (2016) Smart logistics corridors and the benefits of intelligent transportation systems. In: Blanquart C, Clausen U, Jacob B (eds) Towards innovative freight and logistics, Science, Society and New Technologies Series, Research for Innovative Transports Set. Wiley, Hoboken
23. Van Pelt SC, Haasnoot M, Arts B, Ludwig F, Swart R, Biesbroek R (2015) Communicating climate (change) uncertainties: simulation games as boundary objects. Environ Sci Policy 45:41–52
24. Lukosch H, Kurapati S, Groen D, Verbraeck A (2016) Microgames for situated learning: a case study in interdependent planning. Simul Gaming 47(3):346–367
25. Bekebrede G, Lo J, Lukosch H (2015) Understanding complex systems through mental models and shared experiences: a case study. Simul Gaming 46(5):536–562
26. Ha M-H, Yang Z, Notteboom T, Ng AKY, Heo M-W (2017) Revisiting port performance measurement: a hybrid multistakeholder framework for the modelling of port performance indicators. Transp Res E 103:1–16
27. Harteveld C (2011) Triadic game design: balancing reality, meaning and play, 1st edn. Springer, London
28. Lukosch HK, Bekebrede G, Kurapati S, Lukosch SG (2018) A scientific foundation of simulation games for the analysis and design of complex systems. Simul Gaming 49(3):279–314

Disrupting Traditional Business Studies Testing by Internet-Based Simulation Game

Krit Pattamaroj and Nopadol Rompho

Abstract Simulation has become a very popular teaching tool in business studies. However, there are few previous studies that have investigated its uses as a testing tool in the area. This study aims to investigate its validity as a testing tool and the possible biases that can occur. Data was obtained from 259 MBA students from Thammasat Business School. The results showed that there is a positive correlation between simulation game scores and students' GPA, their grades in each subject, and students' perception of their abilities. Therefore, its validity is arguably confirmed. Further investigation revealed that there is no statistical differences between the simulation game scores among different organizations where students work, different sectors of their organization, or the different positions in an organization. Nevertheless, some differences in simulation game scores were found among the different areas of specialization and the ages of students.

Keywords Business management · Simulation game · Managers

1 Introduction

As the general business setting becomes more complicated, organizations are continuously searching for competent managers. One of the sources of these employees is business school. MBA graduates are one type of candidate that many organizations are looking for, believing that MBA graduates can contribute to the successful management of their organization. As a result, many business schools are focusing on how to produce such graduates. Before graduation, each MBA candidate needs to pass a comprehensive exam. The purpose of this process is to guarantee that MBA graduates are equipped with functional knowledge of areas such as marketing, finance, and operations but also to ensure that these graduates can apply this

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knowledge in the real business world. Usually, a traditional, paper-based, comprehensive exam is provided. However, this type of exam is limited in its ability to test students' integration of business knowledge, since it is both difficult and time-consuming to integrate questions concerning all knowledge into one single test. The quality of the examiner who prepared such an exam also has an influence, since it is difficult to find someone who is knowledgeable in all the required areas and who can develop an appropriate comprehensive exam.

Business simulation games are currently being used in many business schools. Numerous previous studies have argued that simulation games could enhance the learning process and provide students with practical business experiences. However, the literature still lacks studies that determine whether these simulations are a valid tool to test students and whether the attributes of students affect the results of the simulation game. For example, this game may be biased toward students who work in a particular industry, are of a certain age, work in a specific type of organization, have a certain work position, or have a certain specialization. Therefore, this study aims to investigate these effects and propose an appropriate model of the simulation game that can be used to comprehensively test the knowledge of business students.

2 Literature Reviews

The business simulation game is widely used in many disciplines [1–3]. These games can enhance students' experiences and simulate real-time interaction. It also enables competition among students, which eventually reflects in their performance. Many existing studies support the application of a simulation game in class [1, 4]. This indicates that simulation games contribute to the learning environment, enhance students' satisfaction, and are more effective than traditional teaching methods [5, 6]. Simulation games have been found to enhance the imagination of students and are entertaining, interactive, rule-based, goal-focused, and competitive [7–10].

The applications of the simulation game were found to be superior to that of traditional learning [5]. It has been used for both undergraduate and graduate students, but more benefits were found when used for graduate students [11]. For a simulation game to be effective, Hyman [12] purposed that the game should do the following: use real-life situations, be easy to understand and relevant, involve every student, be able to include approximately five to eight students in one group, create specific roles, enable students to revise to meet the objectives of the game, incorporate role-play, enable students to move from one area to another, and have a scoring system to determine a winner. The simulation games were found to be highly motivating, encouraging students to put more effort into learning with enjoyment. Students are then more likely to apply the material outside the simulation game [13]. This finding is consistent with the cognitive-oriented learning theories purposed by Bruner [14] and Piaget [15].

Garris [16] used an input-process-output model to explain the nature of a simulation game. Instructions and game characteristics can be treated as an input, while the game cycle is the process that leads to learning outcomes. Game cycles are the source of students' motivation, as they provide enjoyment, task involvement, and self-efficacy. They also encourage students to invest more effort into the task and make decisions to continue playing the game. Finally, the game itself provides feedback in terms of students' performance. These phenomena can create a flow state where students pay attention to the game and to nothing else [17].

To learn effectively, students need both affective and cognitive structures [18]. Affective structures include motivation and attitude, while cognitive structure includes memory, knowledge, and executive control. According to this theory, simulation games are more effective than traditional teaching methods, because it involves both structures [6]. Simulation games are not only entertaining but also promote active learning. This type of learning helps students make decisions and explore tasks to achieve performance [19, 20].

However, there were some studies that presented arguments regarding the effectiveness of simulation games [5, 9, 10, 21, 22]. These arguments include pointing out the fact that there are no clear guidelines describing how simulation games can enhance students' learning [16, 18, 23, 24]. According to these works, it might not even recreate work-related experiences [25–27].

Although there are many studies that investigated the effectiveness of using simulation games as a teaching method, few studies—if any—explore the effectiveness of using simulation games as a testing method. This study explores the ability of a business management simulation game to evaluate students' performance in a multidimensional environment. The validity of the game is tested according to the hypothesis that simulation game results have a positive relationship with students' grade. Additionally, the attributes of candidates will also be tested in relation to the simulation game performance to explore whether the simulation game is biased toward a certain type of candidate. No significant differences are expected in the game scores among the different types of candidates.

3 Methodology

This study adopts a quantitative approach. Two hundred and fifty-nine MBA students from Thammasat Business School were selected as sample for this study. These students were about to take the comprehensive exam to receive their MBA degrees. Questionnaires were used to collect data concerning students' attributes—including the industry in which they work, age, type of organization, work position, area of specialization, the students' perception on their performance, GPA, and their grades for each subject that they studied in the MBA program.

The simulation game for this study that was used as the comprehensive exam was developed by CAPSIM Inc., the leading business simulation game provider. The game is called the Comp-XM™ examination and is an online simulation game used specifically to test the users' knowledge. In this game, each candidate will act as a CEO of one of the four competing companies: Andrew, Baldwin, Chester, and Digby. For the purposes of our study, the candidate's team is Andrew, and the rest are operated by the program. Each company sells sensors in four different markets—Thrift, Core, Elite, and Nano—and each market segment has different needs for the product. Candidates need to first perform R&D to develop product for their specific needs and then decide on marketing strategies to attract customers within each market, followed by producing the product and managing their finances.

The results of the simulation were judged by the Balanced Scorecard score, which include scores from four perspectives: financial, customer, internal process, and learning and growth. There are four rounds to compete. The overall Balanced Scorecard score consists of 500 points. Additionally, each candidate also needs to answer approximately five to eight questions during each round and at the end of the game (five sets of questions overall). This is called board quarries. These questions account for another 500 points. Thus, the overall score of the entire simulation is 1000 points.

At the end of the game, Comp-XM™ reported the candidates' overall scores along with in-depth analyses. This includes the score for each knowledge function, which includes accounting, finance, strategy, marketing, operations, and human resources. The game is self-paced. Students were required to complete the entire game within 7 h. The game was played in a computer lab at the Thammasat Business School, and students need to pass at the 50th percentile to successfully complete this comprehensive exam.

After the data from the game was obtained along with the data from the questionnaires, it was analyzed using a correlational analysis and ANOVA. The results are reported in the following section.

4 Results and Findings

Out of the 259 MBA students who participated in this study, most are employed by a private company (76.8%), in the service industry (44.4%), and at operational level (66.8%). Their main responsibilities are general management (21.6%) followed by marketing (19.7%). Their average age is 28.5 years with an average GPA of 3.54 and an average simulation game score of 746.2 out of 1000 points. Table 1 shows the sample characteristics.

Table 2 shows that the performance scores of the simulation game were highly correlated with the students' GPA, with a correlation coefficient of 0.60. This relationship also has a significance level of 0.05 with p-value of 0.00. This finding indicates that the simulation game used in this study is arguably valid, as it reflects the overall performance of students using their GPA as a measure. A similar positive

Table 1 Characteristics of samples in this study

Type of organization			
	Private companies	76.80%	
	Government/state enterprise	12.00%	
	Entrepreneur/freelance	4.20%	
	Others	6.90%	
Sector			
	Manufacturing	17.80%	
	Service	44.40%	
	Manufacturing and service	18.90%	
	Retail (no manufacturing)	6.20%	
	Others	12.70%	
Level in organization			
	Operational staff	66.80%	
	First-line manager	21.20%	
	Middle manager	4.60%	
	Senior manager	4.00%	
	Entrepreneur	1.20%	
	Others	5.80%	
Area of specialization			
	General management	21.60%	
	Marketing	19.70%	
	Accounting	4.20%	
	Finance	12.40%	
	Operations/logistics	8.50%	
	Human resources	4.20%	
	Information technology	6.20%	
	Engineering	11.20%	
	Health science	2.70%	
	Others	9.30%	
Average age		28.5	*Years*
Average GPA		3.54	
Average simulation game score		746.2	*Points*

correlation was found between the overall score and the students' perception of their overall abilities, with a correlation coefficient of 0.453 (p-value=0.0). This evidence confirms the validity of the use of simulation games as a comprehensive exam.

Further investigation also revealed that there was a positive relationship between the simulation game score in a particular area and the grade in that particular subject. This applies to every area: accounting, finance, strategic management, marketing, operations, and human resources. A positive relationship was also found between each area's simulation game score and the students' perception of their abilities in that particular area. This finding supports the above statement that this

Table 2 The relationship between the simulation game scores and students' grades obtained in MBA classes

Relationship between		Correlation coefficient	*p*-value
Overall score from game vs.	Overall GPA	0.602**	0.00
	Students' perception of overall ability	0.453**	0.00
Accounting score from game vs.	Grade in accounting course	0.471**	0.00
	Students' perception of accounting ability	N/A	N/A
Finance score from game vs.	Grade in finance course	0.406**	0.00
	Students' perception of finance ability	0.364**	0.00
Strategic management score from game vs.	Grade in strategic management course	0.171**	0.006
	Students' perception of strategic management ability	N/A	N/A
Marketing score from game vs.	Grade in marketing course	0.134*	0.031
	Students' perception of marketing ability	0.161**	0.009
Operations score from game vs.	Grade in operations management course	0.396**	0.00
	Students' perception of operations management ability	0.273**	0.00
Human resources score from game vs.	Grade in human resources management course	0.264**	0.00
	Students' perception of human resources management ability	N/A	N/A

**Significant at the 0.01 level; *significant at the 0.05 level

simulation is a valid and appropriate tool to test students' knowledge. Students who performed well in a particular area of the simulation game tended to receive a good grade and also personally believe that they are good in that area. It should be noted that there are no data available concerning students' perception of their own accounting, strategic management, and human resources management abilities. Therefore, the correlation coefficient cannot be calculated.

The ANOVA tests were performed to determine whether the simulation is biased toward any of the candidates. Table 3 shows that there were no statistically significant differences in the simulation scores of all areas for students who work in different types of organizations, different sectors within their organizations, or work at different levels of their organization. However, the ANOVA test on the area of specialization showed that there were statistically significant differences in the simulation scores of the overall score, strategic management, and the operations area. The main difference is due to the performance of the candidates who specialize in information technology. Their overall simulation game score is 68%, while the overall average score is 75%. Their strategic management score is 67% compared to the average strategic management score of 73%, and their operations management score is only 65% compared to the average overall operations management score of 76%. Apart from these differences, there is no evidence that students' specialization scores differ in any other areas.

Table 3 ANOVA test for differences of the mean simulation game score for different variables

Variables	Overall score	Accounting score	Finance score	Strategic management score	Marketing score	Operations management score	Human resources score
Type of organization	1.619 (0.185)	1.699 (0.168)	1.088 (0.355)	0.706 (0.549)	1.311 (0.271)	0.820 (0.484)	0.095 (0.963)
Sector	1.900 (0.111)	1.408 (0.232)	0.865 (0.485)	1.775 (0.134)	0.935 (0.444)	2.027 (0.091)	1.562 (0.185)
Level in organization	0.616 (0.688)	0.746 (0.589)	0.227 (0.950)	0.518 (0.762)	1.435 (0.212)	0.793 (0.556)	0.203 (0.961)
Area of specialization	2.048∗ (0.035)	1.648 (0.102)	1.792 (0.070)	1.974∗ (0.043)	1.750 (0.078)	2.581∗∗ (0.007)	1.194 (0.299)

Numbers in table are F scores; numbers in parentheses are *p*-values
∗∗Significant at the 0.01 level; ∗ significant at 0.05 level

Table 4 Correlation analysis between age and simulation game score

Variables	Overall score	Accounting score	Finance score	Strategic management score	Marketing score	Operations score	Human resources score
Age	−0.110 (0.082)	−0.137∗ (0.029)	−0.093 (0.141)	−0.066 (0.297)	−0.014 (0.820)	−0.147∗ (0.020)	−0.064 (0.311)

The numbers in the table are the correlation coefficients and the numbers in parentheses are the *p*-values
∗Significant at the 0.01 level; ∗significant at the 0.05 level

The results in Table 4 show that in terms of age, there is no statistically significant relationship between age and either the overall score or the score of each individual area, except for the subjects of accounting and operations management, which shows a negative relationship. Older students tend to perform poorly in the operations management and accounting areas compared to younger candidates.

5 Conclusions

Simulation games are used extensively as a study method in class and have been argued to be preferable to traditional teaching methods. However, there are few existing studies—if any—that examine its application as an examination method. Therefore, this study investigated its validity as an examination method as well as whether there could be bias toward a certain type of candidate. Based on the results, it was found that the simulation game is arguably a valid examination tool. There are strong positive correlations between the results that were obtained from the simulation game and students' GPAs, grades in each subject, and students' perception of their abilities, overall and in each individual subject. Concerning the test for possible bias, in most cases, there were no statistically significant differences in the simulation game score among different types of organizations where students work, the different sectors of their organization, or the different positions they are employed in. Nevertheless, it was found that there are the differences in the simulation game scores among different areas of specialization—especially between the overall score and the scores of strategic management and operations management. Lastly, there is no relationship between the ages of students and the simulation game scores, except for accounting and operations management, where younger students tend to perform better. Further investigation is obviously needed to confirm whether this effect will hold true for larger sample sizes.

According to the findings of this study, it can be concluded that simulation games are valid tools that can be used to test the business knowledge of MBA students. Although there are some questionable areas, they can definitely be investigated further. This study will hopefully be a starting point that leads to further studies in this area, causing simulation games to become powerful teaching and testing tools in business studies.

References

1. Anderson C (2008) Simulation game playing – a nursing instructional strategy. Clin Simul Nurs 4(1):7–15
2. Oţoiu C, Oţoiu G (2012) Testing a simulation game as a potential teaching method for a master's course in human resources management. Procedia Soc Behav Sci 33:845–849
3. Hauge J, Riedel J (2012) Evaluation of simulation games for teaching engineering and manufacturing. Procedia Comput Sci 15:210–220
4. Reise C, Müller B, Seliger G (2014) Resource efficiency learning game – electric scooter game. Procedia CIRP 15:355–360
5. Randel J, Morris B, Wetzel C, Whitehill B (1992) The effectiveness of games for educational purposes: a review of recent research. Simul Gaming 25:261–276
6. Sitzmann T (2011) A meta-analytic examination of the instructional effectiveness of computer-based simulation games. Pers Psychol 64:489–528
7. Driskell J, Dwyer D (1984) Microcomputer videogame based training. Educ Technol 24:11–17
8. Gredler M (1996) Educational games and simulations: a technology in search of a research paradigm. In: Jonassen DH (ed) Handbook of research for educational communications and technology. Macmillan, New York
9. Tobias S, Fletcher J (2007) What research has to say about designing computer games for learning. Educ Technol 47:20–29
10. Vogel J, Vogel D, Cannon-Bowers J, Bowers C, Muse K, Wright M (2006) Computer gaming and interactive simulations for learning: a meta-analysis. J Educ Comput Res 34:229–243
11. Romme AG, Micro worlds for management: education and learning. www.unice.fr/sg/resourcesindex/html. Last visited on 2018/01/05
12. Hyman R (1974) Ways of teaching. Lippincott, Philadelphia
13. Malone TW (1981) Toward a theory of intrinsically motivating instruction. Cogn Sci 4:333–369
14. Bruner J (1962) On knowing: essays for the left hand. Harvard University Press, Cambridge, MA
15. Piaget J (1951) Psychology of intelligence. Routledge and Kegan Paul, London
16. Garris R, Ahlers R, Driskell JE (2002) Games, motivation, and learning: a research and practice model. Simul Gaming 33:441–467
17. Csikszentmihalyi M (1990) Flow: the psychology of optimal experience. Harper & Row, New York

18. Tennyson RD, Jorczak RL (2008) A conceptual framework for the empirical study of instructional games. In: O'Neil HF, Perez RS (eds) Computer games and team and individual learning. Elsevier, Oxford, pp 39–54
19. Bell BS, Kanar AM, Kozlowski SWJ (2008) Current issues and future directions in simulation-based training in North America. Int J Hum Resour Manag 19:1416–1436
20. Frese M, Brodbeck FC, Heinbokel T, Mooser C, Schleiffenbaum E, Thiemann P (1991) Errors in training computer skills: on the positive function of errors. Hum Comput Interact 6:77–93
21. O'Neil HF, Wainess R, Baker EL (2005) Classification of learning outcomes: evidence from the computer games literature. Curric J 16:455–474
22. Prensky M (2001) Digital game-based learning. McGraw-Hill, New York
23. Bell BS, Kozlowski SWJ (2008) Active learning: effects of core training design elements on self-regulatory processes, learning, and adaptability. J Appl Psychol 93:296–316
24. Federation of American Scientists (2006) Summit on educational games: harnessing the power of video games for learning, Washington, DC
25. North MM, Sessum J, Zakalev A (2003) Immersive visualization tool for pedagogical practices of computer science concepts, a pilot study. JCSC 19:207–215
26. Shute VJ, Glaser R (1990) A large-scale evaluation of an intelligent discovery world: Smithtown. Interact Learn Environ 1:51–77
27. Taylor RS, Chi MTH (2006) Simulation versus text: acquisition of implicit and explicit information. J Educ Comput Res 35:289–313

Part III
S&G to Learn Environmental Issues

Methodology for Environmental Learning Based on Material Flow Diagram of Green Multidimensional Bookkeeping System

Keiko Zaima

Abstract The purpose of this study was to develop a methodology for environmental learning that enables qualitative understanding of environmental burdens. The tool in the methodology used the Material Flow Diagram of the Green Multidimensional Bookkeeping System (Green MDBS). Green MDBS is an environmental information system that enables bottom-up aggregation of environmental burden data in an individual process. In Green MDBS, all materials are regarded as "potential environmental burdens," meaning that input or output of any material can potentially affect the environment. To accurately reduce environmental burdens, it is important that the types of materials and services are understood prior to quantitative measurements and calculations. Thus, the first step of the Green MDBS is to identify all types of materials and services, related to a relevant process. It is suggested that this step could be used as a simulation tool for environmental learning when applied to previous studies. In this paper, methodology for environmental learning using the Material Flow Diagram is presented, and some results of implementing this methodology in university classrooms are presented. Challenges faced in the application of the methodology to active learning, concerning environmental burdens in daily and economic activities, are further discussed.

Keywords Material Flow Diagram · Environmental learning · Potential environmental burden · Environmental management · Green Multidimensional Bookkeeping System

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1 Introduction

The Earth is a closed system, except for energy, and the carrying capacity of the Earth is not infinite. Human society should consider resource constraint, and our current generation must assume the responsibility of passing on a sustainable Earth to future generations through adequate green management.

Environmental management can be adequately implemented, based on an assessment of related environmental burdens that may affect the environment. Although conventional methods, such as life-cycle assessment (LCA) of a product, are useful for estimation of environmental burdens and their impacts, their implementation can be difficult for the following reasons. First, these methods follow a top-down approach, which means that information regarding the entire process needs to be gathered, which might not always be possible. For instance, in case of supply chain analysis, it is difficult even for the core company to access companies farther away in the supply chain. Second, only some specific environmental burdens such as carbon dioxide and water are targeted in majority of the cases. Third, these methods are used only by a small number of companies that practice corporate environmental management.

Zaima [1] and Zaima, Deguchi, and Lee [2] have developed a methodology termed the Green Multidimensional Bookkeeping System (Green MDBS) that enables bottom-up aggregation of environmental burden data and its on-site implementation. The first stage of the Green MDBS is to identify all types of materials and services as "potential environmental burdens" related to a relevant process. Zaima, Lee, and Deguchi [3] suggested that the identification process in the first stage of the system could be used as a simulation method for environmental learning.

The purpose of this study was to develop a methodology for environmental learning that enables qualitative understanding based on the Material Flow Diagram of the Green MDBS. In this paper, some results of its implementation in university classrooms are presented, and challenges in applying the methodology to active learning concerning environmental burdens in daily and economic activities are discussed.

The remainder of this paper is organized as follows. Section 2 provides a definition of the term "potential environmental burden" and discusses the necessity of a new tool for qualitative understanding related to environmental management. Section 3 explains the objectives, targets, and outlines of the new methodology using the Material Flow Diagram based on the Green MDBS. Section 4 shows implementation results of environmental qualitative learning and discusses advantages and limitations of the new methodology. Some research challenges in its application to active environmental learning are discussed. Finally, conclusions are presented in Sect. 5.

2 Necessity of Qualitative Environmental Learning

2.1 Concept of Potential Environmental Burden

In general, the term "environmental burden" refers to an entity that would have a negative impact on the natural environment; it is defined as "invested natural resources and generated unnecessary materials such as pollutants and wastes" [4]. However, whether the generated material is necessary or not depends on social and scientific situations such as culture, technology, environmental policy, and development stage of the society. For example, in Japan, used polyethylene terephthalate (PET) beverage bottles are collected and recycled, since the environmental policy for the Sound Material-Cycle Society was enacted. However prior to the policy, they were incinerated as "general combustible waste."

There is no activity, product, or material that is not related to environmental burden. For example, washing clothes uses water resources, and dirty water is subsequently drained. Similarly, although rice is one of the staple foods, it cannot be used when toxic chemicals are detected in it or after its long-term storage.

In this research, a new concept of "potential environmental burden" is defined as "all materials relating to a certain process or an activity." It means that any material has the potential to impact the natural environment. A "material" is defined as "something that is invested or used, or something that is generated or emitted, during a process." In other words, materials are those that would affect the natural environment as environmental burdens related to a process. Materials, invested or used, include resources, energy, raw materials, machines, and equipment. Materials, generated or emitted, include products or services, by-products, pollutants, and wastes.

2.2 Necessity for a Tool for Qualitative Understanding

There are some environmental learning tools for understanding environmental burdens. The Environmental Shopping Game and Environmental Accounting Housekeeping Book (Kankyou Kakeibo) are representative tools.

The former, developed by Matsumura and Miyake [5], is a shopping card game. Participants of the game select cards of food shops, transportation, and foodstuffs. After shopping, participants study the emission of carbon dioxides calculated from the weight and transport distance of each food as "Food Mileages." Food Mileage was defined by Nakata [6], extending the concept of Food Miles. Although the original Food Miles mainly focused on domestic foods, Food Mileage includes transportation from abroad and enables comparison of carbon emission between nations.

The calculation of Food Mileage is related to the distance of places between shopping and production, that is, where the foodstuffs originate and where they are consumed. While the tool shows invisible environmental burdens of shopping, Green MDBS focuses on environmental burdens on-site, understands the data, and sends it from a process to the next process.

The latter was developed by Morioka and Sueishi [7], and the purpose was to provide a new comparison tool for a voluntary approach of environmental policies. The Environmental Accounting Housekeeping Book enables one to calculate environmental burdens concerning daily activities such as energy consumption and related carbon dioxide emissions, water resources consumption, and garbage disposal [8]. The Environmental Accounting Housekeeping Book has been arranged for students in various grades, as well as for households. Fukushima, Yamada, and Hirao [9] applied it to an environmental management system concerning daily activities. Although their system also involves the analysis of material flow, the Green MDBS consists of three components (explained in the next section), and it enables one to apply it as an on-site learning tool.

These tools focus on the volume of environmental burdens. A quantitative understanding of environmental burdens is important. However, before quantitative understanding, it is also necessary to understand that all activities can have a relationship with environmental burdens, though there are differences in degree. In addition, to accurately reduce environmental burdens, the types of materials and services must be grasped prior to quantitative measurement and calculation. However, environmental learning of potential environmental burdens has not been incorporated into both conventional evaluation methods such as LCA and existing environmental learning tools such as the Environmental Shopping Game with Food Mileage and the Environmental Accounting Housekeeping Book.

3 Objective and Outline of the New Methodology

3.1 Objective and Target

The objective of environmental learning in this research was to deepen the qualitative understanding of potential environmental burdens and to understand the economics of their management. However, as the first stage, this study suggests a methodology based on the Material Flow Diagram of the Green MDBS for environmentally qualitative learning and discusses further research challenges. The aim is to understand all types of materials relating to a focused process, understand their aspects as potential environmental burdens, and consider the significance of their management.

The targets of the environmental learning are both business personnel and students. Originally, the Green MDBS was suggested for corporate environmental management. However, it has become clear that the Green MDBS can be applied to any type of process or activity, including daily life. Therefore, all personnel who can understand the meaning of environmental burden can be targeted.

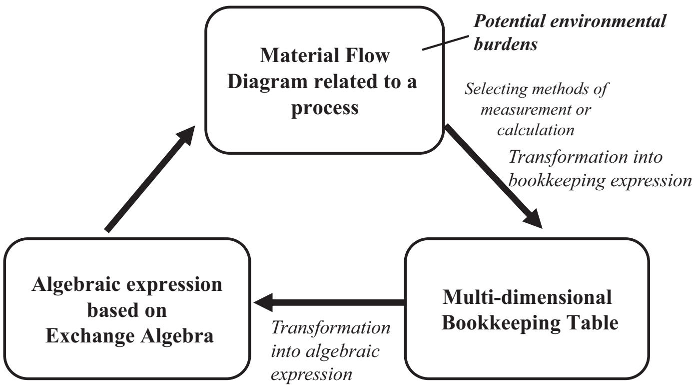

Fig. 1 Three components of the green MDBS

3.2 Outline of the Green MDBS

The Green MDBS consists of three components: a Material Flow Diagram related to a focused process, its Multidimensional Bookkeeping Table, and its algebraic expression by Exchange Algebra. Although the general bookkeeping describes all transaction events in terms of monetary value only, the Multidimensional Bookkeeping Table in the Green MDBS is described using both monetary and physical values. Thus, the units of the parameters vary. Multidimensional Bookkeeping System and Exchange Algebra, which are the basis for the Green MDBS, were developed by Deguchi [10].

Although three components can be transformed among one another, the Green MDBS uses a stepwise method as shown in Fig. 1.

The Green MDBS starts from the Material Flow Diagram to understand names and all types of materials and services as potential environmental burdens during the process. Here, a service means an activity that uses managerial resources during a process. Managerial resources include human resources, machines and equipment, information and knowledge, and capital and budgets. Methods for measurement and calculation and units of description depend on the type of environmental burden. Methods and units can be determined after the types of environmental burdens are understood. It is not until the types of environmental burdens are clarified that their numerical values can be described in the Multidimensional Bookkeeping Table and Exchange Algebraic representation. The Green MDBS can be applied to reconsider the process and product design.

3.3 Material Flow Diagram of the Green MDBS

As previously mentioned, a material is defined as something that is invested or used, or generated or emitted, during a process. In the Green MDBS, materials are basically classified into six categories. A process can be expressed as a flow of materials

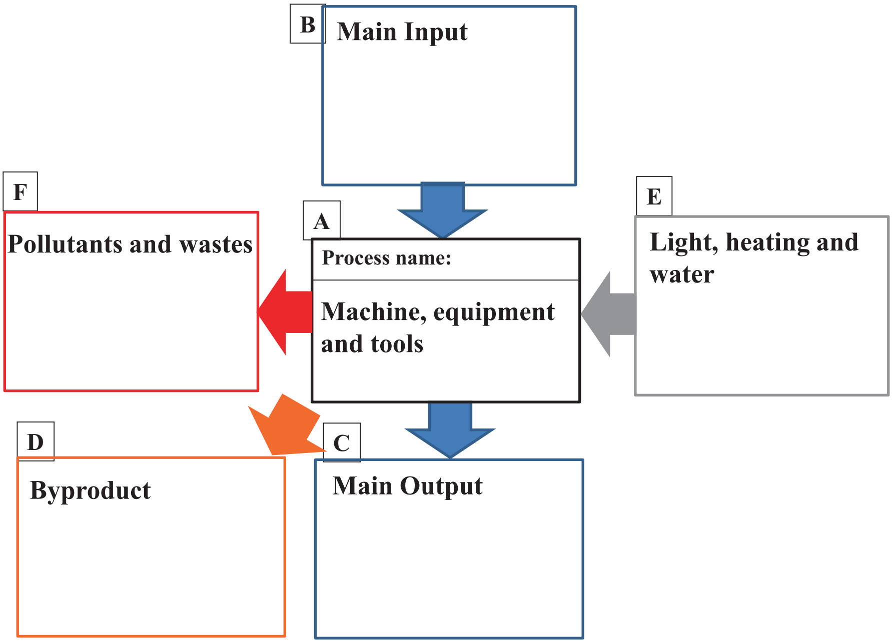

Fig. 2 Material Flow Diagram of the Green MDBS

within the six categories as shown in Fig. 2. The Material Flow Diagram of the Green MDBS is used for a qualitative understanding of potential environmental burdens.

The first category of materials is the "main output" which is the target of the process. It is indicated as box "C" in Fig. 2. This category includes products, parts, and works in progress (WIP). It includes both tangible and intangible materials.

The second category is the "machine, equipment, and tools" of managerial resources that are used during the process (box "A," Fig. 2).

The third category is the "main input" used for providing the main output (box "B," Fig. 2).

The fourth category is the "by-product" produced during the process (box "D," Fig. 2). Some by-products need post-processing such as purification and chemical treatment, and others can be directly used or sold as resources or products. This category includes both types.

The fifth category is the "light, heating, and water" related to using machines, equipment, and tools during the process (box "E," Fig. 2). This category includes electric power, fuels, and water utilities.

The sixth category is "wastes and pollutants." It is indicated as box "F" in Fig. 2. Some wastes and pollutants need purification, but some are emitted into the air or water without any treatment. This category includes both types.

3.4 Economic Aspects of Managing Potential Environmental Burdens

For each of the potential environmental burdens described in boxes A through F in Fig. 2, it is desirable to “be at an appropriate amount” or “to reduce,” but the content of each management and its economic meaning are different. Using the Material Flow Diagram, it is possible to understand meanings including the economic aspects of reducing and quantifying the potential environmental burdens described in each box.

As for the machine/equipment/tool in box A, maintenance of production facilities improves production efficiency, in the long term. In addition, although the renewal of old machines requires an initial investment, utility costs decrease after the payback period. For the main input in box B, a reduction of resources and materials to be invested would improve resource productivity and reduce the cost of purchasing resources and materials.

In box C (main output), it is desirable to have an appropriate volume of production, not only from the aspect of environmental impact but also economically. The reason for this is the increase in parts and products, with concomitant increase in their storage costs, leading to their increased non-utilization. In case of the output with an expiration date, an excess will result in disposal, and its environmental burden will increase since the cost for disposal will also be incorporated. In addition, even if the by-product (box D) can be used or sold, it is desirable to reduce the output volume or make the volume appropriate. Particularly, when additional processing such as purification is required, the environmental burden and cost for doing so will increase.

In terms of light, heating, and water described in box E, conservation will reduce the fee required for their use, improving productivity in terms of energy and water. As for wastes and pollutants that need processing, and materials emitted into the air or water, shown in box F, decreased emissions lead to a reduction in measures and processing costs.

3.5 Procedures of Environmental Learning

Learning via the Material Flow Diagram can be completed by groups or individuals. It can be implemented in a workshop style to share information and understanding when the number of participants is relatively small such as at a manufacturing site of a company or classes with a small number of students.

Learning is performed according to the following procedure from Steps 1 to 5.

Step 1. The facilitator explains the purpose of the implementation and shares it with the participants.
Step 2. Participants list their tasks at the site. For educational purposes, participants are asked to write about five activities related to their own part-time job or daily

life behavior. Each task or action is termed a "process," and participants are asked to select one of the processes to consider the material flow.

Step 3. The material flow of the process is created by the following procedure. First, one fills in the process name in box A and writes the names of machines/equipment/tools used during the process. Next, one places the main input and output of the process in boxes B and C, respectively. In addition, if there is a by-product, it is placed in box D. Lighting, water, and heat resources are placed in box E. Finally, wastes and pollutants, irrespective of whether they require treatment or not, are placed in box F.

Step 4. After the facilitator explains that all materials filled in the six boxes are regarded as potential environmental burdens, participants are asked to discuss their relative importance for the purpose of management or reduction at the site.

Step 5. Participants are asked to consider the economic aspects of the materials with respect to the management of their corresponding environmental burdens. Lastly, the facilitator explains the meanings of the management for the entities in all of the boxes, as described in the aforementioned section.

4 Results and Discussion

4.1 Material Flow Diagram Implementation in a Large Classroom

Learning using the Material Flow Diagram was conducted twice at Kyoto Sangyo University on November 9, 2015, and November 8, 2016, in a large classroom. The purpose was to understand input-process-output (IPO) analysis of material flow and the concept of potential environmental burdens. In these cases, although all (Steps 1–5) were implemented, during Steps 4 and 5, work by students was omitted because of time restriction. That is, the facilitator explained that all materials filled in the six boxes should be regarded as potential environmental burdens. Then, the facilitator explained the economic aspects of managing potential environmental burdens, as explained in Sect. 3.4.

The number of participants was 178 and 152, and the number of adequate descriptions was 171 and 145, respectively. The items written by students in the latter case are shown in Table 1. As for each written worksheet by the students, the process that was focused upon and the adequacy of the response were checked.

In both cases, the most frequently described item was cooking including cutting, boiling, frying, and baking. The items widely varied, including washing, cleaning, displaying, cashiering, packaging, delivering, serving, ordering, inventorying, manufacturing, and other activities.

Table 1 Result of implementation of Material Flow Diagram in a large classroom

Items	Number
Cooking (cutting, boiling, frying, etc.) including both jobs and daily activities	62
Washing (dishes, clothes, cars, etc.) including both jobs and daily activities	23
Cleaning (rooms, bathrooms, etc.) including both jobs and daily activities	16
Displaying	14
Cashier/accounting	7
Packaging/wrapping	4
Delivery	3
Serving dishes	3
Ordering	2
Processing/manufacturing	2
Inventory	1
Filling gasoline	1
Others (daily activities except for cooking, washing, and cleaning)	7
Others (not adequately written)	7
Total	152

4.2 Implementation of Material Flow Diagram in a Small Classroom

Learning using the Material Flow Diagram was conducted at Kyoto Sangyo University on April 13, 2018, in a small classroom. The purpose was to understand that there are potential environmental burdens related to one's activities. In addition, it served as the initial workshop of a new seminar to study environmental business and management. Eight students participated. Although two of them entered the seminar at the first request, they did not have much knowledge regarding environmental issues. The remaining students chose the seminar as it was not filled to capacity after they failed to be admitted into their desired seminar, and they did not have interest in environmental issues.

The workshop was conducted as follows. First, individual students wrote in the Material Flow Diagram according to the procedures from Steps 1 to 3. Second, the students were divided into three groups sitting near one another, and then each student provided a presentation of their description. Third, for Step 4, the facilitator explained the concept of potential environmental burdens and then asked students to discuss which item they thought should be reduced or adequately managed. Each group presented the results of discussion. Finally, the facilitator facilitated students in finding common points and explained the meaning of managing environmental burdens as Step 5. Then, students provided some comments in the worksheet.

Table 2 Student groups and the discussion item of each group

Group ID	Student ID	Process described	Discussion item that should be reduced
A	1	Frying potatoes at a fast-food shop	Fried potatoes that remain unsold after 7 min
	2	Taking bath daily	
	3	Unpacking and displaying goods at a supermarket	
B	4	Cooking fried rice at a noodle store	Fried rice that fell from the frying pan while cooking
	5	Controlling the quality of pool water	
	6	Unpacking and displaying goods at a supermarket	
C	7	Cleaning the bathroom in a house	Spoiled and leftover fried foods
	8	Frying foods at a restaurant	

The results are shown in Table 2. Each student's worksheet for the Material Flow Diagram was omitted given space limitations.

All three groups noted food loss and waste as the most serious item. According to the Food and Agriculture Organization (FAO) of the United Nation, "food loss and waste" is defined as "the decrease of food in subsequent stages of the food supply chain intended for human consumption" [11]. The concept of food loss and waste includes both the case that food is discarded because of deterioration of the quality and that in which food is discarded despite it being available for consumption. Food loss and waste can occur during any process of the food supply chain, from production to final household consumption.

The students, who described the item, suggested that the volume of food loss and waste seemed large. According to their experiences of part-time jobs, although the amount of the food waste is weighed in the cutlet shop, others do not measure, and an effort to reduce it has not be completed in all stores. Students discussed the factors causing food loss and waste. They insisted that every food store largely employs unskilled part-time employees, and this results in a large amount of food loss and waste. They discussed that the amount of food lost and/or wasted results in a financial loss and increases the cost. Then, students found that it is important that the amount of food loss and waste should be measured and that its reduction would accompany adequate management of cooking or processing. Students felt the worksheet was interesting because they could reconsider their daily behavior by investigating the IPO of the material flow.

4.3 Discussion

Implementation of the Material Flow Diagram of the Green MDBS twice in the large classroom suggested that it is adequate to describe the IPO of material flow of a wide range of processes, including daily activities and jobs. From the implementation in the small classroom, it was found that the Material Flow Diagram can be used as a communication tool concerning environmental burden of focused processes.

The limitations of this study are as follows. Although the goal of the research was to develop a methodology for qualitative environmental learning as active learning, this study is in the initial stages of research. At present, it has only confirmed the availability of describing various processes and the possibility of communication among participants.

In further research, the following two challenges must be overcome to improve the methodology for use in active learning. The first is to incorporate a questionnaire that can confirm whether participants accurately understand potential environmental burdens and the environmental burdens that should be managed. The second is to incorporate a tool that can stimulate discussion among participants and assess their meanings.

5 Concluding Remarks

Although there are several estimating or learning tools to understand environmental burdens, they are quantitative approaches, that is, they focus on the numerical value of materials. A qualitative approach is equally important (if not more so), as it describes the potential environmental burdens as related to a process; this aspect should be understood prior to numerical evaluation. This research presented a methodology for environmental learning using the Material Flow Diagram, which is one of the three components of the Green MDBS. Via implementation in classrooms, it was found that the tool fit a wide range of processes and fostered communication among participants. Further research studies should incorporate tools for assessing the effectiveness of learning and communication as previously mentioned, establish a learning methodology by repeated implementation, and apply the methodology on-site for to initiate or improve corporate environmental management.

In this research, the participants of the workshop using the Material Flow Diagram noted the issue of food loss and waste that they are facing in their jobs. This fact indicates that the new methodology is helpful for problem identification and that the Material Flow Diagram and the Green MDBS can be used as a methodology for treating the issue of food loss and waste. Improving the efficiency of production and service in the food supply chain is among the important issues of the service industry. In addition, reduction of food loss and waste is one solution to achieve the Sustainable Development Goals (SDGs) of the United Nations. The issue is particularly related to goal 2, “end hunger, achieve food security and improved nutrition and promote sustainable agriculture,” and goal 12, “ensure sustainable consumption and production patterns.” The SDGs adopted at the UN Summit in 2015 are common goals and targets to be achieved by 2030. Future research topics include the study of an advanced methodology based on environmental learning using the Material Flow Diagram of the Green MDBS to address the issues of food loss and waste generation to further the SDGs. To achieve SDGs, learning and/or performance tools, that everyone can easily use, are necessary. User-friendly tools such as a gaming simulation will be helpful in achieving SDGs. One of the future studies is aimed at to developing a gaming simulation concerning food loss and waste-related issues using the Material Flow Diagram of the Green MDBS.

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References

1. Zaima K (2015) A methodology of an environmental information system for designing an environmental conscious society, Doctoral thesis, Tokyo Institute of Technology, in Japanese with English abstract
2. Zaima K, Deguchi H, Lee H (2015) A methodology for environmental information system based on multi-dimensional bookkeeping system for material & service accounts. In: Proceedings of 2015 IEEE/SICE international symposium on system integration (SII2015): 894–899. IEEE. https://doi.org/10.1109/SII.2015.7405118
3. Zaima K, Lee H, Deguchi H (2015) A methodology for environmental learning simulation based on the environmental bookkeeping system. Proc Jpn Assoc Simulat Gaming 2015(Autumn):50–55. (in Japanese)
4. Fujikura R, Fujikura M (2008) Bunkei no tame no kankyou kagaku nyuumon (introduction to environmental science for liberal arts). Yuhikaku Publishing Co., Ltd., Tokyo. (in Japanese)
5. Matsumura N, Miyake N (2009) Development and effect of a workshop program regarding environmentally friendly shopping behavior on consumer attitude and behavior modification. Glob Environ Eng Res 17:29–37. in Japanese with English abstract
6. Nakata T (2003) A study on the volume and transportation distance as to food imports ("food mileage") and its influence on the environment. J Agric Policy Res 5:45–59. in Japanese with English abstract
7. Morioka T, Sueishi T (1983) Kankyou gakushuu no yougu toshiteno kankyou kakeibo to kankyou karute (environmental accounting housekeeping book and environmental chart as tools for environmental learning). Kankyou Mondai symposium Kouen Rombunshuu (proceedings of symposium on environmental issues), vol 11, pp 80–92 (in Japanese)
8. Yamada K (1996) 1 okunin no Kankyou Kakeibo (environmental accounting housekeeping book for 100 million people). Fujiwara-shoten Publishing, Tokyo. (in Japanese)
9. Fukushima Y, Yamashita M, Hirao M (2005) Function and information flow model of an adaptive environmental management system in households: a progressive use of customized environmental balance sheets. Environ Sci 18(2):103–113
10. Deguchi H (2004) Economics as an agent-based complex system: toward agent-based social systems sciences. Springer, Tokyo
11. Food and Agriculture Organization of the United Nations (2011) Global food losses and food waste; extent, causes and prevention. Rome, Italy

Board Game for Collective Learning on Green Roof Ecosystem Services

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Abstract "The green roof game" was created for collective learning on green roof ecosystem services. The ultimate goal was to raise awareness of people to increase urban green space. The game was composed of a gameboard and artefacts including 3D-tokens of trees, shrubs, herbs, grass, ponds, and solar panels. Each token contained an ecosystem service point. Each gaming session was begun by the players answering the pretest. Then, they were asked to construct their own green roof. After finishing, the players were asked to calculate the ecosystem service score of their roof in four dimensions followed by completing the posttest. A debriefing was then conducted. This game was implemented with 285 participants. The results showed that this game could facilitate participants' understanding on green roof ecosystem services. Players suggested to have more plant species to make the game be more fun and real. They also suggested the researchers create an online computer version for greater public use.

Keywords Roof garden · 3D board game · Urban · Thailand

1 Introduction

A green roof is an installation of plants, substrate, and specific structures on the rooftop of a building [1]. Several benefits from a green roof ecosystem can be utilised by humans, which can be called ecosystem services. Ecosystem services are goods and services that humans gain from ecosystems, which can be classified into four categories: provisioning services, regulatory services, cultural services, and support services [2]. However, most of the green roof research has only focussed on the aspects of the architecture and engineering, such as the design of the rooftop

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garden [3]. Moreover, many previous individual research studies have been conducted by topic, such as storm water management [4], building temperature control [5], roof farming [6], and biodiversity [7]. Therefore, holistic research of the four types of ecosystem services on green roofs should be investigated.

In Bangkok, Thailand, green space has continuously increased since 2011 because of the policy from various related organisations [8]. However, the ratio between the total amount of green space and population in 2017 was only 6.16 square metres per person [9]. This is less than the international standard of 9 square metres of green space per person proposed by the World Health Organisation (WHO) [10]. Therefore, enhancing the amount of green space in Bangkok is considerably needed; however, the awareness of the people about the importance of green space is still limited. Hence, it is necessary to raise the people's consciousness of increasing urban green space.

Based on the two important aspects mentioned above, the authors attempted to create a new tool for shared learning, increased awareness, and integrated ecosystem services. As such, the authors found that gaming and simulation would be effective tools for this purpose, as these tools had already been widely used for various aspects including learning and management issues, e.g. students' learning performance in science courses [11], chronic disease management [12], and forest management [13]. In natural resource management, gaming and simulation have been implemented with stakeholders in the form of role plays and agent-based computer simulations to facilitate understanding about the complex interactions of the system to be managed and to support management's decision-making, e.g. a "soil analysis game" for soil management [14], "Sathing Phra millionaire game" for learning about environmental issues from land use changes [15], simulation games for learning about climate change adaptation [16], and a simulation game for water management [17].

Therefore, this study aimed to test the green roof board game for collective learning on green roof ecosystem services. Ultimately, this simple and innovative game might increase the awareness of the people to increase a better quality and greater quantity of urban green space for a sustainable environment.

2 Methods

"The green roof game" was created with two successive versions. The second version was slightly adjusted and improved after receiving suggestions from the players. The game composed of a gameboard and artefacts. The gameboard was made from hard paper with 10 × 15 cells (5 cm × 5 cm) to represent a bare roof. The game artefacts represented the green roof components. The 3D-tokens of trees (coconut and orange jessamine), shrubs (hibiscus), herbs (cabbage), grass, ponds, and solar panels were used in the first version of the game (refer to Fig. 1). However, *aloe vera*, African marigold, rice, and birds were added to the second version of the game as shown in Fig. 2. Each token contained an ecosystem service point.

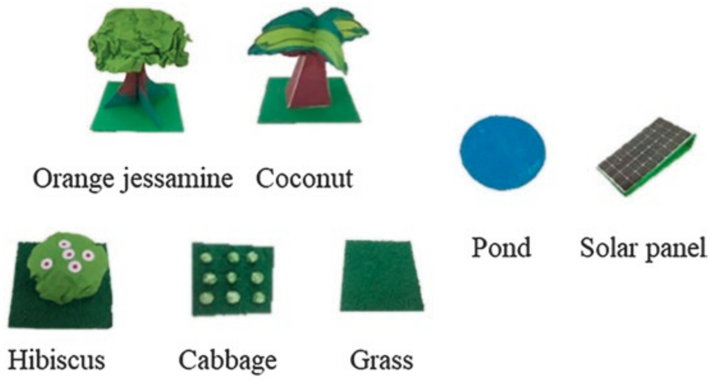

Fig. 1 3D-tokens used in the first version of the game

Fig. 2 3D-tokens that were used in the second version of the game

The game was calibrated for 8–12 players. To use the game, it was started by players answering the pretest about green roof knowledge (refer to Table 1). Then, the players were separated into two groups of 4–6 players. They were asked to construct their own green roof in a period of 5 min using the provided materials. After

Table 1 Pretest and posttest about green roof knowledge

No.	Question	Yes	No
1	Green roofs are the only rooftop with an installation for growing media and plants		
2	The ratio of the green space area per person in Thailand is similar to the international standard		
3	Green roofs can provide four benefits including global warming mitigation, scenery provision, habitat provision, and product provision		
4	Green roofs can help to decrease the building's temperature and air pollution		
5	Green roofs can play a role as a habitat for some resident birds		
6	The scenery on green roofs can be used to attract tourists and to be a learning centre		
7	The diversity of plants on green roofs can help to provide a habitat for several animals		
8	Green roofs can increase waste water of the building		
9	Green roofs are suitable for growing small flowers		
10	Green roofs are the alternative way for increasing green space in an urban area		

finishing, the players were asked to calculate the score of their roof in the four dimensions of the ecosystem services (provisioning, habitat, regulation, and cultural services). Then, they completed the posttest that had the same questions as the pretest. A debriefing was then conducted by exchanging ideas about the roof design between the groups as well as discussing the diverse ecosystem services provided by each roof. Thereafter, another set of questions was used to ask about improving the game (refer to Table 2). To analyse the result, a t-test for dependent samples (paired t-test) was used to compare the understanding of the players about green roof ecosystem services.

This game was implemented during the Chulalongkorn University Academic Expo activity on 15–19 March 2017. The first version was used for 2 days and slightly modified to the second version and used for another 3 days. A total of 285 participants engaged in the game (148 and 137 players for the first and second versions, respectively).

3 Results and Discussion

3.1 Green Roofs from Gaming Sessions

The players were able to use the provided materials to create their own green roofs. The players in each version of the game had different ideas and decisions regarding the selection of the green roof components and about constructing the roof. When comparing the green roof designs from the two versions of the game, players in the first version decided to use trees on their green roof, while many herbs were selected by the players in the second version (refer to Fig. 3). This might be a result of the

Table 2 Questions for the game's assessment

No	Ability of the board game for collective learning	Score				
		1	2	3	4	5
1	Playing the game helps me to understand more about the benefits of a green roof					
2	The game is easy to play and is not complex					
3	Playing the game makes me want to increase green space at my residence					
4	I want to transfer the knowledge from this game to other people if I have a chance					
5	The game's atmosphere is fun and is not stressful					
6	Staff are friendly					
No	Satisfaction of the game's features and process	Too small	Suitable		Too large	
1	Size of the board game					
2	Number of plant types					
3	Number of plants					
4	The given time for creating own green roof					
5	The given time for the conclusion					
6	The given time overall for the game's session					

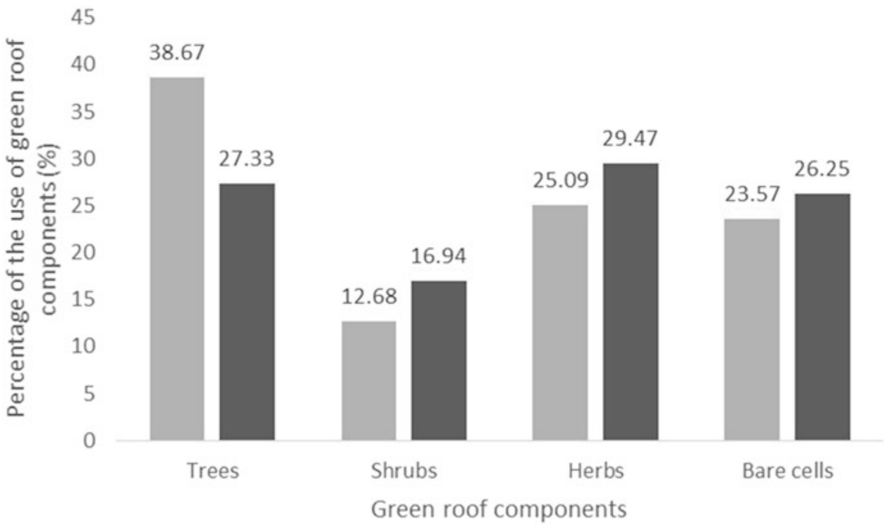

Fig. 3 Percentage of the use of the green roof components

more available choices in the second version. Therefore, the diversity of the green roof components was likely to affect their plant selection and green roof design in the games. In a future study, the installation cost of each component should be included in the calculation stage in order to investigate whether it has an effect on the players' decision-making or not. However, bare spaces that occurred on the green roof construction in both versions were similar because players wanted to keep space for walking or using as a recreation area. This result showed that the game was not difficult for them to play.

In the process of the green roof construction (refer to Fig. 4), the players could exchange their design concept and knowledge. For example, the players who had knowledge about plants shared their concept that small plants should not be installed near big trees because this would result in the lack of sunlight. Some players were more concerned about the aesthetic value; therefore, they constructed their green roofs depending on the landscape architecture. For instance, a symmetrical design was used on their green roofs. Then, the game could show the players had the ability to provide ecosystem services because of the differences based on the design concept that they had used. Moreover, some players suggested that the game should have a larger number of plant species for the ability to absorb pollution, and some players asked for extra time in the construction step. Consequently, apart from knowledge exchange, this step might help the players to realise that their green roof design could indicate ecosystem services.

3.2 Participants' Learning

In the first version of the game, the results showed that the average score of the pretest (8.13 ± 2.85) was significantly different from the posttest (8.50 ± 2.92) ($p < 0.05$). Players provided more correct answers about the ecosystem services on green roofs after playing and engaging in discussion. Table 3 shows the percentage of the players who provided the correct answer in each question. Most of the questions received the right answers, and question numbers 3, 7, and 10, which were about the benefits of green roofs, gained the highest percentage of the correct answers. Therefore, this apparently showed that the players could learn about ecosystem services through this game.

However, in the first version there were two questions, number 1 and 5, that some players provided the wrong answers after the game. The first question was about the definition of green roofs. The lower score might be a result from the game leaders

Fig. 4 (**a**) Green roof construction, (**b**) example of a constructed green roof, and (**c**) example of the players' discussion and sharing ideas about the green roof design

Table 3 Percentage of the correct answer in each question in the first and second versions of the game

	1st game version		2nd game version	
Question No.	Pretest	Posttest	Pretest	Posttest
1	85.7	72.8	85.0	85.0
2	70.7	90.5	62.2	96.1
3	89.1	98.0	4.7	54.3
4	88.4	95.2	89.0	89.8
5	59.9	44.2	88.2	89.0
6	91.2	93.9	87.4	87.4
7	87.8	98.0	88.2	95.3
8	80.3	87.8	73.2	89.8
9	66.0	72.8	55.1	84.3
10	93.9	98.0	89.0	99.2

that did not emphasise the meaning of a green roof, which could be a roof with solar cells, a kind of green energy. Moreover, the game focussed on the growing of plants; therefore, participants might think that only a rooftop with plants is a "green roof". The fifth question was about using green roofs as the habitat for resident birds. The lower score in the posttest might be a result from the wording used in the question that may have been not clear enough for the players.

In the second version, the average score of the pretest (7.23 ± 1.36) was significantly different from the posttest (8.70 ± 1.26) ($p < 0.05$). After playing the game, players could answer the questions more correctly. Table 3 shows the percentage of the players with the right answer in each question in the posttest. However, the average score of the pretest and posttest in the second version was less than the first version. This might be because of the different backgrounds of the players.

Moreover, during the discussion, many players shared their own ideas to start growing some plant species in the terrace of their condominium. Some of them said that they would search for more information on the Internet about the plants that could absorb some pollutants and they would grow them to help the city. These reflections showed the impact of the research tool on the urban environment. It is unfortunate that there was no chance to monitor if those ideas had been implemented or not.

3.3 Limitation and Suggestion for Further Improvement

Because this game was tested during the Chulalongkorn University Academic Expo activity, therefore, the duration of each session had to be set for 30 min per round to match with other activities in this event. As a result, there was shorter time for each game's session, and then there was less knowledge exchange occurring than the expectation. However, the authors expected that using this game in the classroom, around 50 min, would provide a better learning result because more time could be allocated for the debriefing. Another limitation was the number of players that a game could support. To solve the problem, several sets of the game could be duplicated to support more players at the same time.

For future improvement, there were suggestions from the participants that (1) more plant species, such as pollutant-absorbing plants and other indigenous species, should be added to the game to provide more knowledge and (2) the game should be modified to be a computer or mobile phone version for greater use by the general public. Therefore, in the new era of simulation and gaming, new technology, such as a mobile application for a green roof game, should be developed in the future. Mobile applications are able to reach more people easily and can also help to solve some limitations of a 3D board game, such as the preparation of the required materials.

4 Conclusion

A green roof provides many ecosystem services, but there is a lack of integrative research. Moreover, to further promote green roof construction as the way to increase green space in many cities, knowledge about green roof ecosystem services should be taken into consideration. In this study, a green roof 3D board game was created. After testing, the authors concluded that the game could be used for shared learning on green roof ecosystem services. Further research should be conducted based on the suggestions from the players, and the game should also be tested with university students from different faculties to test the feasibility of the game for teaching in various related topics, such as ecology, landscaping, and urban management.

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References

1. Oberndorfer E et al (2007) Green roofs as urban ecosystems: ecological structures, functions, and services. Bioscience 57:823–833. https://doi.org/10.1641/B571005
2. Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: synthesis. Island Press
3. Lertpitiwatana P (2015) Roof garden design. Art Archit J Naresuan University 6:19–34
4. Stovin V, Poë S, Berretta C (2013) A modelling study of long term green roof retention performance. J Environ Manag 131:206–215. https://doi.org/10.1016/j.jenvman.2013.09.026
5. Morakinyo TE, Dahanayake KWDKC, Ng E, Chow CL (2017) Temperature and cooling demand reduction by green-roof types in different climates and urban densities: a co-simulation parametric study. Energ Buildings 145:226–237. https://doi.org/10.1016/j.enbuild.2017.03.066

6. Thai City Farm (2012) Rooftop vegetable garden. http://www.thaicityfarm.com. Last accessed 31 Jan 2018
7. Williams NSG, Lundholm J, Scott MacIvor J (2014) Do green roofs help urban biodiversity conservation? J Appl Ecol 51:1643–1649. https://doi.org/10.1111/1365-2664.12333
8. Office of Natural Resources and Environmental Policy and Planning (2016) Markers for green space and the ratio of green space in urban area. http://www.onep.go.th/env_data/2016/01_62. Last Accessed 17 Mar 2017
9. Strategy and Evaluation department BMA (2016) Summary of 7 types of green space (Bangkok). http://203.155.220.118/userfiles/files/park59.pdf. Last Accessed 17 Mar 2017
10. Thai Civil Rights and Investigative Journalism (2015) Green space in Bangkok. http://www.tcijthai.com/news/2015/26/watch/5526. Last Accessed 17 Mar 2017
11. Sung H-Y, Hwang G-J (2013) A collaborative game-based learning approach to improving students' learning performance in science courses. Comput Educ 63:43–51. https://doi.org/10.1016/j.compedu.2012.11.019
12. Miller AS, Cafazzo JA, Seto E (2016) A game plan: gamification design principles in mHealth applications for chronic disease management. Health Informatics J 22:184–193. https://doi.org/10.1177/1460458214537511
13. Spies TA et al (2017) Using an agent-based model to examine forest management outcomes in a fire-prone landscape in Oregon, USA. Ecol Soc 22
14. Pruksakorn S, Kiratiprayoon S, Uttaranakorn S, Sukreeyapongse O, Dumrongrojwatthana P (2018) Game for low-formal education farmers to learn how to improve soil quality. Simul Gaming 49(2):146–167
15. Wanich K, Dumrongrojwatthana P (2016) Learning the environmental impact from land use changes by Sathing Phra millionaire game. ThaiSim J Learn Dev 1:1–22
16. Rumore D, Schenk T, Susskind L (2016) Role-play simulations for climate change adaptation education and engagement. Nat Clim Chang 6:745. https://doi.org/10.1038/nclimate3084
17. Craven J, Angarita H, Corzo Perez GA, Vasquez D (2017) Development and testing of a river basin management simulation game for integrated management of the Magdalena-Cauca river basin. Environ Model Softw 90:78–88. https://doi.org/10.1016/j.envsoft.2017.01.002

Design of Simulation and Gaming to Promote the Energy Transition from Fossil Fuels to Renewables

Kengo Suzuki, Keita Nakai, and Arashi Ogihara

Abstract To design policies for energy transition from fossil fuels to renewables, this study proposes an analytical framework combining simulation and gaming. The aim of this framework is to clarify the effect of subjective recognition by managers of energy companies on the promotion of renewables. Considering the purpose, the authors design a multiplayer computer game dealing with energy supply business in a competitive market. In the gaming experiment, participants play the game and answer some questionnaires during the game. The relationship between the subjective recognition of players, their behavior, and the results of the game is analyzed from the records of the game and questionnaires. The results of preliminary experiments suggest that the pessimistic outlook of players in the earlier stage of game heats up price competition in the market and prevents the promotion of renewables as the players place more emphasis on short-term competition than on long-term investments. The results of preliminary experiments show that the proposed framework can analyze the effect of subjective recognitions of players on the results of the game.

Keywords Simulation · Gaming · Energy transition · Renewable energy · Fossil fuels

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1 Introduction

To ensure the sustainability in a modern society, the main sources of primary energy must be switched from fossil fuels to renewables. About 81% of world primary energy is supplied by fossil fuels, such as coal, oil, and natural gas [1]. However, the reserves of these fossil fuels are limited; the proven reserve of crude oil will be exhausted within 51 years as far as we consume it in the current rate [2]. Further, the CO_2 emissions from fossil fuel consumptions cause the global warming and the resulting catastrophic climate change on the world. To hold the global average temperature below 2 °C above pre-industrial levels, world CO_2 emissions from the energy supply sector need to drop 40–70% below 2010 levels until 2050 [3]. The energy transition from fossil fuels to renewables is a critical target for all over the world in terms of the stable supply of energy and the mitigation of global warming.

Such an energy transition requires further reductions in the cost for renewables, and investments in the renewable technologies play key roles in the cost reductions. However, managers of energy companies tend to provide more priority to short-term price competitions than long-term investments to survive in a deregulated market. Then, the policy-makers must design rules of the market such that the managers can believe in the superiority of long-term investments over short-term competitions. There are several previous studies investigating the optimal path of such investments [4, 5] and the effects of energy policies in the past [6, 7]. However, these studies do not encapsulate the subjective recognitions of market status by managers, while it appears to strongly affect their decisions.

The authors aim to clarify how the subjective recognition of market status by the managers of energy companies affects the long-term promotion of renewable energy and propose a novel analytical framework combining gaming experiments and optimization simulations. In the framework, the multiplayer computer game which models energy supply business in a competitive market is played by individuals. The behavior of players and the results of the games are recorded on the computer, and the subjective recognitions of players are surveyed by questionnaires during games. Apart from the games played by individuals, the “ideal” behavior of the market is estimated by using the optimization simulations. The difference between the ideal and actual behavior of players is investigated by comparing the results of simulations and games. Further, the effects of subjective recognitions of players on the behaviors of the market as a whole are investigated from the records of games and questionnaires.

The purpose of this paper is to verify that the proposed framework can contribute to the aim of our study. The game and simulation designed for this study are explained, and the results and discussions of preliminary experiments are analyzed.

2 Design of Game and Simulation

2.1 Description of the Game

The authors developed a multiplayer computer game "Energy Transition" which models energy supply business in a competitive market. The game is played by five individuals. The roles of the players are managers of energy companies whose business is to supply final energy produced from fossil fuels or renewables. It is assumed that there is one type of fossil fuel, renewable resource, and final energy. The purpose of game is to earn the largest amount of money among all players. The game proceeds by repeating a time step called "term." Each term consists of two parts: decision-makings by players and updates of players' status by a game system. In each term, players decide their energy mix between fossil fuels and renewables, retail price of final energy, and investments in research and development (R&D). The game ends at the end of term 25.

Figure 1 shows the relationship among the variables in "Energy Transition" focusing on a single player. Black, white, and gray squares indicate command, endogenous, and exogenous variables, respectively. The command variables represent the decision-making by player i at time t. There are three types of command variables: amount of energy production by renewables (E_r), retail price of final energy (p_s), and investments in R&D (I). The endogenous variables represent the status of players. There are six types of endogenous variables: money (V), demand (D), knowledge stock for renewables technology (N), accumulation of renewables usage (R), unit production cost for final energy by renewables (p_r), and amount of

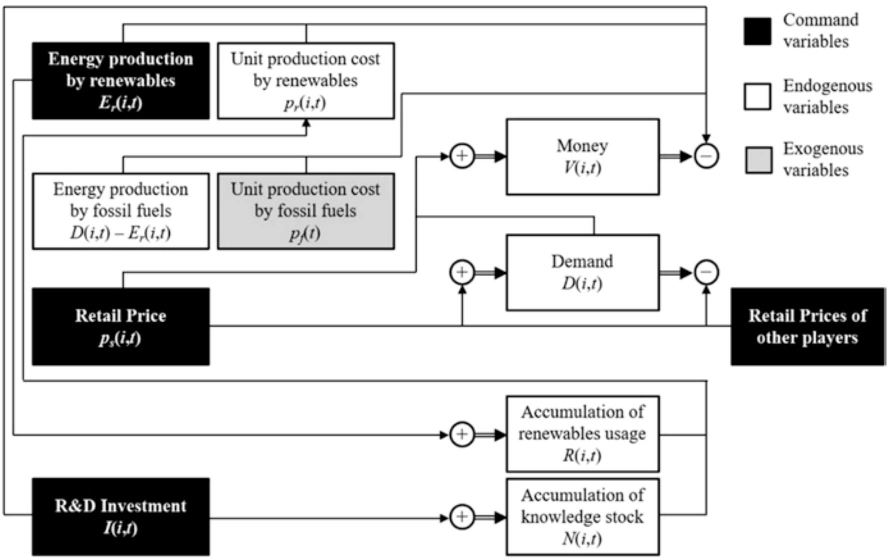

Fig. 1 Relationships among variables in "Energy Transition" focusing on a player

energy production by fossil fuels (D–E_r). In this game, the unit production cost for final energy by fossil fuels (p_f) is exogenously given. The cost for fossil fuels is much lower than that for renewables at the beginning of game, while it increases every term following the preset pattern.

The money income is determined by demand and retail price, and the expenditure for final energy production is determined by the amount of production and unit production costs for two types of energy sources. The R&D investments in renewable technology also decrease the money. The production cost of renewables is reduced by the accumulation of knowledge stock and usage. This relationship is represented by the typical two-factor learning curve [8]. The knowledge stock is assumed to be effectively accumulated by continuous R&D investments over a long period rather than concentrative investments in a single period [5]. The total demand for final energy in the market is assumed to be constant over the game. At the beginning of the game, the total demand is evenly assigned to each player. In other words, each player has contracts with the same number of consumers and has a duty to supply final energy to them. The energy demand moves from the players with higher retail prices to those with lower retail prices in every term in line with the difference in prices.

2.2 Optimization Model

In addition to the multiplayer game, the authors developed the mathematical programming model to estimate the "ideal" behavior of players which maximizes the total profit of the market at the end of a game. Different from the games played by individuals, this ideal game satisfies the three conditions below. First, all players work together to maximize the total profit of the market. Second, they preliminarily know all the parameters of the game, such as the rate of cost reduction against R&D investments and the trend of fossil fuels prices in the future. Third, they take the same action over a game; in other words, they input the same values to command variables and do not compete against each other. The objective of the model is to maximize the sum of profits of all players, and the constraints are equations representing the relationships in Fig. 1. Further, the upper limit is set to the average retail price of final energy over a game. By repeatedly solving the model for different levels of this upper limit, the maximum profit of the market and corresponding amount of renewables promotion are estimated for different levels of the average retail price.

2.3 Parameter Settings

The parameters of the game must be set such that the players can experience the dilemma between long-term investments and short-term competitions. This study sets up four guidelines to represent such experiences as follows. First, all energy sources must be substituted by renewables until the end of a game when all the players work together to maximize the long-term profit of the entire market. Second, the energy transition must not be achieved in the early stage of a game. Third, the game must ensure the possibility of a win for various strategies, such as the preferential investments for long-term profit, the aggressive price competition, and their combinations. Fourth, such a variety of strategies must be taken by the players, and the results of games must be varied affected by the combination of strategies. The parameters of the game are set to adhere to these guidelines. The first and second guidelines are tested by the optimization model. The third guideline is tested by computer simulations in which the agents with different strategies play the game. The fourth guideline is judged from the results of playtests, including the preliminary experiments. This paper does not provide the discussions about these guidelines due to space limitations.

2.4 Outline of the Gaming Experiment

The environment for the gaming experiment comprises of five personal computers (PCs) for players, one PC as a game server, and a Wi-Fi router to connect PCs. The PCs for the players have functions to view records of the games and to enter commands. The records can be freely browsed as graphs. The game server receives commands from the PCs for players, calculates endogenous variables, and returns the updated records to the players. An experimenter can check the current status of a game displayed on the server at any point in time. In addition to the PCs, a questionnaire sheet is distributed to each player. On the sheet, there are questions concerning the three types of subjective recognitions: degree of hope to win the game, degree of recognition of effort by other players to promote renewables, and degree of fear to lose price competition. Players answer these questions on a five-point scale at the end of every five terms of a game. The questionnaire sheets are collected after a game.

3 Results

3.1 Preliminary Experiments

The authors target university students as participants of actual experiments. However, we held two preliminary experiments targeting professionals of businesses and gaming before the actual experiments. The first game (called “game 1” hereafter) is played by a teacher and students of a graduate school who teach and study business games. The second game (called “game 2” hereafter) is played by the staff and members of an economic federation, including professionals of energy business.

The first purpose of preliminary experiments is to check if the game is well designed. The results of the game must be different among the experiments; if all the results are similar, the game will fail to represent the complexity of the real world. Even if the results of the games are different, the cause of difference must be explained in relation to the difference in the behavior of players. Further, the difference in behavior must be associated with the difference in their subjective recognitions. The second purpose is to listen about the playability and reality of the game and the procedure of the experiment.

3.2 Results of the Experiments

Figure 2a, b shows the total usage of renewables and profit of all players at the end in the ideal and actual games. The horizontal axes show the average retail price of all players weighted by their market shares over a game. The lines show the solutions of optimization model for different levels of the average retail price. The plots show the results of the two preliminary experiments.

Focusing on optimal solutions, the total usage of renewables is constant, regardless of the average retail price and total profit linearly increases in proportion to the average retail price. These results indicate that there is an optimal level of renewables promotion independent to the level of retail price under the current setting of parameters. Even when players earn the more profit by increasing the retail price, they should keep it in their reserve; the investments in renewables over the optimal level do not increase their final profit.

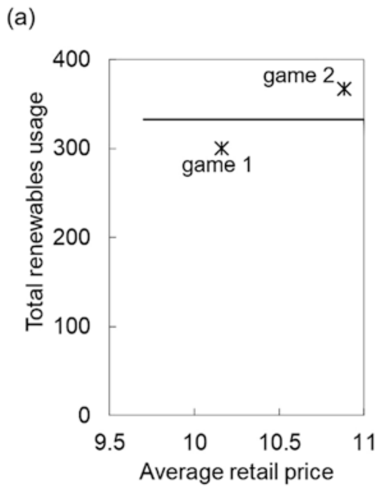

Fig. 2 (**a**) Total renewables usage and (**b**) total profit in the optimization model (lines) and preliminary experiments (plots)

The results of games 1 and 2 are different from the optimal solutions. The plots for game 1 are below the lines in both figures. In this game, the renewables usage and profit are smaller than the optimal solutions with the same level of average retail price, and players could have increased the usage of renewables without decreasing their profit. On the other hand, the plot for game 2 is above the line in (a) while below the line in (b). In this game, the usage of renewables is larger than that of optimal solutions with the same level of average retail price; the players gave priority to social benefit than their own profit, probably by accident.

Comparing the results of the two games, both the usage of renewables and profit are higher in game 2. The retail price is lower in game 1, suggesting that game 1 is more competitive than game 2.

Figure 3a–d shows the time series changes in accumulated usage of renewables, accumulated profit, accumulated R&D investments, and average retail price in the two games. Twenty-five terms are aggregated to five term blocks which consist of five terms; the first time block includes terms 1–5, the seconds includes terms 6–10, and so on. The retail price is an average for all the players weighted by their market shares, and the other values are the total amount for all the players.

The usage of renewables, profit, and R&D investments is higher in game 2 than in game 1, and the difference between the two games becomes larger in the earlier stages of the games. On the other hand, the retail price is higher in game 2 than in game 1, only in the first term block. These results suggest that game 1 is more competitive than game 2 in an early stage. Such an environment appears to reduce the profit of the players and hinder the investments in renewables.

Figure 4a, b shows the time series changes in demand of each player in the two games. The vertical axes are the changes in demand from the beginning of a game. In game 1, the gaps among the players begin to increase from the first term block and expand as the game proceeds. In game 2, such an expansion of gaps is moderate in comparison to game 1, while player 1 failed to keep his or her customers. These results confirm that game 1 is more competitive than game 2 in its early stage.

Figure 5a, b shows time series changes in the two types of subjective recognitions of players: hope to win the game and fear to lose the price competitions. Each plot shows the average value of answers to the questionnaire by all players. The players answered the questions at the end of every five terms corresponding to the end of each term block. The answers in term 25 cannot be obtained owing to the design mistake of the questionnaire sheet. The authors assume that these average values indicate the shared reality among the players.

The hope to win is lower in game 1 than in game 2 in term 5; the average value is 2.2 in game 1 and 3.6 in game 2. The results indicate that the players in game 1 are pessimistic about their future in comparison to the players in game 2. Such a difference may affect the intensity of price competition; pessimistic players may place priority on short-term profit than long-term profit. The fear to lose a game is higher in game 1 than game 2 in the earlier stage, while the difference is small. This result may also suggest the pessimistic recognitions of players in game 1. The results of other questionnaires are not shown here as there are few differences between the games.

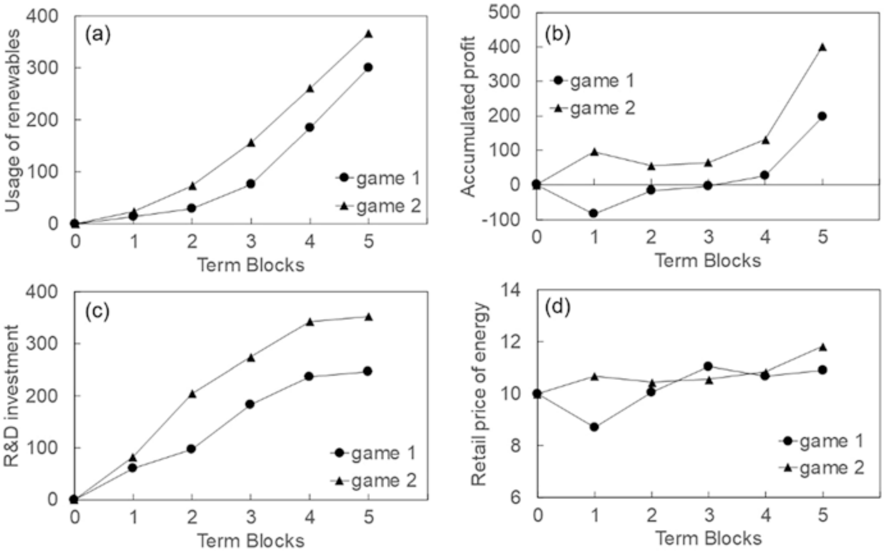

Fig. 3 Records of two games: (**a**) accumulated usage of renewables for energy production, (**b**) accumulated profit, (**c**) accumulated R&D investments, (d) retail price of final energy. (**a**–**c**) show the total amount for all the players, and (**d**) shows the average price for all the players weighted by their market shares. Twenty-five terms are aggregated to five term blocks

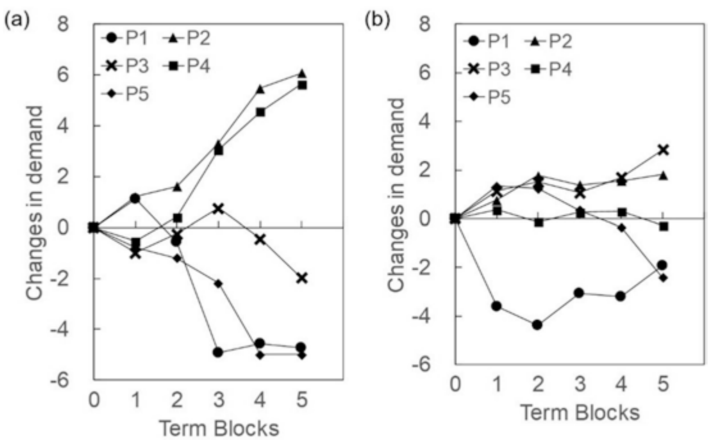

Fig. 4 Time series changes in demand of each player in the two games: (**a**) game 1 and (**b**) game 2. The values in the vertical axes are the changes in demand from the beginning of a game

It is not clear whether the competition among the players resulted in the pessimistic mood in the market or the pessimistic character of players resulted in the competitive environment in game 1. At any rate, the subjective recognitions of players in the earlier stage of the game appear to relate with the intensity of competition

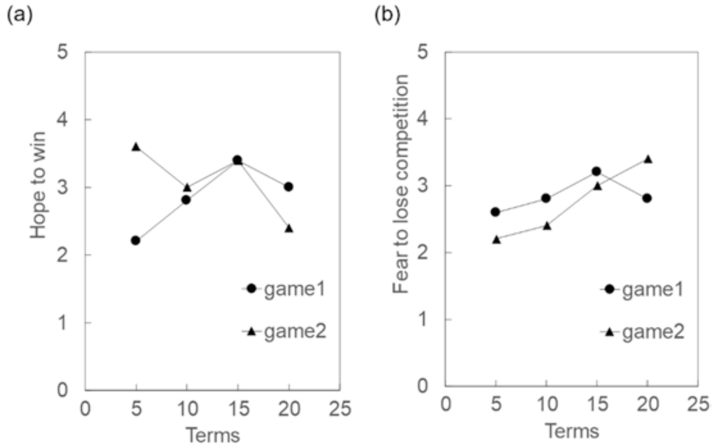

Fig. 5 Answers to the questionnaire: (**a**) hope to win, (**b**) fear to lose competitions. The vertical axes show the average answers by all the players. Larger values reflect stronger recognitions

and induce the difference in the promotion of renewables. While this preliminary insight must be confirmed by the larger numbers of experiments later, we conclude here that the proposed framework can analyze the effect of subjective recognitions of players on the results of a game. Tables should be used to present the results of investigations and large sets of figures clearly.

4 Conclusions

This study proposed an analytical framework combining the gaming experiments and optimization simulations and verified that the framework is useful to clarify the psychological aspects of energy transition from fossil fuels to renewables. The results of the experiments suggested that the promotion of renewables is affected by the subjective recognition of market status by the managers of energy companies. If a majority of players doubt a success in the future, the promotion of renewables may be delayed as the players place more emphasis on short-term competition than long-term investments.

The analytical framework of this study targets the energy transition over several decades, and each term in the game corresponds to a few years in the real world. Then, this framework is not suitable to analyze the microscopic dynamics of actual market, such as daily or hourly changes in electricity prices in spot markets. Further, such settings of time scale must be shared with players so that the virtual experiences of actual market players are properly represented by the game. Some comments from the participants of preliminary experiments suggest that the explanation about the time scale needs to be further cultivated.

In terms of the playability of the game, some participants of preliminary experiments requested the graphical alerts for important events such as the price inversion between fossil fuels and renewables. If players do not find that the cost for renewables becomes cheaper than that for fossil fuels, they continue using fossil fuels while that is not a rational decision. The improvement of playability such as graphical alerts appears to help the participants to play a role of actors in real markets.

Through the preliminary experiments and listening, authors found that the recognitions of uncertainty in the market environments, such as learning rate and fossil fuel prices, may also affect the decision-making of players. The questionnaire sheet will be upgraded before the actual experiments to survey.

This study focused on the effect of a shared reality among the players because social systems such as market appear to be driven by such shared reality. However, there may be another approach to analyze the results of games focusing on the relationship between the recognitions and behaviors of each player. Such an approach may classify the players into several types such as optimistic or pessimistic players and explain the results of games from the combinations of these types of players. This approach will also be tested after a number of experiments are performed.

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References

1. International Energy Agency (IEA) (2016) World energy outlook 2016. OECD/IEA, Paris
2. British Petroleum (BP) (2017) Statistical review of world energy 2017, BP website. https://www.bp.com/en/global/corporate/energy-economics.html. Last accessed 31 May 2018
3. Intergovernmental Panel on Climate Change (IPCC) (2014) Fifth assessment report, IPCC Website. https://www.ipcc.ch/report/ar5/. Last accessed 31 May 2018
4. Tsur Y, Zemel M (2003) Optimal transition to backstop substitutes for nonrenewable resources. J Econ Dyn Control 27:551–572
5. Gupta SD (2015) Dynamics of switching from polluting resources to green technologies. IJEEP 5(4):1109–1124
6. Traber T, Kemfert C (2009) Impact of the German support for renewable energy on electricity prices, emissions, and firms. Energy J 30(3):155–178
7. Doherty R, O'Malley M (2011) The efficiency of Ireland's Renewable Energy Feed-In Tariff (REFIT) for wind generation. Energy Policy 39:4911–4919
8. Rubin ES, Azevedo IML, Jaramillo P, Yeh S (2015) A review of learning rates for electricity supply technologies. Energy Policy 86:198–218

Agent-Based Gaming for Two-Sided Electricity Markets

Setsuya Kurahashi

Abstract An electricity market in Japan has been an oligopolistic market since the previous century, but it has been a liberalized competitive market due to a policy change since 2016. It also has high possibilities to become two-sided markets with strong wholesalers. The two-sided markets have been researched using a mathematical economics model in recent years. The model, however, can only deal with one or two players on a market; therefore it has limitations to analyze more various players. On the other hand, research projects of dynamic pricing and incentive mechanisms have been carried out on power markets. These studies have shown interesting results, but they also have limitations to analyze complex markets and decision-making processes of market players taking managing conditions into consideration. In this study, we adopt agent-based gaming to analyze them on a two-sided electricity market.

Keywords Electricity market · Agent-based game · Two-sided market

1 Introduction

An ideal electricity market can promote innovation based on free participation and selection of consumers and free economic activities done by enterprises while serving as collective intelligence where electric power supply and demand can naturally be balanced. The government of Japan has clearly announced that it has realized liberation for participation of power operators into small consumers such as general households since 2016. It would launch unbundling of power generation and distribution during the period around 2018–2020. Unbundling of power generation and power distribution has been examined in the electricity market, with retail liberalization.

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The purpose of this research is to achieve an efficient market while taking into consideration electricity market liberalization. Additionally, this research studies incentive mechanisms for a competitive electricity markets for enabling energy transformation from fossil energy to renewable energy. In this research, social systems and infrastructures are referred to as the electricity market platform. Here, the focus is placed on aggregators that bring electricity consumers together as a community. And it is also focused on imbalance settlement which is implemented among power distribution operators and power producers/retailers for the purpose of supply and demand adjustments for renewable energy.

In a new liberalized energy market, old and new energy companies will base their actions and plans on the behavior of their competitors as well as on the (expected) responses of the consumer market. We propose using an agent-based simulation of a market of consumers as a laboratory setting to study the behavior of human decision-makers in an energy transition game.

2 Research Background

In the ICT market which has two sides, consumers and suppliers, platform competitions are being developed on a global basis. These are attractive on the price side, the supply side, and the service side. This two-sided market mechanism has been analyzed by using mathematical models [1, 2]. In addition, recently, studies regarding real-time dynamic pricing based on agent modelling and studies regarding incentive mechanisms have been made.

On the other hand, an approach based on a serious game has attracted attention in the field of gaming. It might be good to explain that traditional models exploring the dynamics of change are less suitable to understand the dynamics of interaction in a two-sided market. Agent-based gaming offers a tool to explore how parties in the energy market make decisions where an artificial population is responding to their decisions. An important challenge here is making the behavior of the artificial population realistic.

An important challenge here is the valid modelling of the population of agents in the model. Realistic agent behavior is important to make an agent-based game a tool that provides applicable insights [3].

In two-sided markets with consumers and suppliers, platform competitions are being developed on a global basis which are attractive on the price side, the supply side, and the service side. This two-sided market mechanism has been analyzed by using mathematical models. However, mathematical models were applied to analyze market mechanisms with only one or two players [4, 5]. Therefore, mathematical models have limitations in analyzing mechanisms with multiple diversified players such as consumers. In addition, studies regarding agent-based dynamic pricing and incentive mechanisms have been in progress. In these studies, however, the decision-making process of agents was controlled by an algorithm. For this reason, there are limitations in these studies to analyze complicated decision-making processes taking into account movements of actual environments, human behavior and complex energy consumers markets, and corporate management conditions. Based on these traditional models, in this research, we made an attempt to build a two-sided market model for electricity markets by applying agent-based gaming.

3 Research Objectives

Market participants are diverse agents, and the market itself also consists of multiple competitive platforms; therefore, these things are considered to be multi-agent and multipurpose optimization problems. Solving such problems requires a multi-agent incentive mechanism, while an appropriate approach is agent-based modelling (ABM). On the other hand, when the decision-making process of power suppliers and aggregators is left to machine agents, the algorithm's capability could affect the decision-making results. However, a human-agent participatory gaming method which has been used for serious games is more likely to obtain the decision-making results that are close to the actual results when human agents as players organically connect and consider information which they obtain from models. In traditional serious games, however, environmental changes as the background are determined in a deterministic manner. This fact makes it difficult to reproduce the complicated movements of an electricity market.

Given that, through this paper, progress has been made in our present research based on the following two points while connecting ABM and serious games and introducing an agent-based gaming method which makes it possible to design multi-agent and multipurpose models.

3.1 Analysis of Market Structure Which Brings About Energy Transition

System design in electricity markets has a significant influence on generation of market rulers. Our additional goal is to design a system which is effective for energy transition to renewable energy. Design of a mechanism for achieving stable electricity supply equilibrium based on utilization of a wide variety of energy sources needs to play the role of a platform for maximizing the utility for both electricity suppliers and consumers. In order to analyze these structures, we use an agent-based model.

3.2 Comparative Analysis of Decision-Making Structures

While expanding electricity consumers and power producers to multiple agents, their behavior is expressed by using a multi-agent model. With that, we conducted comparative analysis on the decision-making results obtained by introducing participatory agent-based gaming. By analyzing differences brought by each individual agent, we evaluated strategies of imbalance adjustment incentives for electricity and government subsidies and tax rate policies. In addition, observing the targeted phenomenon is not only from a single viewpoint but from several different viewpoints, in order that each phenomenon can be expressed accurately by using only one model [6].

4 Energy Transition Gaming Model

In energy transition gaming models based on agent-based gaming models (Fig. 1), in an electricity market where power producer players and aggregator players participate, power producers make their decisions based on electricity sale prices, advertising investments, and plans for power generation facilities. Sale prices are adjusted based on imbalance settlement in supply and demand with electricity distribution operators.

On the other hand, we can expect that marketers, brokers, local public organizations, and nonprofit groups which organize electric needs of consumers in order to provide energy management services effectively will participate in electricity markets. They play their roles as aggregators which serve as a bridge between retail

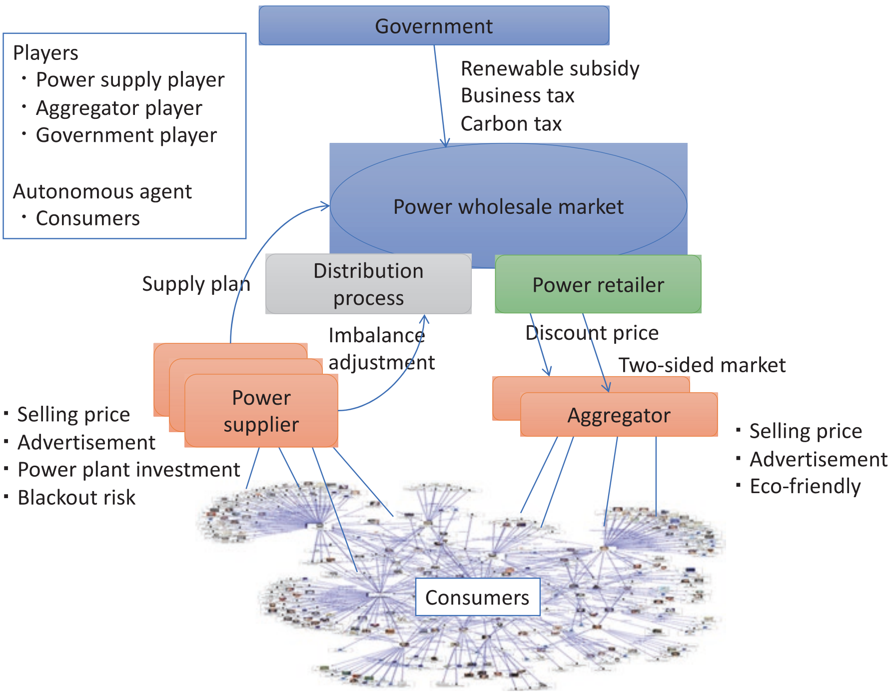

Fig. 1 Energy transition gaming model

players and general households/operators. Aggregators are expected to provide a wide variety of services based on advanced energy management systems by using smart meters while developing demand responses and negawatt[1] services. This might allow aggregators to dominate market circulation in a two-sided market and to have the power to determine not only the price but also to profit allocation. This possibility brings the same structure as IT markets including music distribution and smartphone app markets, where fierce competition for dominating markets can be caused. Therefore, it is extremely important to study on market system design which can promote development of renewable energy and sound market competition.

The proposed agent-based gaming model is based on the government plan of energy market reform in Japan. In this gaming model, the actual participants participate in the game playing the roles of power producers, electricity retailers, and aggregators. In addition, computer agents also participate in the market autonomously as a number of consumer agents. The government agents conduct imbalance settlement based on the predetermined market rules. Based on this gaming model, the game participants can experience the complexity of this market, and they can design a market system while verifying the effectiveness of the system designed.

Our ultimate goal is to verify whether real-time characteristics are satisfied by conducting simulation based on the actual climate data in order to develop further verification.

5 Model Outline

State variables are defined as follows:

- Electricity suppliers
- Sale prices, discount rates for major clients, investments (advertising, thermal, nuclear, and renewable energy), costs (thermal, nuclear, and renewable energy), carbon generation rates (thermal, nuclear, and renewable energy), power generation amounts (thermal, nuclear, and renewable energy), operator attractiveness, carbon gas generated, and rate of power failure occurrences
- Aggregators
- Sale prices, advertising investment, the number of operators that purchase electricity, and energy proportions (thermal, nuclear, and renewable energy)
- Government
- Norm effect parameters, information effect parameters, network generation parameters, and the number of consumers

Process overview and scheduling are as below. Suppliers generate power and sell it to consumers and aggregators. While taking into account the environment of

[1] Negawatt power is a theoretical unit of power representing an amount of energy (measured in watts) saved.

consumers and their intentions toward prices, suppliers determine the power generation proportions of thermal power generation, nuclear power generation, and renewable energy, electricity prices (discounts for general/major clients), and advertising investments in order to maximize their own profits. Increase in the proportion of renewable energy increases the power failure probability, resulting in paying the imbalance cost. Additionally, their own competitiveness declines in proportion to the power failure probability.

Aggregators purchase electricity with discounts for major clients from suppliers while reselling the electricity to consumers. While taking into account the environment of consumers and their intentions toward prices, aggregators determine the power generation proportions of thermal power generation, nuclear power generation, and renewable energy, electricity prices (for general clients), and advertising investments.

While considering their own preferences for electric power and electric power charges, consumers purchase electric power from appropriate suppliers. Consumers are network-linked with their acquaintances receiving the norm effect. The government determines imbalance prices, business taxes, carbon taxes, and renewable energy subsidies. Based on these, the total amount of carbon gas generated and the entire probability of power failure are determined. The goal of the government is to optimize these variables.

An electricity gaming model was implemented by the agent programming environments, NetLogo and HubNet, which was operated from each terminal connected to the local network.

6 Results and Discussion

Figure 2 shows the proportion of each energy source, the amount of CO2 emissions, and the transition of the power failure probability. In the initial stage, the proportion of thermal power generation exceeded 60%; however, it declined gradually, finally going down to less than 40%. This also reduced the amount of carbon emissions (Fig. 3). The first hypothesis, which energy transition to renewable source is achieved by players while keeping their profit, has been adopted with this result.

On the other hand, the proportions of nuclear power generation and renewable energy power generation increased. This is because of the influence given by the energy orientation of consumers. In particular, the proportion of renewable energy gradually increased in tune with the orientation of consumers, while it declined in the later stages. This result might be because whereas the power generation proportion of each electric power supplier was inclined toward the use of thermal power generation in the initial stage, the energy orientation of consumers was about 1/3. Therefore, there must have been an incentive that worked where the order volume increased by changing the power generation investment according to this proportion (Fig. 4).

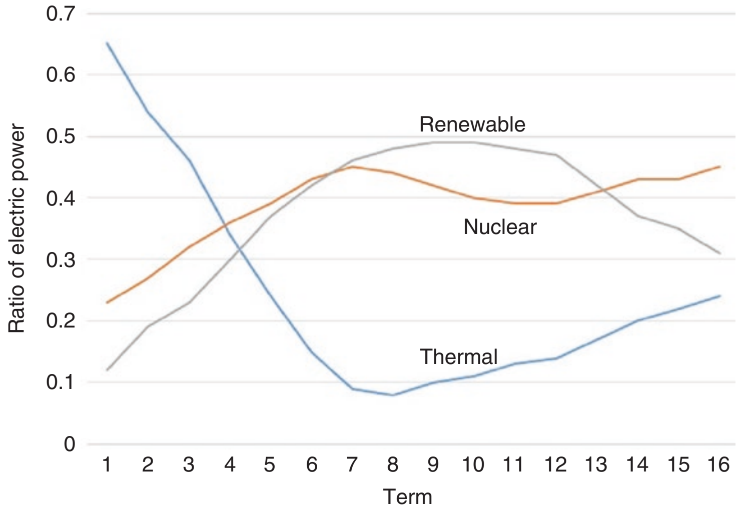

Fig. 2 Trend of energy source rate

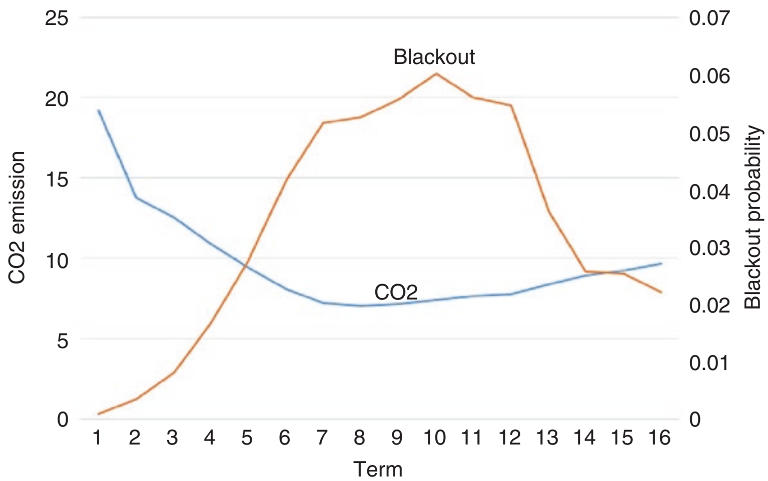

Fig. 3 Trend of CO2 and blackout rate

However, the situation, which was originally expected that the proportion of nuclear power generation decreased, was not observed, while nuclear energy with lower cost and carbon gas emissions continue to be relied on. This result shows that the management of electric power suppliers gave the first priority to maximizing their profits while giving almost no consideration to risks of nuclear power generation accidents. On the other hand, the aggregator agent made profit as well as suppliers players, but it could not monopolize the electric consumer market because

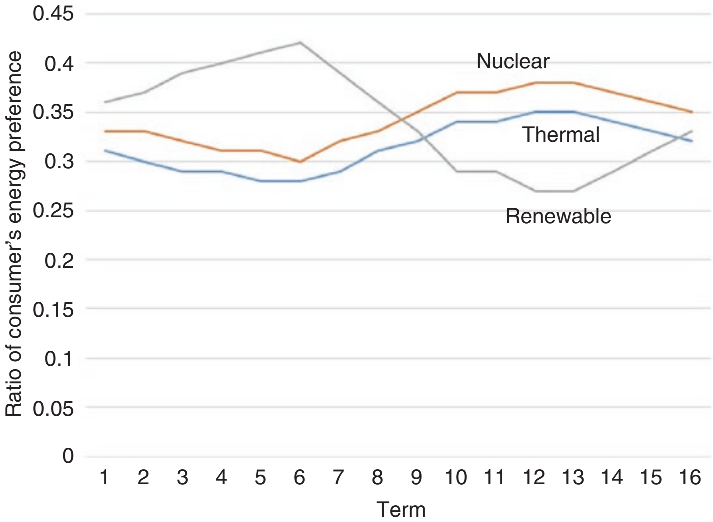

Fig. 4 Trend of consumers' energy preference

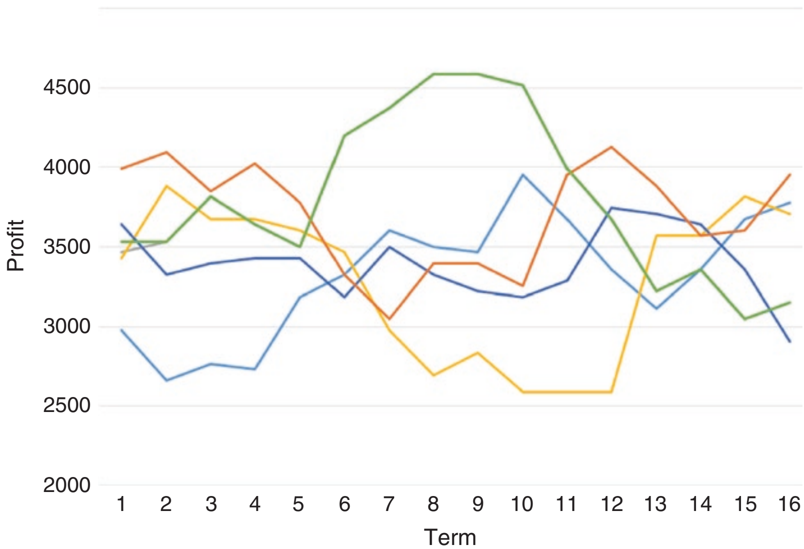

Fig. 5 Trend of players' sales in the power market

one possibility is that the supplier players learnt how to keep their market share in competition from the aggregator (Fig. 5). The second hypothesis, which aggregators have ability to control the energy market through the share of consumers' power market as well as other two-sided markets, was rejected with the result.

7 Conclusion

In this research, based on agent-based models, serious games, design of electricity market platforms, and social network models, we built a model having the items below as purposes.

- Design of competitive electricity market platforms
- Design of incentive mechanisms for imbalance adjustment
- Evaluation and examination of mechanism design based on agent-based gaming

The goal of this study is to clarify decisive factors for making decision of energy selection based on human competitive and collaboration behavior to be helpful for an incentive design of energy markets. For the purpose, two hypotheses were set in the experiment. First is that energy transition to renewable source is achieved by players while keeping their profit. Second is that aggregators have ability to control the energy market through the share of consumers' power market as well as other two-sided markets.

Our experiment confirmed that the energy orientation of electric power consumers could give a significant influence on power generation investment of electric power suppliers, and the risk of nuclear energy was underestimated. And the first hypothesis was adopted, and the second was rejected by the experiments through the agent-based gaming. These findings enabled us to analyze the decision-making process of people and operators while being able to obtain effective knowledge regarding social ecosystems which disseminate renewable energy and adaptive behavior. In the future, we are going to examine gaming models for system evaluation in liberalized electricity markets including aggregators as electric power wholesalers.

Acknowledgment Supported by JSPS KAKENHI Grant Number JP17H02035.

References

1. Unno M, Xu H (2012) Optimal platform strategies in the smartphone market, the trans-actions of the Institute of Electrical Engineers of Japan. C, A publication of Electronics, Information and Systems Society 132(3):467–476
2. Bacon DF et al (2012) Predicting your own effort, international conference on Autonomous Agents & Multiagent Systems (AAMAS'12) (2): 695–702
3. Jager W, Van der Vegt G (2015) Management of complex systems: towards agent-based gaming for policy. In: Janssen M (ed). Policy practice and digital science: integrating complex systems, social simulation and public administration in policy research Springer Science in the Public Administration and Information Technology series edited Christopher G. Reddick
4. Rochet J, Tirol J (2006) Two-sided markets: a progress report. RAND J Econ 37(3):645–667
5. Sannikov Y (2008) A continuous time version of the principal-agent problem. Rev Econ J Stud 75(3):957–984
6. Grimm V (2005) Pattern-oriented modeling of agent-based complex systems: lessons from ecology. Science 310:987–991

Using Role-Play Game for Active Learning to Solve Water Inequity

Warong Naivinit, Wanpen Suwanna, Satit Sena, and Duangmanee Nareenuch

Abstract In 2009, a challenging policy of the Ubon Ratchathani Provincial Administrative Office was launched aiming at the better livelihood of farmers. One scheme was to supply more water to farming areas through pipeline infrastructure. The piping irrigation is beneficial to rice-producing areas by boosting rice productivity. As a result, members of this water user group have expended and caused water use conflict since the water is inequitably managed. The objective of this research was to solve the water use conflict and facilitate the water users to create an equitable and sustainable piping irrigation management through an active learning process. A role-play game (RPG) was built and used for active knowledge exchange activities organized in the village. Playing RPG assisted the participating water users to build a shared representation of the piping irrigation system and observed the "butterfly effect" of interactions at micro level to the system at macro level during gaming sessions.

Keywords Role-play game · Active learning · Equitable water management

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1 Introduction

Northeast Thailand is mainly a large plateau on sandstone, called “Isaan,” which is usually characterized by poor soils and under the influence of the erratic monsoon rainfall. It covers one third of the Kingdom’s area and contains a third of its total population. The Isaan region is also, by far, the poorest of the country which has an average monthly household income of about 8800 baht (190 euro) as reported by the National Statistical Office of Thailand and is still a major “rainfed lowland rice (RLR)”-growing area on 5.7 millions of hectares [1–3]. Because of its severe agro-ecological constraints, the paddy yields are low with an average of some 1.8 t-ha^{-1} [4]. Two sub-regions can be distinguished: the Chi and Kong Basins in the upper part and the Mun Basin in the lower northeast. The upper northeast is characterized by an undulating topography favoring the adoption of important industrial cash crops such as kenaf, cassava, and sugarcane. In the more monotonous lower north-east, the agricultural diversification out of rice is still far more limited.

Although the northeast has the largest rice-producing area of the country, only 6% of its paddy fields were irrigated in 2005. Inadequate access to irrigation forces agricultural production to depend mainly on highly variable rainfall, and successful crops are still relying on “a bet on the monsoon” approach. At the household level, the development of on-farm water resources based on tens of thousands of small farm ponds (storing a maximum of some 1260 m^3 of water), under the responsibility of the Agricultural Land Reform Office (ALRO), Ministry of Agriculture and Cooperatives, has been well-adopted by farmers during the past 15 years. Even if the past agricultural research and development efforts emphasized agricultural intensification by alleviating the risk of drought and improving soil fertility, their impact has been limited.

In 2009, a challenging development program of the Ubon Ratchathani Provincial Administrative Office (PAO) was made to improve the livelihood of RLR farmers. One important scheme was to supply more water to farming areas belonging to resource-poor farmers through pipeline infrastructure. To get this support, however, farmers have to express their strong will by forming an official water user group. As a result, a water user group of RLR farmers from five villages (five subgroups of water users) in Bungmalang sub-district, Sawangweerawong district, Ubon Ratchathani province was quickly established, and subsequently, the piping irrigation was constructed in 2009 (Fig. 1). Piping is considered an effective small-scale irrigation to increase farm productivity and mitigate drought because the loss of water on delivery is minimized. Nonetheless, it requires considerably high financial support for construction and constant maintenance to ensure that the system can be fully operated. The other drawback of piping irrigation is its limited access making its usefulness exclusively for farming areas where the pipe is rested. To overcome these shortcomings, it is important that water users must regulate this system with fairness in terms of management and charges of operational cost.

After the piping irrigation was constructed, it is beneficial to rice-producing areas by boosting rice productivity, e.g., double rice crops per year. For farming areas where water is limited in dry season, farmers are able to grow cash crops such

Fig. 1 Piping irrigation system completely constructed in Bungmalang sub-district, Sawangweerawong district, Ubon Ratchathani province, 2009

as vegetables. Consequently, more farmers have registered to be members. Unfortunately, nothing regarding the proper water and group management was transferred to this water user group prior to construction of these irrigating pipes. Thus, the profit generated from this costly infrastructure was inequitable causing conflicts among water users and becoming more intense. The only solution that RLR farmers could figure out was to increase water availability.

However, after completing site survey and analysis, we found that the volume of water was enough to supply the targeted farming areas. Instead of questioning the improper water management, most water users perceived this as troublesome as it was caused by inadequate water budget. As a result, they requested the state agencies for physical improvement of water sources and more piping network. This misunderstanding became our initial research question which helps the water users realized that the problem they are facing is caused by their improper water management and not by inadequate water quantity and limited piping network. The second question was how to help them comprehend that their current farming practices at the individual level have impacts on other water users and the available water budget as a whole. We assumed that the active learning process involving all subgroups of water users to build a shared representation of the system by integrating perceptions of diverse water users should be able to assist them to understand each other and attempt to find solutions collectively. Therefore, our research objective was threefold: (i) to understand interactions between biophysical (piping networks, rice production, water resources) and socioeconomic (water use behaviors and economic return) dynamics, (ii) co-design an interactive mediation with water users and use it for group discussion, and (iii) get collective agreement among water users about water management problem.

2 Conceptual Framework and Methodology

The study site is located in Bungmalang sub-district, Sawangweerawong district, Ubon Ratchathani province, Thailand (Fig. 2). At the initial stage, our research team was founded on the basis of active collaboration among four key stakeholders including RLR farmers as representatives from five villages, Ubon Ratchathani Provincial Administrative Office (PAO), Nature Care Foundation as a representative of Thailand Research Fund (TRF), and Faculty of Agriculture, Ubon Ratchathani University (UBU).

This action-oriented research is based on people's participation [5] and collaborative or participatory approaches that rely heavily on the active involvement of concerned stakeholders from the initial stage to the end of research process (Fig. 3). The collaborative or participatory approaches emerged as a response to lengthy and top-down planning process in rural development projects and to the failure of the transfer-of-technology model which had been predominant from the 1960s to the early 1980s [6]. Such technological transfers are likely to fail in highly heterogeneous and marginal areas when top-down developments are implemented regardless of the involvement of concerned stakeholders [7]. In this case study, the research process refers to the collaborative design of role-play game (RPG) and uses this RPG as a promising mediated tool for active knowledge sharing activities among heterogeneous stakeholders including water users, scientists, and local administrative officers (Fig. 4). The collaborative process supports knowledge integration between academic and indigenous knowledge. This process also supports capacity building [8], helps to resolve conflicts and build consensus [9], and creates networking opportunity [10].

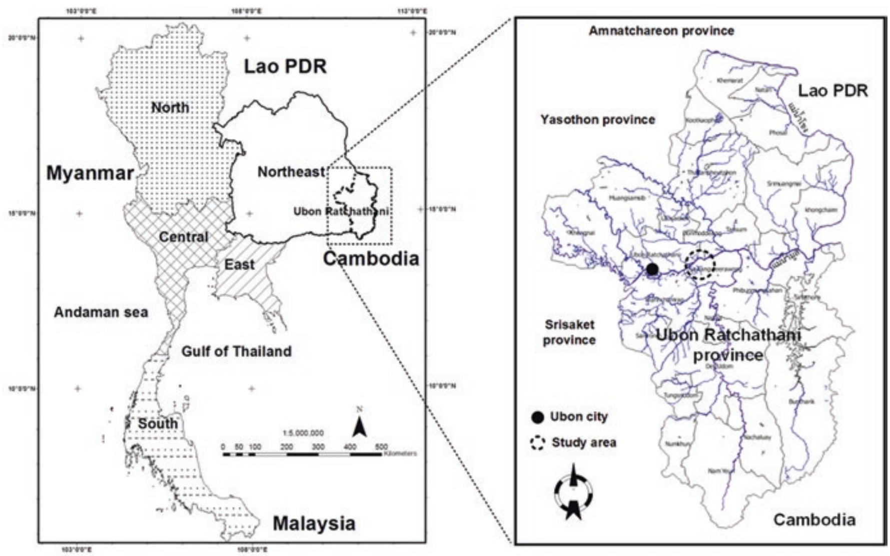

Fig. 2 Location of the study site in Bungmalang sub-district, Sawangweerawong district, Ubon Ratchathani province

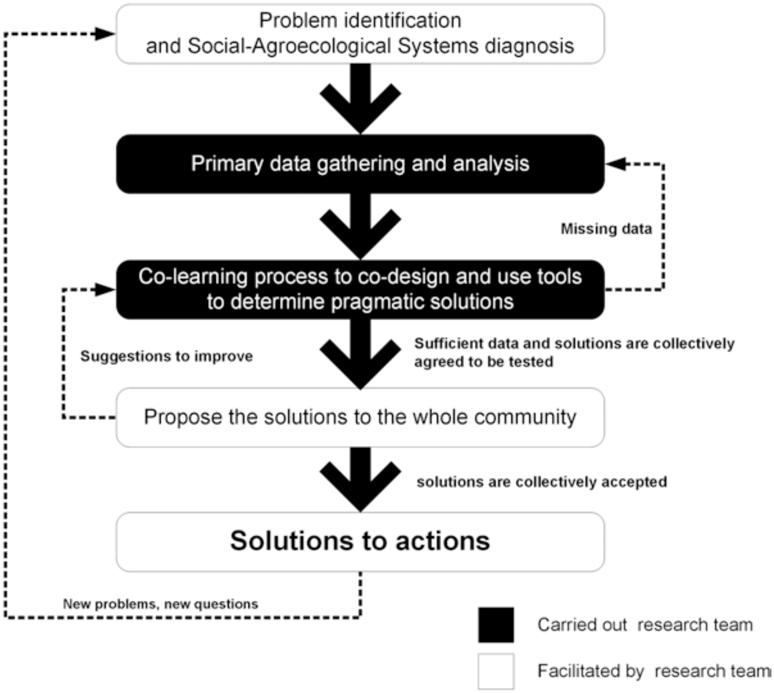

Fig. 3 Conceptual framework of this research project

To understand interactions between biophysical and socioeconomic dynamics, we reviewed the agrarian diagnosis results of another research project carried out in the same study area [11]. The information obtained from such a review were synthesized with the preliminary findings on specific issue regarding interactions between piping networks, rice production, water resources, water use behaviors, and economic return. To verify and validate our understandings, we organized several participatory workshops with water users. At the beginning, we applied a method called PARDI [12] to build a mutual understanding with water users about the water management problem and related elements found in this piping irrigation system. Then, we elucidated the opportunities and constraints of each subgroup of water users regarding biophysical settings through a participatory mapping and self-cropping calendar workshop (Fig. 5). Although, after such workshops had been organized, all water users better understood the current situation and agreed upon that the problem was improper water management issue rather than the water resource limitation, the methods and tools that we used could not effectively disclose the interactions among water users. The exploration of possible solutions was not achieved. Such explorative foresights are important to simulate the participants to collectively find pragmatic ways to solve their water management problem.

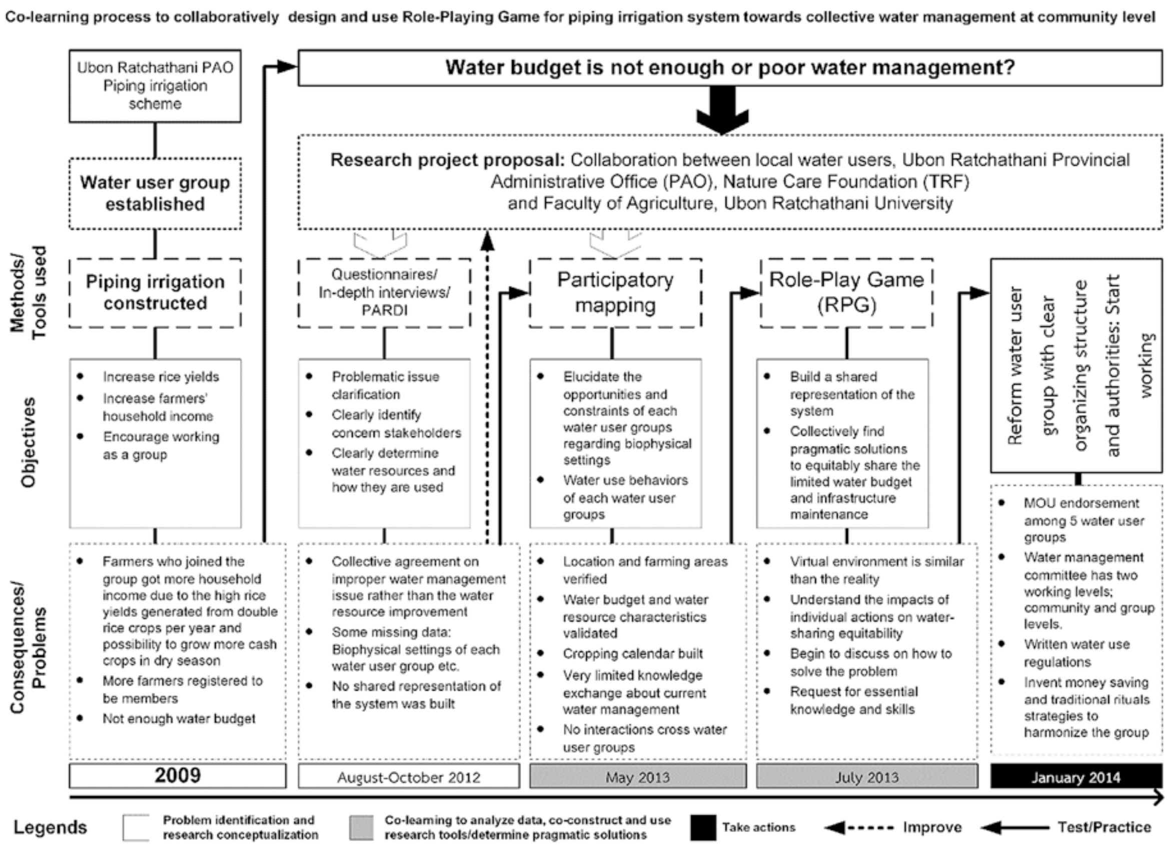

Fig. 4 A series of participatory workshops through the research process from 2009 to 2014

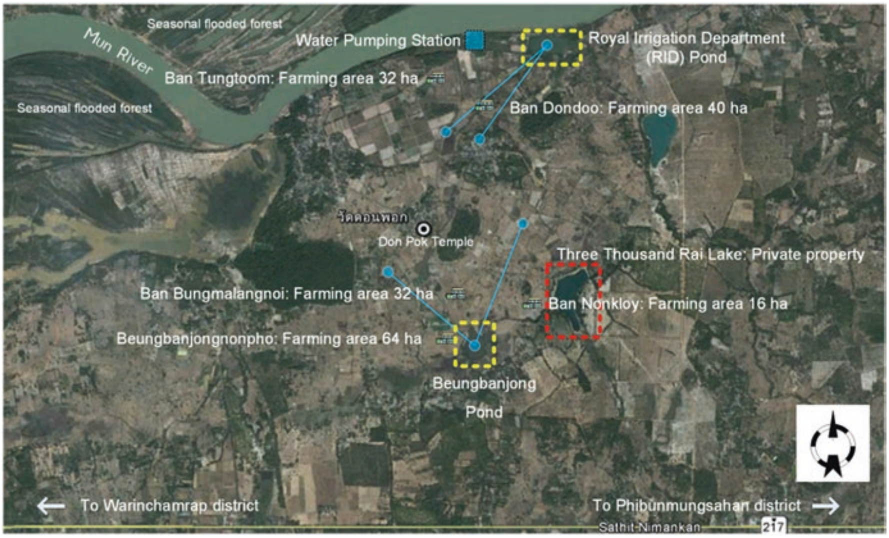

Fig. 5 Piping irrigation network created by water users during participatory mapping activity

3 Water-Sharing Role-Play Game

Because of limitations found in the previous methods and tools, a highly interactive tool, role-play game (RPG) of another research project that was purposely used for an agent-based model design on food security issue in this study area [9], was co-modified with participating water users. A RPG is a kind of model, which is a simplified representation of the actual system, a synthesis of what we know about the system with references to the problem at stake [13]. In this case study, the water-sharing RPG was used to reveal the interactions between water budget dynamic and water use behaviors so that a shared representation of the system would be built through a series of participatory gaming workshops played by representatives from five subgroups of water users. The gaming session comprised four predefined successive scenarios, i.e., dream, business as usual (baseline), ideal, and worst-case.

3.1 Predefined Scenarios

"Dream" scenario simply refers to "all-good," i.e., adequate water budget for all groups, free water access, and high price of rice (25 baht per kg). The objective of this scenario is to test the players' understandings about game settings and procedure. In addition, the players become accustomed to playing on the virtual environment with simple game settings before playing scenarios that are more complicated.

“Business as usual” or “baseline” is a scenario when the players deal with real conditions that natural and economic factor is uncertain and limited water budget is exploited as it is now. The weekly precipitation based on actual statistic annual rainfall quantity and distribution is announced at the beginning of each gaming step, and the players decide what action they would like to take. In this scenario, the players are not allowed to discuss across subgroups of water users. The price of rice is set at 15 baht per kg and could be changed over time. This scenario is proposed to reveal the impacts of individual actions on the entire system.

“Ideal scenario” is similar to the “business as usual,” but all players are allowed to discuss prior to take actions. This scenario is designed to illustrate the effect of better communication and use the outputs of this scenario to show differences between collective actions and individual ones played in the baseline scenario.

“Worst-case” scenario plays a critical role in stimulating the players to acquire a foresight how to adapt their farm management to handle undesirable circumstances caused by low precipitation and very low price of rice at 5 baht per kg.

3.2 Game Settings

The gaming step is week and one playing-round represents one cropping year. We played four rounds (scenarios) per gaming session. The RPG was played by ten selective players from five villages. The game board is produced based on the landscape in reality, but it is much simpler and more abstract (Fig. 6). One grid is equal to 3.2 ha (20 rai). Once the game begins, the game moderator announces week and month (lunar calendar) and weekly precipitation. Then, the players decide what actions, e.g., grow rice, use water, and sell rice, they want to take. The players need to record their actions on the decision paper and submit it to a game assistant to put the data in the Excel spreadsheet. The players will be charged if they use water and will get their income when their rice is sold (Fig. 7). Two workshops were organized in the village. The first gaming workshop was facilitated by the research team, while the experienced players took a game moderator role for the second workshop (Fig. 8).

4 Results

The water-sharing RPG was accepted by the players that it sufficiently represented the reality and issue at stake. Thus, the players’ actions that happened in the game were not different from what were found in the reality. Furthermore, thanks to the RPG co-design/co-modification process, the sense of ownership and understanding of game algorithms found in the players is exceptional. The RPG successfully stimulated the players to realize “the butterfly effect” caused by unintended actions at the individual level. This incident was obvious when the baseline scenario was

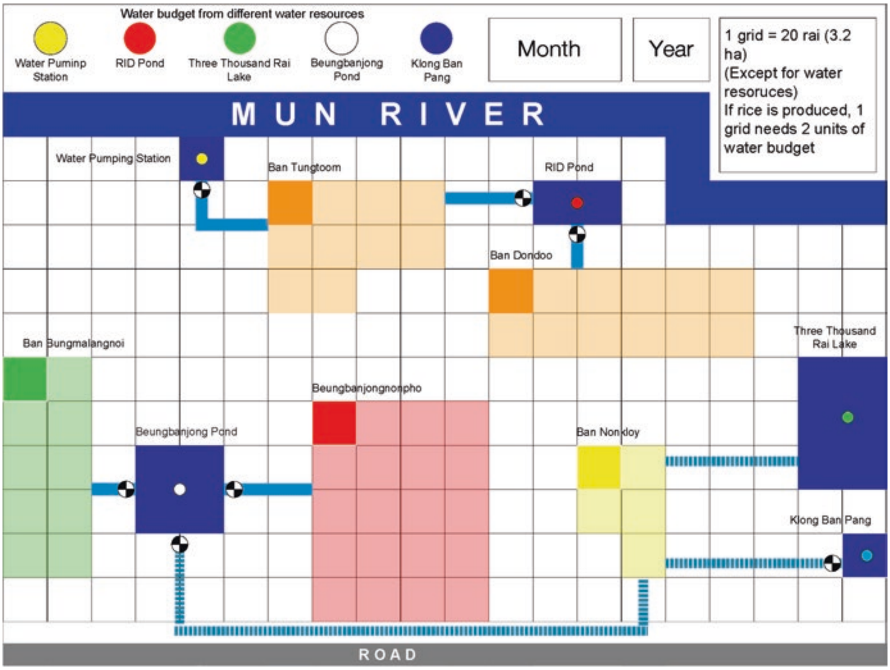

Fig. 6 Game board representing simple settings of agroecological system and piping irrigation network found in the study site

played. In the "baseline" scenario, players' actions were mainly based on weekly precipitation information and observed virtual water budget in public water resources. Six players belonging to three subgroups of water users could not use water to grow rice because two subgroups of water users whose farming areas are located close to public water resources used all limited water budget. They began discussing about this undesirable result of this scenario.

In the "ideal" scenario, the game settings are not different from the baseline one, but the players were allowed to freely discuss before taking actions what they wanted to do. We found that the players adapted their water management practices. It is not only the water budget that was shared more fairly, but also it was conservatively used to ensure water availability for off-season rice production. Some players also adapted their rice-producing practices in order to minimize the effect of water scarcity such as decreasing rice-producing area, looking for alternative water sources (even more expensive ones), and applying less-water-consuming direct seeding technique instead of transplanting one. The "worst-case" scenario stimulated the players to realize how collaboration and communication were so important to reduce the negative impacts caused by natural and economic factors. Moreover, the players perceived that there were many unpredictable and uncontrollable factors influencing their livelihoods. They even said if the situation like what they experienced in the "worst-case" scenario had happened, they would not have been able to

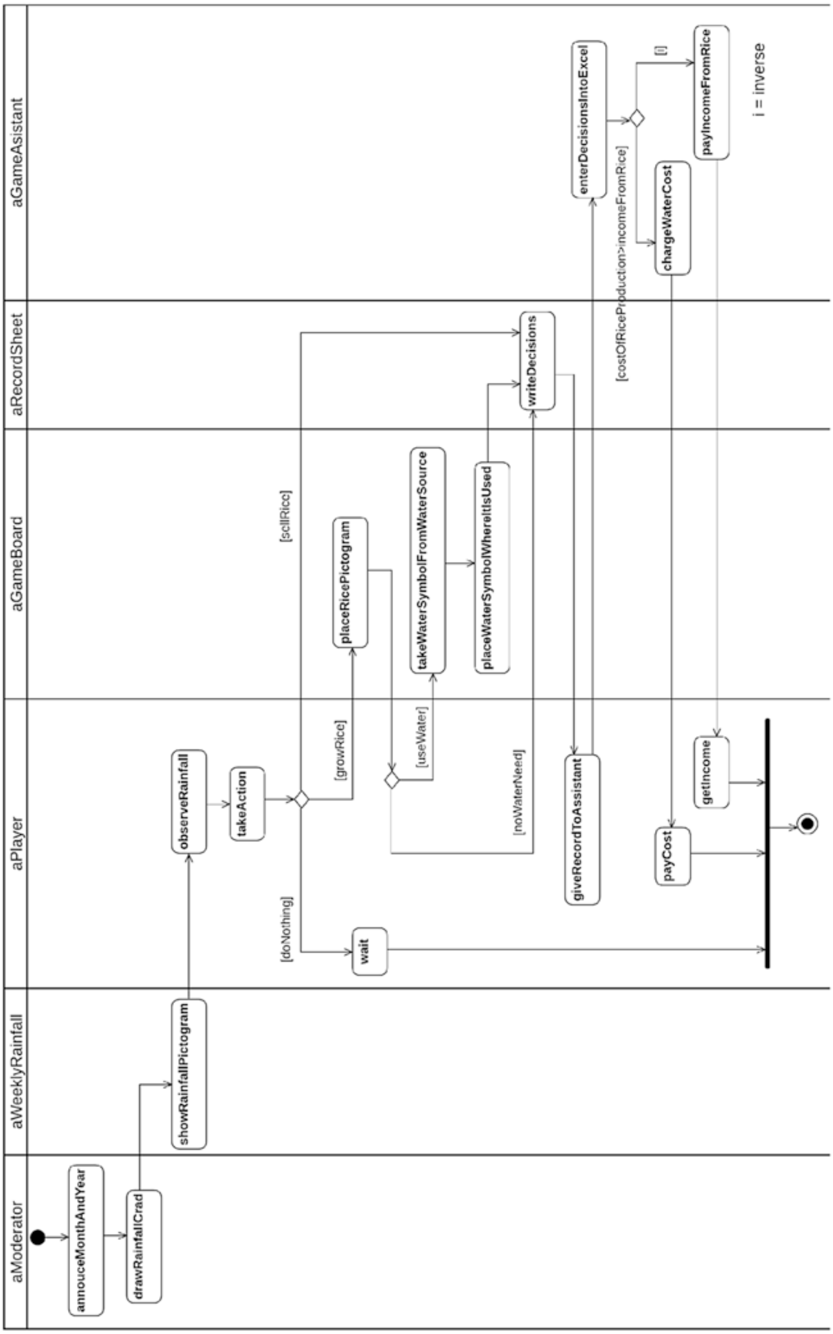

Fig. 7 Gaming steps shown in an UML activity diagram

Fig. 8 Gaming session played by ten representatives of water users from five villages at Don Pok Temple, Bungmalangnoi village, and facilitated by research team on July 7, 2013

get through. During the debriefing, comparison between scenarios in particular for baseline and ideal scenarios was very useful to show the significant positive changes, e.g., rice yields, water uses, and household income distribution. Once the shared representation of the system was built through the gaming sessions, we found changes as the following.

Knowledge Acquisition After two participatory gaming workshops were organized, the participating water users shared their experiences of what they did during these two workshops to their neighbors. All groups then agreed that they were not capable to manage a large number of water users. They asked the research team to provide essential knowledge and strategies to minimize this drawback. Since the group management is not an expertise of this research team, we facilitated a special workshop led by invited experts from UBU to help water users on this matter. Money saving and traditional ritual strategies were the outputs from this special workshop. These strategies are used to attract people to join the water user group and motivate them to attend the meetings. Another concern was what cash crops should be produced to replace the heavy water-consumption rice production. On this matter, we invited the head of sub-district agricultural extension to give them the list of possible cash crops and how to grow them. Furthermore, we organized a field trip for the representatives of five villages to exchange their knowledge and experiences with other farmers who succeeded in vegetable production.

Change in Perception All water users realized that without effective regulation enforcement, current limited water budget would lead to serious water-sharing conflicts. The equitable water use regulation and water budget monitoring were urgently needed.

Change in Decision-Making More RLR farmers adopted to grow the less-water-consumption crops based on knowledge shared and actively learnt from experienced RLR farmers and invited speakers.

Change in Behavior A number of water users who attended in the meeting are increasing, thanks to the money saving strategy. In addition, better and friendlier communication among water users was also noticeable, in particular the communication skill of participating water users who joined the research project at the beginning.

Change in Actions The representatives of five villages developed water management strategic plan and endorsed the first memorandum of understanding (MOU). The previous water use regulations were revised, and a new goal was set to harmonize with the water users for unity of the community as a whole. A new water management committee consisting of two working levels, community and subgroup levels, was formed to replace the former one. The heads of each subgroup are ex officio committee at the community level. The community committee looks after the entire piping irrigation system, while five working teams led by five heads of each subgroup manage the piping irrigation rested in their own village.

With this clear organizing hierarchy, all necessary information can go through the leaders of each group to water users. Likewise, all demands of water users can reach at the community level. Moreover, the community committee as a representative of all water users becomes more powerful to consider which state supports should be implemented to achieve the community's goal. Consequently, in 2017, the Tambon (sub-district) Administrative Office accepted the success of this research project and decided to take part as a facilitator. The other eight groups of water users in this sub-district decided to join and applied the same regulations and strategies to manage their piping irrigation.

5 Conclusions and Discussion

The research proved that the active involvement of concerned stakeholders throughout the active learning process is indispensable when dealing with any complex issues in particular, the renewable resource management. The diversity of participants plays a vital role in building a shared representation of the system leading to mutual understanding of each other.

In this case study, the engagement of four key stakeholders including farmers as resource users collaborating with Ubon Ratchathani PAO as policymaker and UBU and Nature Care Foundation as accepted neutral facilitators play an important role in achieving conflict resolution regarding the equitable piping irrigation management. However, changing attitudes and keeping development momentum through this kind of participatory process are time-consuming and still require continuous motivations and collaboration from these four partners. Once the research project completes, the monitoring and long-term evaluation should be carried out. Unfortunately, this interesting activity was not propositioned in this research project.

Co-design and/or co-modification of water-sharing RPG is very effective to create a sense of ownership leading to the acceptance of results that emerged from the use of RPG. Additionally, the relationship between the research team and participants was promoted through friendly interactive knowledge sharing activities. With the transparent RPG structures and rules, the RPG can be potentially used to facilitate the knowledge exchange among concerned stakeholders. During the evaluation, participants underlined the importance of instant group discussion while playing the game. They agreed that it was an effective way to exchange experiences, ideas, and opinions. They also agreed that non-threatening and playful atmosphere of active knowledge sharing activities triggered lively and friendly debate on topics people usually did not discuss.

Nevertheless, this complicated RPG requires some computer-assisted game plays, such as Excel spreadsheets, and it, hence, necessitates having game assistants to help players. With these shortcomings, particularly about analytical and computer skills, our local researchers are incapable to design and facilitate a RPG by themselves. Furthermore, the neutrality could become an issue, especially if the local researcher who acts as a facilitator is one of the key stakeholders. Therefore, the method and knowledge of this research process should be transferred to agricultural extension officers so that they can develop and use tools to solve problems together with farmers.

Based on the in-depth interviews with our research collaborators, we found interesting reflection. In political point of view (PAO), development schemes such as improvement of water resources are certainly necessary to levitate livelihood of local farmers, but it should be done due to the needs of the community through participatory learning processes. In academic perspectives (UBU), the systematic monitoring and evaluation should be considered as a core activity in this kind of research process to clearly identify that any changes that have taken place are the outcomes and impacts of the research. Regarding the research tools used, since playing RPG is costly, time-consuming, and difficult to be modified to discover undefined scenarios while it is being played, the conversion of RPG to agent-based model (ABM) and use of AMB in a participatory simulation workshop would overcome these constraints. Particularly, when issues of concern have not yet reached a crisis point but it is likely to cause problems in the future, the active learning process may take a longer time and require special tools such as computerized models for participatory analysis and exploration.

Acknowledgment The author would like to thank the Thailand Research Fund (TRF) for its financial support.

References

1. Office of Agricultural Economics, Agricultural statistics of Thailand, crop year 2006/2007 (2007) Office of Agricultural Economics (OAE), Ministry of Agriculture and Co-operatives: 151, Bangkok, Thailand
2. Jongdee B et al (2006) Improving drought tolerance in rainfed lowland rice: an example from Thailand. Agric Water Manag 80(1–3):225–240
3. National Economic and Social Development Board (2003) Thailand's official poverty line. National Economic and Social Development Board (NESDB): 14, Bangkok, Thailand
4. Somrith B (1997) Cultivar improvement for rainfed lowland rice in Thailand. In: Proceedings of breeding strategies for rainfed lowland rice in drought-prone environments, ACIAR Proceedings 77. Ubon Ratchathani, Thailand
5. Cohen JM, Uphoff NT (1980) Participation's place in rural development: seeking clarity through specificity. World Dev 8(3):213–235
6. Neef A (2005) Participatory approaches for sustainable land use in Southeast Asia: 407, White Lotus, Bangkok, Thailand
7. Ashby JA, Sperling L (1995) Institutionalizing participatory, client-driven research and technology development in agriculture. Dev Chang 26:753–770
8. Fitzpatrick P, Sinclair AJ (2003) Learning through public involvement in environmental assessment hearing. J Environ Manag 67(2):161–174
9. Walkerden G (2006) Adaptive management planning projects as conflict resolution processes. Ecol Soc 11(1):48
10. Roux DJ et al (2006) Bridging the science management divide: moving from unidirectional knowledge transfer to knowledge interfacing and sharing. Ecol Soc 11(1):4
11. Naivinit W (2014) Collaborative modeling to co-produce risk analysis with multi-stakeholders: relationship between seasonal flooded forest management and local food security: 176, Faculty of Agriculture, Ubon Ratchathani University, Bangkok, Thailand
12. Etienne M, Toit D, Pollard S (2008) ARDI: a co-construction method for participatory modelling in natural resources management: iEMSs: international congress on environmental modelling and software: integrating sciences and information technology for environmental assessment and decision making. 2008. Barcelona, Spain
13. Banks J (ed) (1998) Principles of simulation, in handbook of simulation: principles, methodology, advances, applications, and practice: 3–30. Wiley, Atlanta

Part IV
S&G in Disaster Management

Gaming Simulation as a Tool of Problem-Based Learning for University Disaster Education

Yusuke Toyoda and Hidehiko Kanegae

Abstract This chapter addresses the connection between gaming simulation (GS) and problem-based learning (PBL) in disaster education. First, the chapter explains their relations theoretically and describes the introduction of Evacuation Simulation Training (EST) for earthquake evacuation to university students. EST empowered both Japanese and international students to conduct research, integrate models and practice, and apply their knowledge and skills to develop viable solutions to defined problems. Finally, the chapter demonstrates the utility of GS as a tool of PBL.

Keywords Gaming simulation · Problem-based learning · Disaster education · Community

1 PBL and GS

Solving regional problems requires cultivating human resources. While some universal or common characteristics exist, each region has its own unique features, such as its history and culture nurtured indigenously. Thus, regions develop according to their own characteristics and strengths.

Problem-based learning (PBL), according to Savery [1], is an instructional learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply their knowledge and skills to develop viable solutions to defined problems. He adds that critical to the success of this approach is the selection of ill-structured problems and a tutor who guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience.

On the other hand, gaming simulation (GS) allows participants to experience important lessons in a game world or virtual world created by games [2]. GS is used as an educational tool in which participants experience what they cannot or hardly

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experience in a model (game) world [3], learn lessons, and apply the lessons to the real world. As this method allows them to learn by experience and often in groups, they understand more holistically through self-experience and social learning than with other pedagogies. Moreover, as it is a game, the students can fail in safety and learn from their mistakes so that they do not make similar mistakes in reality [2].

From the viewpoint of students, the learning environments of PBL and GS are different. Specifically, PBL takes place in the real world whereas GS offers a virtual world. However, when it comes to the pedagogical design, both start with ill-structured problems facing real society. PBL and GS have some components in common or close learning bases, such that PBL's learning process, as Dolmans [4] puts it, is based on constructive, self-directed, collaborative, and contextual learning, all of which are applied in GS, and therefore, the two pedagogies may be combined effectively for education.

This chapter introduces GS for community-based disaster risk reduction (DRR) and shows that this GS can be applied within university disaster education in the form of PBL. The following sections briefly address the advantages of GS for community-based DRR, explain one GS designed by the authors for the aforementioned purpose, and describe the results of one implementation of the GS in the form of PBL for university students.

2 GS for Community-Based DRR

One of the lessons learned from past disasters in Japan is the importance of mutual help among residents. They are the first responders after disasters and the ones who know the most about their living areas, which means they can give valuable input on the appropriateness of policies in their local community [5]. The Japanese government and other national governments promote residents' mutual help by seeking their participation and cooperation in preparation for a potential disaster. However, preparation efforts are only partway to the goal, and earthquakes do not wait for human preparation. Improving mutual help is an urgent task. Moreover, it is important for the younger generations, such as university students, to recognize this need.

Related to disaster education, previous studies have concluded that DRR education is more likely to succeed if educators focus on students' behavior based on experience rather than teaching classes or seminars using textbooks. Toyoda [6], referring to Shaw et al. [7] and Yamori [8], summarizes that in addition to increasing disaster awareness, it is important to encourage participants to find solutions and understand their capacity and to connect their learning with their communities or own lives.

In GS, players experience disaster situations in a virtual gaming world and can learn lessons from failure without any risks. Such experiences teach them more than lectures or other conventional education methods. Moreover, as one of the GS components in interactive role-play, participants experience and understand reality through the virtual world and gain varying viewpoints; therefore, GS involves learning-by-doing.

One of the most important GS components is the after-game play debriefing, during which trained facilitators calm the participants down and encourage them to (re-)recognize what they experienced in the game and reflect on its connection to reality, which strengthens their learning and gives the participants a stronger connection to the reality of disaster situations than more conventional methodologies.

When designing these types of GS, designers are able to incorporate models based on lessons learned from past disasters in the game world, which means that the participants experience the realities of the real world through the game play, achieve their own goals by following the rules and their assigned roles, and understand how their decisions influence the game results through a dynamic model where decisions are the inputs and consequences are the outputs.

In a community-based DRR context, the participants can take on the role of residents who have no evacuation information, local community leaders, or any other roles in the game world. By playing within their designated roles, players learn the effect of their decisions after the disaster changes the situation. They experience what they can do and the consequences in disaster situations, all of which are reflected in the debriefing. As such, theoretically, GS can fulfill all the main objectives of disaster education.

3 Evacuation Simulation Training for DRR

This section introduces university students' experience of Evacuation Simulation Training (EST) that was originally designed to promote community-based DRR [5].

3.1 Outline of EST

Developed based on past disasters or previous studies on conditions in local communities, the EST first randomly assigns certain roles to participants that evacuees might be expected to face in an earthquake evacuation, such as being an injured person unable to navigate a street blocked by bricks or being someone who goes to a wrong evacuation shelter (based on wrong information). The participants are then required to act within these roles as players in the game world. The players evacuate from their own houses; however, they encounter various situations on their way to the evacuation shelter, such as streets being blocked by bricks or interactions with other players that they need to resolve. The goal is to reach the designated evacuation shelter. The EST can create situations similar to real disaster conditions. The EST was first implemented in a local community in Japan and then applied at the university level by the present authors.

3.2 EST for Japanese and International Students

In May 2017, the EST was carried out with ten Japanese university students and one teaching assistant (as one student came late, the participant numbers were nine or ten in this study, excluding the teaching assistant) who had registered for the "Simulation & Gaming" course in the College of Policy Science, Ritsumeikan University. The students first practiced engaging in GS and then designed and tried their own GS prototypes. The students were interested in a variety of subject areas from international relations to urban planning but had little knowledge about community-based DRR. The EST was one of the GSs for the students in the course (for detailed results of the game application for Japanese students, see Toyoda et al. [6]).

In addition, in November 2017, the EST was carried out with 13 foreign university students who had registered for the course "Sustainable Urban Policy I" held in the same faculty, in which students learn about DRR in general. Although they had some knowledge of DRR, the students had no experience of EST (while some students had experience with GS in another class taught by the first author of this chapter).

The students were asked to assume that their school building was the local community for the game and were required to evacuate from their houses to the evacuation shelter, which was a designated site inside the building. Following the initial briefing when the rules were given and roles distributed, the students as residents were required to go to designated sites (their houses) one by one so that they did not know where the other residents would evacuate from. At a designated time, they started to evacuate.

Some encountered events such as blocked streets, while others had to wait for rescue as their houses had collapsed and they were unable to evacuate. The specific situations and roles are shown in Table 1.

After the game, the students shared their evacuation experiences and discussed what they should have done during the evacuation and what they should have done before the earthquake. The game and discussion together took about 2 h.

Only in the Japanese student group, after the first game round, the students played the EST again (second round) but with different situations (only situation locations were changed from the first round) and different roles created by the facilitator based on their first-round suggestions, as itemized in Table 2, after which they had a second debriefing. The total time for the two EST rounds was about 4 h.

At the end of the game (after the discussion), the students received debriefing explaining the importance of mutual cooperation among residents based on past disasters and were given instructions for community-based DRR.

The questionnaires were distributed prior to the EST, and the Japanese students filled it out three times; before, during (after the first game), and after the debriefing, while international students completed it twice (before the game and after the

Table 1 Situations and roles in the EST (first round)

Situation	Role in the initial situation[a]	Knowledge[a]
1. The block walls fell down! The street is shut down and you cannot pass.	1. You are fine (no furniture has fallen down). You can begin to evacuate.	1. You do not know the location of an evacuation shelter.
2. Because of an aftershock, a house collapsed! If you are alone, you are stopped by the collapsed house. If you are in a group of two or more, another resident rescues you and you can pass.	2. You are injured by furniture falling down. But you can start evacuation.	2. You have overheard neighbors say that the location of an evacuation site is A (room number).
3. The block walls fell down! If you are injured on your leg. You can pass after 5 s if you are with one player who has no injuries.	3. You are buried under your collapsed house. You cannot evacuate without the support of three or more residents As you are pressed by heavy debris, you cannot talk until you are rescued. You are not injured.	3. You have heard from the neighbor that the location of an evacuation site is A (room number).
4. Because of an aftershock, a house collapsed! If you are alone or two, you got stocked by the collapsed house. You need three a more residents to get rescued. You need to wait for them. If you are in a group of three or more, you can escape, but it takes 30 s. You can pass after 30 s.	4. You are the community leader. You are buried under your collapsed house. You cannot evacuate without the support of three or more residents. As you are pressed by heavy debris, you cannot talk until you are rescued. Three years ago, you and the leader of Jisyubosaikai (community-based DRR group) designated the location of an evacuation site at B (site name). However, you are worried because many residents do not know it.	4. You have heard from the leader of Jisyubosaikai (community-based DRR group) the location of an evacuation site as B (site name).
5. The area seems dangerous because there are many wooden houses close together. But it is safe and you can pass.[b]		
6. This way seems safe and you can pass.		

[a]Roles distributed to participants are a combination of the initial situation and knowledge
[b]This situation is located near Situation 2

debriefing). The analysis hereafter is based on the student discussions, the questionnaire results, and the authors' observations as game facilitators.

4 Evacuation Experiences and Solutions Provided by Students

This section describes the results of the EST played firstly by Japanese students and then by international students.

Table 2 Situations and roles in the EST (second round)

Role in the initial situation[a]	Knowledge[a]
1. You are fine (no furniture has fallen down). You can start evacuation.	1. You do not know the location of an evacuation shelter.
2. You are the injured by furniture falling down. You can begin evacuating.	2. You have heard from the neighbor the location of an evacuation site is at B (site name).
3. You are the buried under your collapsed house. You cannot evacuate without the support of three or more residents. As you are pressed by heavy debris, you cannot talk until you are rescued. You are not injured.	3. You do not know the location of an evacuation site, but you know that the leader of Jisyubosaikai (community-based DRR group) knows the location and lives at E (room number).
4. You are the leader of Jisyubosaikai (community-based DRR group). You were traveling when the earthquake struck and were not at home. Please wait at D (site name) until the game ends.	4. You have seen the location of an evacuation site at C through a smartphone application provided by the city.
	5. You are a member of Jisyubosaikai (community-based DRR group). You know the location of an evacuation site at C. You are trained, so you have the capacity of two other people (even if one needs two people, you can rescue him/her by yourself alone).

[a]Rotes distributed to participants are a combination of the initial situation and knowledge

4.1 Experience of the Japanese Students

In the Japanese students' case, some students evacuated smoothly to the shelter, while others did not. The left-hand column of Table 3 presents some of the students' experiences. To alleviate the challenges in the game, the students proposed several solutions, which are shown in the right-hand column of the table. Although the students did not come up with suggestions for all the challenges, they offered suggestions for some.

Roles were revised in the second round according to the students' solutions in the first round. Some residents shared information and developed a housing map of residents who agreed to share their information (all decided by the facilitator), some residents were trained so they could perform rescues more effectively than others (one trained resident can perform rescues as effectively as two untrained residents), and some residents used a smartphone application to locate the evacuation shelter. The second EST also included a resident who was traveling and was not in the local community but had not informed the neighbors. This scenario was added so that the students could be aware of the uncertainties in disaster situations.

The second debriefing was conducted after the second game when the students were discussing the evacuation challenges. Although the students were more effective in searching for missing residents than in the first round, there were some additional challenges, some of which are listed in Table 3. Some new challenges revealed the insufficiencies of their solutions. It is evident that assessing suggested solutions is important and GS could be a tool for that purpose.

Table 3 Japanese students' challenges and suggestions for the EST

	Challenge/problem as input	Suggestion
1st round	Necessity of reinforcing houses	
	Finding out where other residents live	Share information about where residents live.
	Communicating with residents on normal days about how to rescue people who are buried alive	Promote communication among neighbors by holding events.
	Quickly finding the injured and the need to move in a group	Train some residents in rescue techniques.
	(With different information on the evacuation site)	Develop a smartphone application that identifies evacuation site locations.
2nd round	Several people searched places other survivors had already checked before separation.	
	It was not enough to simply make a resident housing map. Since people evacuated after the disaster, when the rescuers went to the houses, the residents were gone.	Residents can leave a note when they evacuate to indicate they have left.

After all the processes of the EST, the students described that they had learned the following: the importance of being prepared for a variety of situations; the importance of mutual help while, at the same time, greater emphasis on self-help since effective mutual help requires strong relationships between neighbors who can manage their own situations; and that the EST offers realistic experiences. Overall, most students recognized the importance of mutual help.

4.2 *Experience of the International Students*

The same process was carried out with the international students but only for one round. The questionnaire was distributed to the international students and analyzed likewise. The international students experienced similar problems to what the Japanese students did, as listed in the left-hand column of Table 4. Although they were less familiar with the Japanese context, the students experienced the simulated aftermath of a big earthquake and suggested solutions accordingly, as shown in the right-hand column of Table 4.

Table 4 International students' challenges and suggestions in the EST

Challenge/problem as input	Suggestion
Buried alive and no one was around. I think that's the biggest problem.	Achieve community help/effort (mutual help) by unifying residents and running drills.
I walked alone and got injured, and then I needed more people to help me.	Make emergency contact lists of neighbors and community members. Scream (if you can).
Aftershock, but at that time we had five people together, so the problem was solved.	
Everyone should know the locations of evacuation sites/shelters.	Display signboards with pictures.
Fake information about evacuation sites	

5 Conclusion

This chapter described the implementation of the EST for earthquake evacuation to university students. It showed that the students could experience the aftermath of a big earthquake and their suggestions were assessed in the second round, verifying that continuous GS play enhanced their DRR capacity. Although the model world was designed, for the students, the situation contained uncertainties.

Even though they made some mistakes or regretted their behaviors (problem), the students thought of solutions based on their learning from the lessons. Following the definition of PBL, the EST empowered the students to conduct research (to consider and discuss what happened and why), integrate theory and practice (in this case, theory was not embedded but lessons learned from past disasters were modeled in the game world, and the students could integrate what they experienced in the game world with what they knew already), and apply knowledge and skills to develop viable solutions (as depicted in Tables 3 and 4) to defined problems (challenges in evacuation after big earthquakes). Thus, this chapter demonstrated that GS can be a tool of PBL. This may be especially useful when students cannot do fieldwork on the topic, for example, the aftermath of a disaster situation.

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References

1. Savery JR (2006) Overview of problem-based learning: definitions and distinctions. Interdiscip J Probl Based Learn 1(1):9–20
2. Toyoda Y (2016) Gaming simulations with action learning for community-based disaster reduction training. Action Learn Action Res J 22(1):162–183

3. Crookall D (2004) Guest editorial: simulating risk and crisis. Simul Gaming Interdiscip J 35:340–343
4. Dolmans DHJM, Grave WD, Wolfhgen IHAP, van der Vleuten CPM (2005) Problem-based learning: future challenges for educational practice and research. Med Educ 39:732–741
5. Toyoda Y, Kanegae H (2014) A community evacuation planning model against urban earthquakes. Reg Sci Policy Pract 6(3):231–249
6. Toyoda Y (2018) Gaming simulations as the medium for disaster education in schools and community-based disaster risk reduction. Internet J Soc Soc Manag Syst 11(2):80–90
7. Shaw R, Shiwaku K, Takeuchi Y (eds) (2011) Disaster education (community, environment and disaster risk management). Emerald Group Publishing, Bingley
8. Yamori K (2013) Risk communication for mass disaster: new forms of disaster information. Minerva Shobo Publishing, Tokyo. (in Japanese)

A Study on Gaming of Participatory Evacuation Planning in Tourist Areas Using Agent Simulation

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Abstract The purpose of this study is to show the effectiveness of a gaming of participatory evacuation planning in tourist areas using agent simulation from the viewpoint of legitimate peripheral participation. This study conducted an experiment of the gaming to take a pre- and post-questionnaire survey of 32 students. We got two findings including two of the central components of legitimate peripheral participation. First, this gaming using agent simulation can function as a practical disaster prevention activity. Second, participants can join this gaming from their standpoint without special knowledge and skills. This study confirms that this gaming using agent simulation can facilitate collaboration between researchers and members of the public, which is an essential component of community disaster prevention.

Keywords Gaming · Evacuation planning · Participatory · Tourist area · Agent simulation · Earthquake

1 Research Background

Today, Japan receives a large number of tourists, both domestic and international, and the Japanese government is implementing policies to promote Japan as a "tourism nation." Meanwhile, there has also been an increase in the number of cases

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where tourists or tourist areas are damaged by typhoons or earthquakes. In the twenty-first century, which has been dubbed as the “century of disaster,” there is a pressing need to protect tourists, who are particularly vulnerable to disasters, from occurrences such as the large Nankai Trough earthquake predicted to occur in the future. Of particular importance is the task of considering how to efficiently evacuate tourists, who tend to be unacquainted with their location and the whereabouts of evacuation shelters.

Although much research has been conducted on the issue of evacuation, these studies have adopted an approach, known as PUS (Public Understanding of Science), similar to the traditional method of science communication, in which knowledge is transferred in a single direction from researchers to the general public. However, more recent forms of science communication have emphasized interactive dialogue between researchers and the public, known as PES (Public Engagement with Science). Attention has focused on the importance of bidirectional activities designed to deepen relationships between experts and non-experts through discussions, opinion sharing, and collaboration between researchers and the public; such activities are also important in the domain of evacuation studies.

When developing initiatives in the field of disaster prevention, what is needed to achieve collaboration between researchers and the public? Citing as an example the field of community disaster prevention, Yamori pointed out the need to apply the framework of “legitimate peripheral participation” of members of the public as an alternative to the model in which experts support members of a community [1]. “Legitimate peripheral participation” is an approach in which various laypersons, such as public servants, residents, and tourists, are involved (participation) as non-specialists (peripheral) in practical disaster prevention activities that are useful in the event of a disaster (legitimate).

Therefore, the purpose of this study is to demonstrate that the legitimate peripheral participation of the public is possible through the evaluation of evacuation plans for tourist areas created by members of the public using the gaming which implements agent simulation.

2 Related Work

This section reviews three categories of previous research on the subject of evacuation: research on evacuation simulations for tourist areas; research on the development of evacuation simulations aimed at public participation, disaster prevention education, and community planning support; and research on public participation and disaster prevention education that use evacuation-related simulations.

Research on evacuation simulations for tourist areas includes case studies of Himeji Castle [2] and Kiyomizu-dera Temple area [3]. However, these studies did not go as far as considering the reinvestment of results obtained through simulations to the public and people involved.

In terms of research on the development of evacuation simulations aimed at disaster prevention education, public participation, and evacuation planning support, some studies have focused on the development of simulations for supporting community planning for tsunami [4–6] and earthquake [7] disaster prevention. Although these studies examine evacuation simulations developed for the purpose of promoting disaster prevention education and public participation and supporting evacuation planning, the method itself has not been evaluated, nor have its effects been measured.

On the other hand, the following research has been conducted on methods that use evacuation simulations aimed at promoting disaster prevention education and public participation and supporting evacuation planning: a study that clarified the positive educational effects on tsunami awareness and evacuation intentions of presenting to members of the public the results of a tsunami evacuation simulation developed by the researchers [8], a study that clarified the potential of public participation-type risk communication using simulations [9], a study that indicated the positive effects on disaster prevention education of using simulations that express the state of the community during a flood [10], and a study that introduced evacuation-related issues using a simulation developed for members of the public in the target area and measured the qualitative effects of this [11].

Although these studies are examples of simulation research in which the areas that the subjects inhabit are examined as case studies, they are different from the present study in that the evacuees considered in the present study are tourists, and the evacuation planners are public servants or employees at tourist attractions. In addition, whereas previous research has used educational and learning effects as evaluation criteria, the present study focuses on whether the simulation-based gaming method facilitates collaboration between researchers and the public.

Thus, this study has two original points. First, it treats gaming to make an evacuation plan in tourist area which has not been done in previous research. Second, it focuses on legitimate peripheral participation, which is needed for community disaster mitigation.

3 The Gaming of Participatory Evacuation Planning Using Agent Simulation

3.1 Overview of the Evacuation Simulation

This section describes the agent simulation used in the gaming and the gaming of participatory evacuation planning.

The simulation used in the study was developed using Spot Oriented Agent Role Simulator (SOARS) [12]. Route networks were constructed as shown in Fig. 1 using Castle I, a fictitious tourist attraction, as the target case. In the model, a tourist enters the castle grounds every 2 s through the entrance, and after an earthquake, tourists

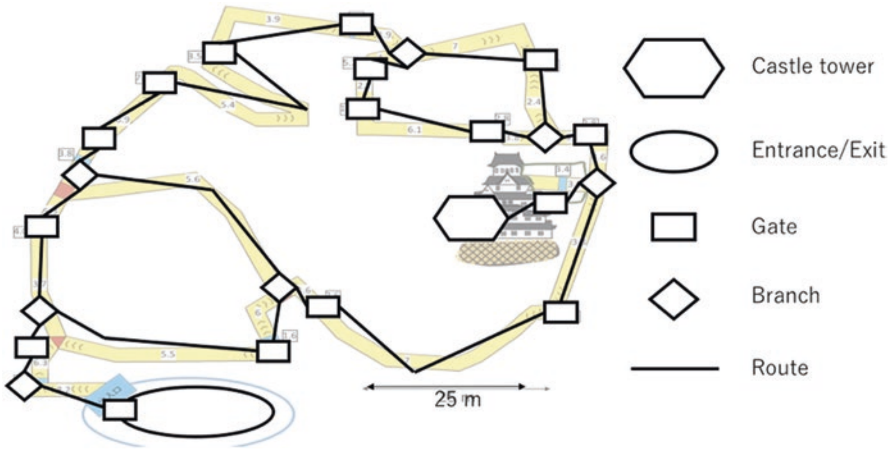


Fig. 1 Network path in the simulation

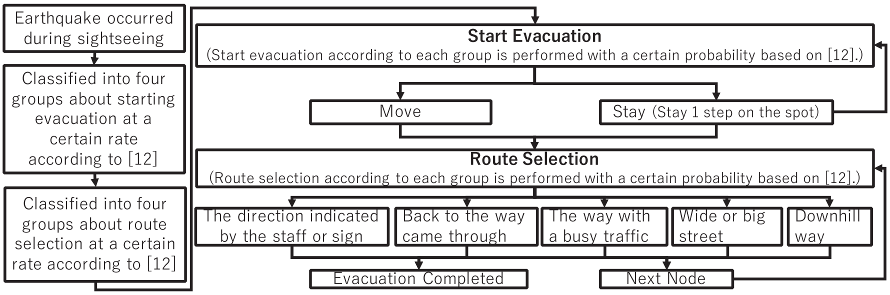


Fig. 2 Behavior rules in the simulation

are prevented from entering and only allowed to leave from the exit. Moreover, the flow of people, restricted by the width of the castle gate, is normally 0.5 p/m/s (people per meter per second) and 1.5 p/m/s during an evacuation. The walking speed is set to 0.5 m/s during sightseeing and 1.5 m/s during a disaster. On the basis of tourist evacuation behavior patterns [13], the evacuation behavior rules of the agents were incorporated in the simulation (Fig. 2).

3.2 *The Gaming of Participatory Evacuation Planning*

Figure 3 shows the procedure for the gaming of participatory evacuation planning. As shown in Fig. 3, (1) participants conduct group discussions with the goal of making an evacuation plan for the tourist area. (2) The components of the plans are entered into the evacuation simulation, and the results are obtained. (3) The

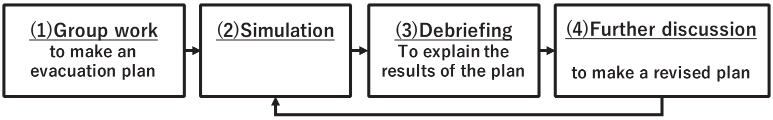


Fig. 3 Procedure for the gaming of participatory evacuation planning

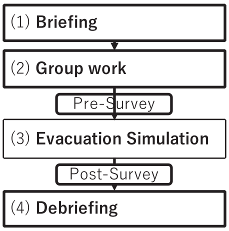
researcher interprets and explains the results comparing each group plan in the debriefing session, (4) a further discussion is conducted on the basis of these results and interpretations, and then the group evacuation plans are revised or reformulated in the final stage of the activity.

4 Overview of the Survey Process

This section provides an overview of the survey process. As shown in Fig. 4, the survey procedure consisted of a pre-survey, conducted after participants had formulated the evacuation plans, and a post-survey, conducted after the plans were evaluated using the simulation. Although the gaming itself consists of processes (1) to (4) above, this particular experiment only included processes (1) and (3), since the objective was to clarify whether legitimate peripheral participation is achieved by presenting agent simulation-based evaluations of evacuation plans. Furthermore, while we expect that the gaming will be used by public servants and facility personnel in tourist areas in the future, the subjects of these experiments were students in the College of Policy Science and Graduate School of Policy Science at Ritsumeikan University, and these experiments were conducted in lectures (Fig. 4). The student subjects included 14 undergraduate students taking lectures in community disaster prevention and 13 undergraduate students enrolled in a seminar on regional disaster prevention, as well as 5 students from the Graduate School of Policy Science, who were taking lectures for new students there, making a total of 32 students, many of whom had an interest in the field of disaster prevention. In addition, the results of the pre-survey indicated that none of the subjects had knowledge or development experience related to agent simulation.

Although public servants and facility employees, who may be under pressure to formulate tourist evacuation plans, often have a sense of crisis concerning disaster prevention and evacuation, they generally do not have knowledge of scientific techniques, such as simulations; therefore, it was considered appropriate to conduct a survey using students as subjects.

The experiment followed the specific procedure set out in Fig. 4. First, problems surrounding tourist attractions, and the problem of evacuation in particular, were introduced in a briefing. Next, subjects were divided into groups of four or five and told to assume the roles of public servants employed by the fictitious city, City I, where there was a possibility of a large earthquake occurring in the future, and to formulate an evacuation plan for a castle in the city, Castle I. At that point, each



	Survey 1	Survey 2	Survey 3
Date	25th December, 2017	25th December, 2017	17th January, 2018
Scope of the survey	Undergraduate students	Graduate students	Undergraduate students
Number	14	5	13
Place	Lecture (Community disaster prevention)	Lecture (Introduction to Policy Science)	Seminar Class (Community disaster prevention)
Time		90 minutes	
Method		Questionnaire survey	

Fig. 4 Survey process

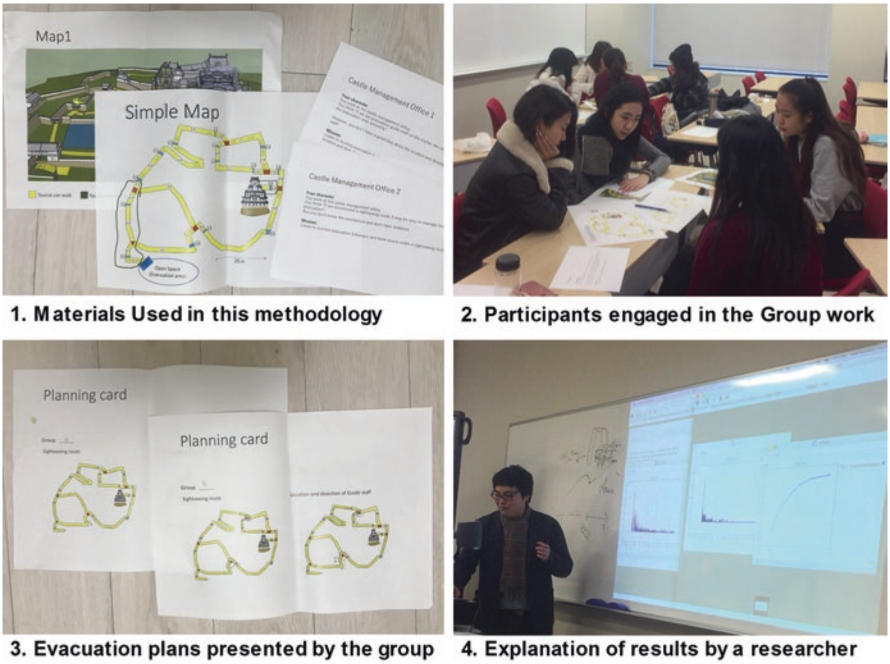


Fig. 5 Pictures of the survey

group was given an explanation about the evacuation behavior characteristics of tourists identified by research on tourist evacuation behavior [13], as well as an explanation of the anticipated situation inside the castle at the time of an earthquake (number of visitors, damage to buildings, etc.). Next, in groups' discussions, subjects were required to make specific decisions on three matters: the establishment of tourist routes, the deployment positions and guiding directions of two evacuation guidance officers, and the timing of an announcement to signal the commencement of the evacuation. After that, the groups were required to present evacuation plans for these three matters (Fig. 5). After the presentations, subjects answered the pre-survey questionnaire, during which time the researchers inputted each group's evac-

Table 1 Questions about legitimate peripheral participation in the survey

	Question	Component
Q1	I am confident that this plan would work in an actual disaster	Legitimate
Q2	I felt as though I was using a professional method	Legitimate
Q3	I felt as though we were making a real evacuation plan	Legitimate
Q4	I felt that special knowledge and skills were necessary for the evacuation planning	Peripheral
Q5	I could understand about evacuation planning from the point of view of a student	Peripheral

uation plan data in the agent simulation and obtained the simulation results. Finally, the researchers gave explanations in the debriefing session while presenting the results of each group's evacuation plan using graphs and numerical values. After the debriefing session, subjects answered the post-survey questionnaire.

Table 1 shows the questions, which included two of the central components of legitimate peripheral participation, "participation in practical disaster prevention activities" and "participation of various members of the public from a non-expert position." In the analysis, responses were scored on a five-point scale ranging from "strongly agree" (5) to "strongly disagree" (1). By comparing the results of the pre- and post- surveys, it was possible to confirm whether legitimate peripheral participation had been achieved.

5 Survey Results and Discussion

This section presents and discusses the survey results. The pre- and post-survey scores for each questionnaire item were compared using the Wilcoxon signed rank test.

First, this paper shows the results of questions about legitimate participation. The score on the post-survey is lower than the score on the pre-survey in Q1 (Table 2). Based on the free description (Table 3), it is reasonable to assume that confidence in the evacuation plans fell because the subjects were able to see objective evacuation results following the simulation-based evaluation of their plans. Further additional survey is needed because there is a possibility that the subjects felt that this gaming was a practical method.

The score increased after the gaming in Q2 and Q3 (Table 2). All of these comments of Q2 indicate that the use of professional tools, such simulations and computers, made subjects feel that the gaming was a professional method (Table 3). In the free description of Q3 (Table 3), there are participants' answers indicating that because they were able to view the results objectively as a result of the simulation-based evaluation of the plans, subjects experienced a sense of reality and felt as though they were formulating a real evacuation plan.

Table 2 Survey results by Wilcoxon signed rank test

	Average (pre-survey)	Average (post-survey)	*p*-value
Q1	3.562	2.968	0.009
Q2	2.656	3.593	0.0002
Q3	2.781	3.312	0.017
Q4	3.125	3.156	0.829
Q5	3.843	3.718	0.378

Table 3 Free description of questions about legitimate participation

	Free description
Q1	Because computers use calculations so it is easier for them to get the correct answers compared to humans
	Because it is difficult to suppose without relying on a computer
	Because I think it's more accurate for a computer to do it than a human
Q2	Because I was using a computer simulation
	Because I didn't know about the simulation method until now
	Because I can't predict the fine details through discussions alone
	Because we were using specialist software
	Because we can see what we discussed in the group as the results of the simulation
Q3	Seeing the computer-based simulation made it seem realistic, and I felt like taking measures
	Because it provided specific numerical values

The above findings suggest that this gaming using agent simulation can function as a practical disaster prevention activity that would be useful during a disaster.

Second, this paper explains the results about peripheral participation. There was no significant difference between the pre- and post-survey values in Q4 and Q5 (Table 2). In Q4, subjects tended to comment on the difficulty of making a plan from various tourists' behaviors on the pre-survey and to focus on the difficulty of the simulation and the interpretation on the post-survey (Table 4). However, as the score is not high, subjects do not think to require special knowledge or skills. Moreover, one participant stated that special knowledge and skills were not necessary because, "Other groups were creating evacuation plans that were quite practical, though they are students." In Q5, since one respondent comments on the possibility of understanding as a student, this gaming is a method that can be understood by people who are not experts and specialists.

The above findings clarify that, since there were no differences between the pre- and post-survey results, the gaming of participatory evacuation planning using agent simulation does not require special knowledge and skills, even compared to the method where it is not used. In other words, the results indicate that this gaming is one in which non-specialists can also participate.

Table 4 Free description of questions about peripheral participation

		Free description
Q4	Pre-survey	It was difficult to grasp the intentions of the evacuees
		It was difficult to plan while considering the positions of the various people involved
		Because when you take into account all the conditions, the plan hits a snag
		It is fun with many ideas. But we need only one better idea to make practical plan
	Post-survey	The data analysis and interpretation was difficult
		It looked difficult to generate the data and create variables
		Other groups were creating evacuation plans that were quite practical, even for students
Q5	Because the evacuation simulation was explained after we made the evacuation plans, I understood it better than I would have if we hadn't made the evacuation plan	

6 Survey Results and Discussion

Ultimately, the study confirmed that legitimate peripheral participation of members of the public is possible through the gaming of participatory evacuation planning using agent simulation. In other words, the findings indicate that this gaming can facilitate collaboration between researchers and members of the public, which is an essential component of community disaster prevention. The subjects in the study were students. It is necessary to demonstrate that the gaming has further utility by implementing it with public servants and facility personnel in tourist areas.

References

1. Yamori K (2013) Improving disaster risk communication: a paradigm shift in disaster information research, 2nd edn. Minerva Publishing, Kyoto (in Japanese)
2. Sakai K, Honda A, Mongkonkerd S et al (2014) A study on evacuation simulation for guiding tourists in Himeji Castle based on a survey of tourists' intentions in evacuation after earthquake. ASEAN J Hosp Tour 13:137–150
3. Sugiyama T, Okubo T, Kim D, Hayashi M (2015) Study of the evacuation plan for the concerning stranded tourists on arounded area of Kiyomizu Temple, Kyoto. J Disaster Mitig Hist Cities 9:127–134
4. Futagami T, Akizuki K, Matsuyama Y, Kunikata Y (2013) Development of the vulnerable people supporting system for a tsunami refuge area. J Japan Soc Civil Eng Ser F6 (Saf Probl) 69:I_1–I_6. https://doi.org/10.2208/jscejsp.69.I_1
5. Gotoh H, Harada E, Maruyama Y et al (2008) Contribution of crowd refuge simulator to town planning against tsunami flood. Proc Coast Eng JSCE 55:1371–1375. https://doi.org/10.2208/proce1989.55.1371

6. Hatayama M, Nakai F, Yamori K (2014) Tsunami evacuation evaluation system for plan development of community based evacuation. IPSJ J 55:1498–1508. (in Japanese)
7. Takayanagi H, Kurita Y, Yamada S, Kimura T (2014) A study on regional urban disaster prevention plans of Otsu City, Shiga prefecture by using of evacuation simulation and multi-agent pedestrian model. AIJ J Technol Des 20:1091–1094. https://doi.org/10.3130/aijt.20.1091
8. Katada T, Kuwasawa N, Kanai M, Hosoi K (2004) Disaster education for Owase citizen by using Tsunami scenario simulator and evaluation of that method. For Soc 2:199–208. https://doi.org/10.3392/sociotechnica.2.199
9. Kuwasawa N, Hosoi K, Katada T (2015) Study on proper location in consideration of guidance effect of tsunami shelter. J Japan Soc Civil Eng Ser D3 (Infrastruct Plan Manag) 71:117–126. https://doi.org/10.2208/jscejipm.71.117
10. Kawashima K, Tatano H, Hatayama M (2006) A flood risk communication support system to promote safe autonomous evacuation. Infrastruct Plan Rev 23:309–318. https://doi.org/10.2208/journalip.23.309
11. Nakai F, Hatayama M, Yamoori Y (2013) Construction of tsunami evacuation evaluation system for support to make evacuation planning. IPSJ SIG Notes 2013:1–8
12. Tanuma H, Deguchi H (2007) Development of agent-based social simulation language: SOARS. IEICE Trans Inf Syst 90:2415–2422
13. Sakai K, Honda A, Monkonkerd S et al (2014) A study on evacuation behavior pattern of tourists after earthquake in Himeji Castle: a survey of consciousness based on multi criteria decision making. J Disaster Mitig Hist Cities 8(1):89–194

A Study on the Effect of 'Information Mismatch' Simulation on Victims' Quality of Life and *Sense of Place* in the Post-disaster Period

Hiroaki Shimizu, Ryoya Tomeno, Quirino Crosta, Micaela Merucuri, Satoru Ono, Hidehiko Kanegae, and Paola Rizzi

Abstract The purpose of this study was to clarify the construction of a gaming simulation model based on information scenarios obtained from questionnaire surveys in L'Aquila. A second objective was to discover the kinds of quality of life (QOL) factors affected by disaster information mismatch (DIM) when using a gaming simulation model based on information scenarios. This study conducted an experiment on the variation of QOL factors by DIM using a questionnaire survey for seven students. It is clarified that, if DIM occurred, then the victim's QOL decreased compared to the situation with no DIM in each disaster phase. The results of this study indicate that the construction of disaster information sharing systems based on residents' needs should be harmonized with public specialized information.

Keywords Quality of life · Disaster information mismatch · Sense of place · Simulation

1 Research Background

The international disasters database (EM-DAT, Centre for Research on the Epidemiology of Disasters, CRED) reported that the number of disasters occurring during the twentieth century was less than 50, though this number was increasing

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exponentially towards the end of the century [1]. To date, the reported number of natural disasters in the twenty-first century is already more than 10 times that compared to the twentieth century, according to the “World trend of natural disasters 1900–2010”. In the case of historic cities, a significant factor to their weakness is their vulnerability. This means that it is easier for these cities to be destroyed during and after earthquakes. Moreover, this leads to vulnerability in residents’ safety following an earthquake. Residents’ living environments should be made safe during all disaster phases. In this sense, consideration should be given to forming an evacuation plan via a participatory process for resident safety in order for them to understand their city’s risks before the occurrence of a large earthquake [2]. However, policy and planning based risk must be considered after a natural disaster has taken place. One suggestion is an information sharing system among victims and information providers, such as national relations, public sector, non-profit organizations (NPOs) or non-governmental organizations (NGOs), volunteer groups, and so on. But, nowadays, information sharing after natural disasters is not working well, due to the lack of time during emergencies. People have to fight for survival resulting from natural disasters, but all aspects of information play a significant role in this, such as where should we evacuate immediately after an earthquake, when will the public sector provide food and water, living in evacuation shelters, and so on. In our survey, a lot of disaster information mismatch (DIM) among the needs of residents and supplies from senders occurred in L’Aquila, Italy. At the same time, if there was DIM, victims felt uneasy and unsettled. In this study, we ask what kinds of information mismatch and which phases affected the feelings of residents following a disaster.

2 Research Objectives and Significance

This study has two objectives. The first objective is the construction of a simulation model based on the information mismatch scenario in the post-disaster period resulting from a questionnaire survey in L’Aquila, Italy. The second objective is to clarify what kinds of victim quality of life (QOL) factors and emotional bonds with their home cities are affected by DIM for use in the constructed simulation model.

The reason for using a simulation model is because it is difficult to measure residents’ feelings when DIM occurred by using a simple questionnaire survey. A simulation model can reproduce the real situation of disaster information shared, but in the virtual world. One of the merits of using simulation is the ability to measure how the test subjects feel and what they are thinking during the precise time of running the simulation. So, this study measures residents’ QOL factors using the constructed simulation model. Clearly, DIM invokes negative feelings, but in this study, simulation is able to measure real residents’ thinking and feelings during every disaster phase, such as going to temporary evacuation locations.

3 Disaster Information Mismatch Among Victims' Needs and Information Senders

This section reviews the DIM among victims' needs and information senders in historical areas. DIM comprises a phenomenon whereby a gap exists between victims' needs and information senders' supply. This phenomenon happens around the world during times of disaster. For instance, in the case of Ayutthaya floods in 2011, the disaster was caused by two periods of heavy rain in the previous year. The flooding damaged the whole of Thailand, including the capital of Ayutthaya, from August to December 2011. There were 813 deaths and three people were missing (the Ministry of Interior, Thailand). During this time, a huge amount of disaster information was shared by public information, mass media, inter-organizational relations, and so on. However, several questions arose from this [3]: how much relevant information was given to victims from amongst the vast quantity of disaster information and was it really necessary to include all of the information provided?

In the field of tourism, people with more severe access needs require additional and more specialized information. However, the supply of this information becomes scarcer for those with greater accessibility requirements. Therefore, the gap between the demand and supply of accessibility increases, with a greater effect on those who depend on this information [4]. In this sense, this situation is same as during the time of a disaster. There are a variety of people, such as babies, young adults, and aged people in the disaster area. Thus, there are multiple specialized information requirements during each disaster phase: temporary evacuation, temporary shelters, and temporary housing. Those kinds of gaps between demand and supply must be filled, and this is an information issue for victims. In this study, those kinds of phenomena as information problems and information mismatch among demand and supply is called DIM.

4 Victims' QOL in the Post-disaster Period

This section reviews two categories of a previous study on the subject QOL: research on components of QOL and research on the necessary conditions in disaster prevention regional inheritance in the field of psychological aspects.

Demura et al. [5] constructed a QOL components model based on a previous study. QOL, which means subjective satisfaction, is composed of conditions of individuals (physical aspects, psychological aspects, social aspects, and so on) and conditions of the environment. When it is focused on psychological aspects, it is composed of feelings of uneasy, bodily pains, and so on. In consideration of victims' QOL during times of disaster, the measure of QOL is decreasing compared to during normal life, because of the changing living environment caused by the disaster (it is increasing the feeling of uneasy). At the same time, historical cities have great vulnerability. These cities have historical buildings, which are easily damaged by natural disasters. Therefore, victims must evacuate to other locations for long periods of time following the occurrence of disasters. Thus, the psychological aspects of QOL must be given great consideration.

On the other hand, regarding research on the necessary conditions in disaster prevention regional inheritance in the field of psychological aspects, Kanegae et al. [6] mentioned that not only national relations and the public sector must acquire disaster preparedness but, also, it is a necessity for residents (victims) to be aware of and act out suitable and immediate disaster responses in order to sustain inheritance of their home cities and to decrease the damage caused by natural disasters. Shirotuski et al. [7] elaborate on the importance of residents' participatory processes after a natural disaster to preserve and restore historical cities and cultural heritage. Participation in those kinds of activities depended on emotional bonding as thoughts, feelings, and beliefs to a specific place and community. Thus, it will be useful to clarify the effect of residents' participatory intention by their emotional bonding to regional inheritance in policy science aspects. In this sense, emotional bonding ('sense of place' [8]) in a time of disaster must be considered the same as QOL. Sense of place is a multidimensional concept, composed of 'place attachment', 'place identity', and 'place dependence'. For each factor, a score is given, calculated from the results of several questions. In this study, sense of place factors are calculated in the same way as QOL factors.

5 Study Area: L'Aquila, Italy

L'Aquila, Italy is the municipality, provincial capital, and prefecture capital located in the center of Italy, with a population of 67,000. A strong earthquake of magnitude 6.3 occurred on 4th April 2009. It is a region susceptible to earthquakes because of collisions between the Eurasia and African plates. This earthquake not only caused 309 deaths but it also damaged many historical buildings, such as the church of Anime Sante, provincial buildings, and so on, some of which collapsed completely. As a historical area in Italy, it possesses 'authenticity' and the need to restore this area. It takes a long time to restore an entire historical city, meaning that victims must evacuate to other locations for a longer period of time compared to other, non-historical cities. In actual fact, nowadays, more than 10,000 people live in temporary houses in L'Aquila municipality (the name of this housing project is Progetto C.A.S.E. e M.A.P.), even though it has been 10 years since the L'Aquila earthquake occurred. In the case of L'Aquila, all aspects following the disaster have been taken care of by the public sector (Department of Civil Protection, DCP).

6 Constructing the Disaster Phase Scenario

This section describes the construction of the disaster phase scenario with information mismatch.

First of all, the phenomenon of DIM happens at various points in time following a major earthquake. Therefore, the disaster is divided into four phases [9]: from occurrence of the earthquake to temporary evacuation phase, living in temporary shelter phase, living in temporary houses phase, and restoration phase. The restoration phase is when victims can live in permanent rather than temporary housing.

Second, this section describes building the scenario. In the scenario, the setting is a large earthquake that occurred in a similar situation to that of the L'Aquila earthquake. The date was set as 28th February 2018 and it was a very cold day. In the case of the L'Aquila earthquake, all aspects following the disaster were taken care of by the public sector (DCP). Therefore, it is estimated that DIM occurred via miscommunication between DCP members and the victims. Moreover, in this study, residents' QOL was measured by the occurrence of DIM, so each scenario had two cases, one without DIM and the other with DIM, both split into four disaster phases to show to the test subject. A questionnaire survey was conducted among victims in L'Aquila (Table 1).

As a result of the questionnaire survey, the most common answer during the first phase (from occurrence of the earthquake to evacuation phase) was "I don't know where is the evacuation place, and which route is safety". Thus, DIM from this phase is misunderstanding the temporary evacuation location and route to safety, as well as the case of understanding the information given.

The next two most common answers were "confirmation of family's safety" and "actual condition of their house and entry to city center". In this case, two scenarios were given. In the first, when a large earthquake occurred, victims must take care of their family's safety. So, one of the DIM situations in the temporary shelter phase is that victims want to know about their family's safety. They need to ask DCP members in order to find out this information but they don't know how to do so. The other scenario is about the actual condition of their house and date of reentry to the city center. Before the L'Aquila earthquake, most peopled lived in or around the city center, having lived there from birth. However, there are numerous historical buildings in the city center. Following the L'Aquila earthquake, no one was allowed to enter the city center due to the number of collapsed buildings and the resulting

Table 1 Abstract of questionnaire survey 1

	Questionnaire survey 1
Date	From 2nd to 26th February
Scope of the survey	Victims living in L'Aquila (including students)
Number	27 samples
Contents	Actual disaster information mismatch (DIM) that occurred following the L'Aquila earthquake in 2009

Table 2 Constructing disaster information mismatch (DIM) scenarios according to disaster phase

Disaster phase	Contents of DIM	Place	When
From earthquake happening to moving to emergency shelter	Temporary evacuation location and route to safety	City center	28th February
Temporary shelter 1	Safety of family	Temporary shelter	17th March
Temporary shelter 2	Actual condition of house and reentry to city center	Temporary shelter	20th March
Temporary house	Applications for living in temporary houses	Temporary shelter	24th September

danger to life. It followed that victims wanted to know the actual condition and damage to their houses and when it would have been possible to reenter the city center. In the second DIM case, the scenario was set whereby victims wanted to know the actual situation of their houses and when it was possible to reenter the city center, so they ask the DCP staff but the response they receive is “we don’t know in detail”.

The last scenario is the application of living in temporary houses during the time of moving from temporary shelters. Italy constructed temporary houses after the L’Aquila earthquake (Progetto C.A.S.E. e M.A.P.). Many victims moved to these temporary houses but respondents of this questionnaire survey were worried about how to apply for them. So, the final DIM scenario is that victims want to know how to apply to live in temporary houses; upon asking someone about this, their answer is “we are not sure now” (Table 2).

7 Overview of the Survey Process

This section describes the study framework and abstract for the gaming simulation model of the DIM scenarios. (1) Briefing: first of all, the researcher introduced the history of L’Aquila and its disaster prevention system. At that time, the students understood all the information given to them. (2) Role: secondly, the researcher gave the students roles as L’Aquila residents (Fig. 1). To provide emphasis to the simulation, we went for a virtual walk around the city center using Google Street View. This made it easier to understand the real situation of L’Aquila for the Japanese students. (3) Game: the researcher showed students the DIM scenarios and answered any questions posed by the simulated L’Aquila residents. Then, players will answer each question after looking at each scenario. (4) Debriefing: after showing the scenarios, the researcher explained the reasons behind administering such a questionnaire and what bases these scenarios set as part of the debriefing.

Figure 2 and Table 3 summarize the findings of this survey. In the survey, questions were asked related to feelings of satisfaction (Q1) and uneasy (Q5), sense of place [8] (Q3, Q4, Q5), and factors and intentions of moving to other places away from L’Aquila (Q6), based on related works. In the feelings of satisfaction and

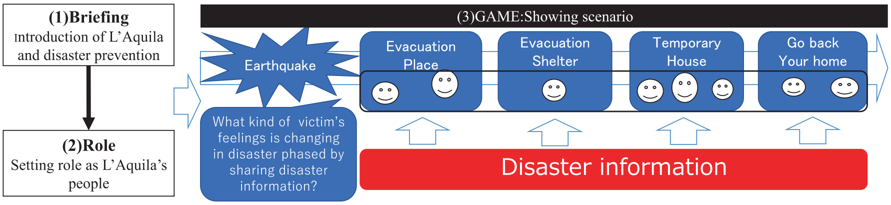

Fig. 1 Process of the simulation model for the disaster information mismatch (DIM) phenomena scenarios

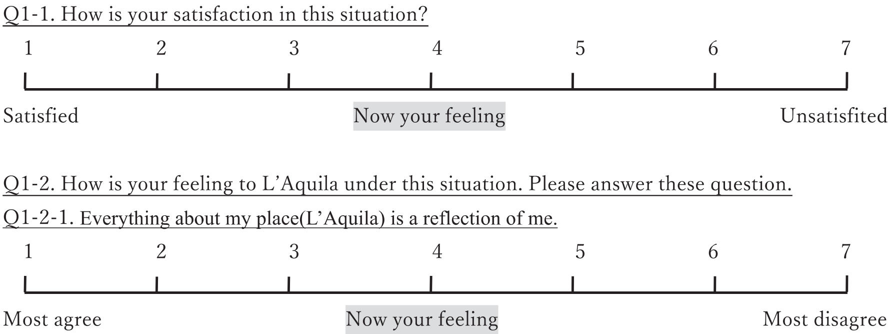

Fig. 2 Example of questionnaires in this simulation

Table 3 Questionnaire survey 2

	Questionnaire survey 2
Date	27th March 2018
Scope of the survey	Undergraduate school students
Number	7 samples
Place	Ritsumeikan University
Contents	Feeling of satisfaction (Q1), feeling of uneasy (Q5), intention of moving to another location away from L'Aquila (Q6), place identity (Q2), place attachment (Q3), place independence (Q4) [8]
Questions	Q1: How is your satisfaction in this situation?
	Q2: Everything about my place (L'Aquila) is a reflection of me.
	Q3: My place (L'Aquila) is my favorite place to be.
	Q4: As far as I am concerned, there are better places to be than at my place (L'Aquila).
	Q5: How do you change your feelings of being uneasy at the moment?

uneasy section, the response was scored on a seven-point scale, ranging from "1 satisfied" to "7 unsatisfied". Initially, the respondents' feeling is "4 no feelings". If respondents did not change their minds after being shown the scenario, they had to choose "4 no feelings". In the sense of place factors section, it was composed of place attachment, place identity, and place dependence. In the analysis, the response

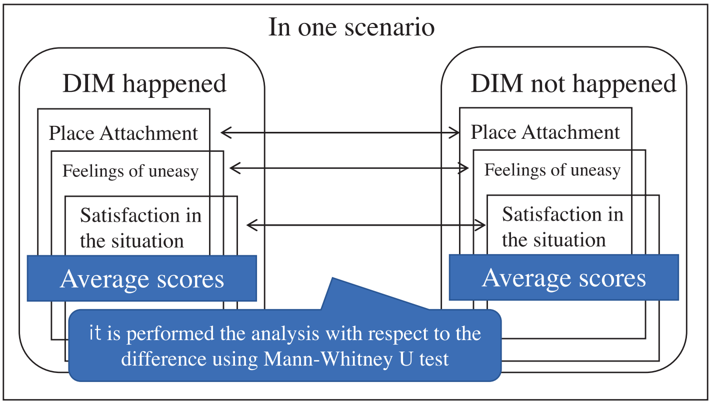

Fig. 3 Methodology of analysis in the simulation

was scored on a seven-point scale, ranging from "1 strongly agree" to "7 strongly disagree".

8 Analytical Methodology in the Simulation

This section explains the analysis method of this simulation. The purpose of this study was to evaluate victims' psychological burden (QOL and sense of place factors), in each disaster phase, with and without DIM, by using the constructed simulation. In the analysis, firstly, the average scores for each factor in the DIM and no DIM cases in one scenario were calculated. Then, the average scores for the other scenarios were calculated in the same way. The analysis was performed with respect to the differences using the Mann–Whitney *U*-test (Fig. 3). If DIM did happen, changes (increase or decrease) in the players' psychological burden factors were verified.

9 Results and Discussion of the Simulation Model with DIM Scenarios

This section presents and discusses the survey results. The DIM and no DIM scores for each questionnaire item were compared using the Mann–Whitney *U*-test in each scenario.

First, for the components of feelings of dissatisfaction and uneasy, it can be seen that the score in the DIM case is higher than the score for the no DIM case in each disaster phase (Table 4). Therefore, if DIM happened, victims will be more unsatisfied and uneasy in each disaster phase. This means that the victim's QOL will decrease. Furthermore, looking at the sense of place factor in the 'Temporary Shelter 1', 'Temporary Shelter 2', and 'Temporary House' scenarios, the scores for the

Table 4 Survey results by the Mann–Whitney *U*-test

	Average (from earthquake happening to moving to emergency shelter)			Average (temporary shelter 1)		
	DIM	No DIM	*p*-Value	DIM	No DIM	*p*-Value
Q1	5.857	3.142	0.007	6.571	5.428	0.015
Q2	4.000	3.714	0.177	4.285	5.142	0.134
Q3	3.571	3.428	0.177	5.285	4.428	0.039
Q4	5.428	4.428	0.066	6.000	5.428	0.051
Q5	5.142	2.571	0.007	5.857	5.000	0.022
Q6	3.571	4.714	0.004	5.142	4.142	0.183

Table 5 Survey results by the Mann–Whitney *U*-test

	Average (temporary shelter 2)			Average (temporary house)		
	DIM	No DIM	*p*-Value	DIM	No DIM	*p*-Value
Q1	5.142	3.142	0.021	6.285	3.000	0.001
Q2	4.857	3.857	0.098	5.285	3.714	0.055
Q3	4.714	3.428	0.024	5.285	3.428	0.013
Q4	5.571	4.571	0.098	5.857	4.285	0.035
Q5	6.000	4.571	0.005	6.000	3.714	0.019
Q6	4.285	4.571	0.400	4.142	4.428	0.400

DIM case are higher than those for the no DIM case (Tables 4 and 5). This means that the victim's place attachment (Q3) decreases when DIM occurs. However, it is difficult to measure sense of place in the gaming simulation, even if respondents take on the role as L'Aquila residents. In this case, the respondents are Japanese students and they have never been to L'Aquila. This makes it difficult to bring about a sense of place among the study participants.

Lastly, regarding intentions of moving away from L'Aquila, we can see that the scores with DIM are lower than the scores without DIM in the "from occurrence of the earthquake to evacuation phase" scenario. It can be explained that, if victims experience a large earthquake, they will have intentions of moving away from L'Aquila. We do not know when an earthquake will take place. If and when an earthquake occurs, people will have intentions of moving away to locations that are less susceptible to earthquakes.

10 Conclusion and Future Design

The above findings clarify that, if DIM occurred, victims' (residents') QOL decreased compared to when there was no DIM. At the same time, sense of place factors, especially place attachment, decreased when DIM happened. In many disaster phases around the world, there is often DIM. To maintain victims' QOL and emotional bonding to their home cities, the amount of DIM must be reduced. In order to do this, information between the municipality and public sector must not be casually shared. Instead, a disaster information sharing system must be constructed based on the residents' needs. Municipalities and researchers should collect residents' needs from past disaster experience. Of course, not only residents' needs but also specialized information possessed by the municipality, such as evacuation routes and evacuation space, are also necessary.

In future designs, it is necessary to reduce DIM to sustain residents' QOL and sense of place factors for building up resilience and speeding up recovery in historic cities. The construction of disaster information sharing systems based on residents' needs and the knowledge of municipalities, such as evacuation route, evacuation plan, and so on, has been undertaken in the form of 'Civic Tech'. This technology provides a way to solve the regional problem using residents' participatory and citizens' technological skills. It is based on the participatory and communication process and is able to collect residents' needs and input this into a database as 'big data'. So, for future design, a disaster information sharing system will be constructed and its processes modeled by using Civic Tech in the Internet of things (IoT) and artificial intelligence (AI) society that this world is heading towards.

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References

1. EM-DAT: The international disaster database (2012). http://www.emdat.be
2. Toyoda Y (2012) A study on community evacuation planning in urban areas during a downsizing period. Doctoral dissertation, Ritsumeikan University
3. Diana C, Thomas B, Michael EH (2017) Lack of spatial resilience in a recovery process: case L'Aquila, Italy. Technol Forecast Soc Chang 121:76–88
4. Eleni M, Dimitrios B (2013) Information provision for challenging markets: the case study of the accessibility requiring market in the context of tourism. Inf Manag 50:229–239
5. Demura S, Sato S Quality of Life (QOL) Assessment for Japanese Elderly (2006) the course of QOL studies and assessments of health-related and subjective QOL. J Jpn Soc Phys Educ Health Sport Sci 51:103–115
6. Kanegae H, Toyoda Y (2013) Text education of disaster prevention of cultural heritage. Ritsumeikan University (in Japanese)
7. Shirotsuki M, Otsuki S (2008) A fundamental study on relationship between resident's emotional bonding to place and disaster preparedness and awareness for conserving Ayutthaya world heritage. J Disaster Mitig Urban Cult Herit Ritsumeikan Univ 2:27–34
8. Bradley S, Richard C (2001) Sense of place as an attitude: lakeshore owners attitude toward their properties. J Environ Psychol 21:233–248
9. Vivacqua AS, Borges MRS (2012) Taking advantage of collective knowledge in emergency response system. J Netw Comput Appl 35(1):189–198

Part V
S&G with the Latest Technology

Empirical Studies on the Role of Matchmaking in Mobile Esports Player Engagement

Małgorzata Ćwil, Marcin Wardaszko, Kajetan Dąbrowski, and Przemysław Chojecki

Abstract The aim of this article is to analyze how matchmaking influences player engagement and satisfaction in mobile Esports games. In the first part, a definition of Esports is presented, and the pace with which the phenomenon is developing is described. In the next part, the literature review of the previously researched factors affecting players' contentment is performed, taking into particular consideration matchmaking systems. Then, 17 most popular Esports mobile games are chosen for the analysis in terms of players' satisfaction in the current matchmaking systems. In this part, the content of the most frequently used forums for players is analyzed. The analysis using netnography techniques is performed, and the players' views about matchmaking mechanics in the chosen games are examined and discussed.

Keywords Esports · Matchmaking · Mobile Esports

1 Esports

Esports is a form of competition using video games that is also known as electronic sports, competitive gaming, or professional gaming. It has been a phenomena for many years now and does not show signs of stopping. According to Deloitte analysis, the Esports market was worth $325 million in 2015 and is estimated to reach the level of $1 billion in 2018. In 2016 spectators spent more than 5 billion hours watching Esports tournaments – it is five times more than in 2010. The largest group of players and spectators comes from China. The biggest league – Electronic Esports

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League – has more than 6 million members with more than 500 thousands of teams [1]. It is also worth mentioning that from November 2017, Esports is officially recognized by the International Olympic Committee as a sport [2] and for the first time Esports is going to be included in 2022 Asian Games that will take place in China [3].

Academic research on Esports started in the early 2000s, with the high rate of growth in the number of published articles in the last years [4]. One of the first endeavors to describe and define this phenomenon was in the article “Cybersport” [5], where “digitally represented sporting worlds” were characterized. One of the most recently formulated definitions of Esports was given by Hamari who describes it as “a form of sports where the primary aspects of the sport are facilitated by electronic systems” [6]. All of the input of Esports players and the output of games are run by human interaction with electronic devices. The vast majority of the Esports definitions underline the concept of competition in this kind of games [7–11]. There are also some attempts to decode e- in Esports as economic not electronic [12] as this is the only kind of sport where a game is designed by specific profit-making company. Esports can be played by both professionals and amateurs, individually or in small teams. Worldwide Esports tournaments are organized every year; the most prestigious are The International Dota 2 contest with the highest prize pool in Esports event, in 2017 it was over $24 million [13], and the League of Legends World Championship where 24 teams from different countries took place in 2017. They are live broadcasted which leads to the enormous audience sizes of billions of people from all over the world. Esports used to be restricted only to human interactions with personal computers; however in recent years, it has started to successfully migrate also to mobile platforms. Nowadays, the most popular mobile Esports – such as Clash Royale or Fifa Mobile – have more than 100 billion of downloads according to Google Play app store [14]. The trend is on the rise, and according to the owner and chief executive officer of Critical Force, mobile Esports will be much more popular in the future, especially in emerging countries where more people can afford phones in comparison to computers [15].

2 Gamer Engagement

2.1 How to Define Player Engagement

Esports attract billions of people all over the world – players as well as spectators. In academia there is an endeavor to find factors which make people be engaged in electronic sports games. This issue is not straightforward and easy to research as there are many aspects influencing the success of the game and number of its players. Games are typically characterized as fun, and intuitively the level of fun should correlate with the interest that people pay to the game. However, if there existed one theory of fun and engagement and one widely established and accepted way to measure it, life of game researchers would be far too easy. According to game designer T. Fullerton, fun in games comes from the combination of challenge, interaction with other players, and competition [16]. At the same time, it is agreed that fun can be differently assessed and viewed by individuals – a game mechanics that would make one person more engaged and more satisfied can be frustrating and depressing for another one [17]. This issue has been studied broadly in the literature in recent years with many attempts to conceptualize the subjective experience of game players using measures such as enjoyment [18], immersion [19], flow [20], involvement [21, 22], attention [23], arousal [24], interest [25], and identification [26].

From all of the abovementioned concepts, we can distinguish some common characteristics that constitute a fun and engaging game. It needs to be appealing to its users – meaning difficult and challenging even for professionals but at the same time acceptable and enjoyable for amateurs [27]. Game developers can influence the level of challenges within the game and the feeling of player competence by introducing different in-game content and game mechanics but also by designing engagement-oriented matchmaking system.

The challenging game is also a condition needed to experience flow – the mental state of being fully immersed and involved in enjoyable activity [20]. Players should have a feeling of deep immersion in the game experience – a feeling of "being there" in this particular moment, feeling of being completely absorbed in what one does. To achieve this, the game should not be too easy as it would be boring for the players nor too hard because it brings the feeling of frustration. Deeply engaged players are fully focused on the gaming activities and are not aware of anything that takes place around them [28].

2.2 Psychological Needs Influencing Motivation to Play

One of the main motivation frameworks is self-determination theory defined by R.M. Ryan and E.L. Deci which states that intrinsic and extrinsic motivations are not two opposing, contradictory states, but rather form a continuum [29]. The continuum starts with the state of amotivation which occurs when there is no regulation whatsoever and behavior quality is completely non-self-determined. Then there is the extrinsic motivation that consists of a few different phases (external regulation, interjected regulation, identified regulation, and integrated regulation) in which an important role is played by external incentive systems – punishments and rewards. The last stage of the continuum and at the same time the one where the most self-determinated behaviors occur is intrinsic motivation where a person feels a desire to participate in particular action.

Game designers attempt to influence players feeling of having fun while playing a game by introducing proper game mechanics. The way in which a game is designed can influence both intrinsic and extrinsic motivation of a player and make him more or less immersed in the activity [30]. Extrinsic motivation is present when the motivation lies outside of the activity and one engages in behaviors in order to obtain rewards and praise or to avoid criticism and punishment. Intrinsic motivation, on the other hand, occurs when people want to do something and feel the need to do this, so the motivation lies inside the activity itself [31].

According to self-determination theory, to internalize motivation, three fundamental psychological needs of human beings, competence, relatedness, and autonomy, should to be satisfied [32]. Stimulating only one of these needs usually fails to lead to motivation internalization [33]. The term competence describes everything related to how people feel about their achievements, skills, and their ability to reach their goals. It means that all of the challenges that people face should be optimally suited to the set of their skills – the same applies to Esports games. Relatedness on the other hand is the feeling of being connected to a community, belonging to society, and having meaningful and deep relationships with others [34]. To satisfy this human need, developers should offer meaningful social interactions in the game. According to Freeman [35] in both professional and amateur gameplays, this builds close interpersonal relationships; one can count on the support from other team members which strongly influences the feeling of relatedness. Autonomy refers to the feeling of control and responsibility for one's actions and behaviors. In games satisfying players' needs in autonomy entails mostly allowing them to make meaningful choices and at the same time making the game systems clear so that players feel in control and can experience a sense of purpose [30].

Game developers can design the environment of the game in a way that stimulates all three basic human needs and builds players intrinsic motivation, feeling of flow, and full immersion in game activities. In many Esports players formulate teams and play online in cooperation with others. It means that in-game content is crucial for obtaining player engagement and that is how their motivation can be influenced.

2.3 How to Measure Player Engagement?

The important question that needs to be answered when discussing factors influencing player engagement is how to measure its levels. Engagement is an objective measurement of user experience in games, and in academia many attempts and many different ways to deal with this issue have been tested. There are large amounts of data that can be obtained from games and analyzed – using the technique called telemetry [36]. The obtained data is used most often to describe player behavior during the play. This data can consist of the information about the time spent in the game, the number of matches played within a time window, money spent within the game, number of levels attempted or completed, the difficulty of levels completed or churn risk [37, 38]. In mobile games the degree of involvement in the game can be also measured by the people's thumbs performance and movement. The churn – a measure of the number of players leaving a game over a period of time – can be predicted on the basis of current elapsed time from the previous player activity within the game, average time between sessions, number of purchases and average spending per session, and cooperation with other players [39, 40].

Recently there have been attempts to research psychological and physiological player reactions as well. Psychological measurements are usually obtained from questionnaires that are conducted during or after the play, while physiological ones can be measured using EMG or devices that measure heart rate or widening of the pupil.

3 Matchmaking

One of the many ways to influence gamer engagement is through the matchmaking system. The way and quality of connecting players together for online play sessions is essential for the feeling of gamer satisfaction.

There are various ways to conduct matchmaking. The basic one is a random system, in which all of the players are put in one queue for random assignment to matches. Another very popular approach to matchmaking in Esports is ranked one. This system matches players of similar abilities and skills and is the dominant approach to connect players [41]. It is not an easy task to measure player skills in fair way, but there are a few systems that handle this not easy task – for example, Xbox Live's TrueSkill [42], Glicko [43], or Elo system [44].

Even if we know how to measure player skills, it can be problematic to design a balanced matchmaking model, where all opponents have similar chances to win the game [45]. Intuitively, when beginners are matched with highly skilled players, the play satisfies no one [46]. But should the matchmaking system always be balanced, so that every player have exactly 50% chances to win and 50% chances to lose? Some of the game developers assume that it means optimizing players' experience, but it is a problem that undoubtedly needs to be more deeply researched. Some of the scholars as well as practitioners doubt this concept and at the same time are looking for some other ways to develop a type of matchmaking system that will maximize player engagement (e.g., Engagement Optimized Matchmaking (EOMM) [47]). There are certainly situations when players would like to be matched with someone playing better or worse than they do. It can be totally non-game-dependent, for example, one's mood influences the level of challenge that one wants to face. It is a fact worth mentioning in the future if some psychological characteristics can be introduced while designing a matchmaking system. What other factors can be taken into consideration while creating a matchmaking system?

Some of the scholars underline the important role that latency plays in improving the player experience. It should be taken into consideration in designing an accurate matchmaking system, and the groups of players with low latencies to each other should be matched together. This approach has been described by S. Agarwal and used in their Htrae matchmaking model [48]. The research on this subject was continued by Manweiler who suggests that using latency estimation is especially important in the case of mobile games, as phones have limited energy and network has limited capacity as well [49]. Others underline that the way a gamer is playing and the roles that he or she prefers also should be taken into consideration in matchmaking process [50, 51].

Horton [41] researched different matchmaking services (e.g., Overdog, Leaping Tiger, Gamerlink, Evolve, Player Finder, etc.), and as it turns out, in those services skills of players are quite rarely introduced in the matchmaking system. The most often encountered features are location of the players, game type, and play style.

In the process of designing a matchmaking system, one can formulate matchmaking as an optimization problem, where the main objective is to maximize player engagement or minimize level of his or her disengagement. As it was already described, there is no single proper way to define and measure engagement. In some research projects, a churn risk was used as a way to measure the level of gamer disengagement [47, 39]. In others, the level of engagement was estimated on the basis of the result of short questionnaires showing player opinions after each match [52].

Matchmaking seems to be an important issue influencing player engagement and however really rarely is taken into consideration while measuring its levels [47, 52]. To check whether this hypothesis is correct, an analysis of matchmaking systems and players' opinions about them in ten most popular mobile Esports has been conducted.

4 Matchmaking in Popular Mobile Esports

In order to analyze the level of player satisfaction from matchmaking systems in mobile Esports, 17 popular games have been chosen for in-depth analysis. The games have been chosen on the basis of the number of downloads in Google Play store. The data about the type of the game, year of release, main game characteristics, and the type of the matchmaking was gathered and presented in Table 1.

In the next step, gamers' opinions about the matchmaking systems were gathered using technique called netnography. This is a qualitative research method that has its origins in ethnography and is used to understand social interaction in online communications [53]. Netnography uses digital conversations – for example, from online forums – as data, and its aim is to find the emotional story behind a subject. The information for the research has been collected from the most frequently used forums for players, such as Reddit and other game-specific forums, then analyzed and interpreted. Selected opinions are presented below.

Selected Opinions About Clash Royale Matchmaking System

JohnnyEdge23 (01.2018)

> For some reason I keep getting paired with players one level above me. At level 5 I thought, well at last when I'm level 6 I'll be paired against level 5's possible. Now, that I'm 6, I'm always paired against 7s. […] It usually takes about 3 seconds to find a game – so why not make me wait 7 seconds and match me with someone my level???? Are they looking to fix this? It is SO frustrating losing by 1 crown with their tower at 100 hp, when you know if they were the same level as you, you would have won. […] Definitely going to delete this app if they don't change this soon.

Source: http://clashroyale.wikia.com/wiki/Thread:80305 (Last Accessed: 19.04.2018)

Brady55 (19.04.2017)

> […] I am a level 8 pushing trophies, and right now Im somewhere around 2600-2700 back and forth. I CANT push up, I am facing all level 10 players right now. […] This is complete crap. I'm about to contact Supercell directly and tell them to fix this or I'm not playing, simple as that. If this issue isn't fixed I'm out. Make matchmaking more about card levels too, because quite frankly I'm sick of the fact that since I'm free to play at a low level, I can't push up.

Source: http://clashroyale.wikia.com/wiki/Thread:80305 (Last Accessed: 19.04.2018)

Table 1 Characteristics of most popular mobile Esports and its matchmaking systems

Title	Number of downloads in Google Play	Publisher	Year of release	Type of game	Type of matchmaking
Clash Royale	> 100 M	Supercell	2016	Collectible card MOBA	Ranked
Fifa Mobile	> 100 M	EA Sports, Electronic Arts	2016	Sport, PVP	Ranked
World of Tanks Blitz	>50 M	Wargaming	2010	MMO	Ranked
Mobile Legends	> 50 M	Moonton	2016	MOBA	
Hearthstone	> 10 M	Blizzard Entertainment	2015	Collectible card game	Ranked/arena
Mortal Kombat X	> 10 M	Warner Bros.	2015	Fighting	Random
War Robots	> 10 M	Pixonic	2014	Third-person shooter, MOBA	Ranked
Knives Out	> 10 M	NetEase Games	2017	Adventure	Ranked
Rules of Survival	> 10 M	NetEase Games	2017	Battle	Ranked
PUBG MOBILE	> 10 M	Tencent Games	2018	Battle	Random/ ranked
Critical Ops	> 10 M	Critical Force Entertainment	2015	Multiplayer first-person shooter	Ranked
Vainglory	> 5 M	Super Evil Megacorp	2014	MOBA	Ranked
Injustice 2	> 5 M	Warner Bros.	2017	Fighting	Random/ ranked
Tekken Mobile	> 5 M	Bandai Namco Entertainment	2017	Fighting	Random/ ranked
Chess – Play & Learn	> 5 M	Chess.com	2010	Logical	Ranked
WarFriends	> 1 M	Electronic Arts, Chillingo	2017	Real-time PvP multiplayer shooter game	Ranked
World of Warships Blitz	> 1 M	Wargaming Group	2018	Action MMO	Ranked

Selected Opinions About Fifa Mobile Matchmaking System

XNau (27.08.2017)

> It is going from bad to worse. In the last weeknd I have several times been matched with teams that are way above own lvl. 10-15 % above!. How *** are we suppose to progress with such a useless an unfair matchmaking? Getting tired of this…

Source: https://fifaforums.easports.com/en/discussion/303855/what-happened-to-the-vs-attack-matchmaking (Last Accessed: 10.04.2018)

Selected Opinions About Mobile Legends Matchmaking System
Nekroz (19.11.2017)

> WHEN I SOLO Q, I FEEL THE MATCHMAKING IS MANIPULATED, HOW CAN I GET A VERY EASY WIN THEN IN THE NEXT MATCH I GET VERY VERY STUPID TEAMMATES WITHOUT MAP AWARENESS, PROPER FARM AND TEAM COORDINATION? […] COME ON DEVELOPERS PLAY YOUR ********* TO FEEL HOW IS THE GAME!!!!!!!!

Source: https://forum.mobilelegends.com/forum.php?mod=viewthread&tid=42444, (Last Accessed: 5.04.2018)

Selected Opinions about Mortal Kombat Matchmaking System
badaaim (17.05.2015)

> Why is it that every single ♥♥♥♥♥♥♥ time, I get matched up against players with really high stats. I don't mind losing; I am a fairly patient person when it comes to things like this. However, this really gets me because I have no chance in the first place to fight against these high stats gold characters against my one gold and two silver team. Stupid matchmaking is annoying as ****. All I want is a fair game and a chance to fight properly but I don't have that with this stupid matchmaking. I always get paired up with people who have spent real money to buy and upgrade their gold characters.

Source: https://steamcommunity.com/app/307780/discussions/0/620713633857037946/, (Last Accessed: 20.03.2018)

Selected Opinions About Critical Ops Matchmaking System
Corey (25.01.2018)

> For long periods of time the ranked matchmaking will not let me enter a game. It says searching but will never connect and this goes on for days. Help?

From the presented opinions, it stands out that matchmaking systems do influence player experience within the game, especially wrongly designed systems that can lead to huge amounts of frustration among the gamers. Two main factors are most often described as problematic in matchmaking systems – criteria that are taken into consideration in the process and the time spent in queue. As these are contrary optimization criteria, if the waiting time is to be reduced, the number of factors taken into account should also be lowered – it would be difficult if not impossible to optimize both criteria. At the same time, it is very important to choose the proper factors and include them in the matchmaking systems, as otherwise it can lead to low player satisfaction, low engagement in the game, and, at the end, high gamer dropout levels. For example, in Clash Royale, Fifa Mobile, and Mortal Kombat, players seem to be very dissatisfied with the fact that they are playing against competitors who are on different levels. It is especially true in the case of the fighting game Mortal Kombat, where random matchmaking is introduced. In Mobile Legends, gamers do complain that the level of their teammates is so different each time they play that makes it hard to appreciate each gameplay. Other players on forums seem to agree with the opinions presented above.

In many cases game developers respond to player complaints, describing the way matchmaking systems are designed and reasons behind their reasoning. For example, according to the information presented by game developer on online forum in Clash Royale, the trophies are the only factors influencing player skill ranking and are included in matchmaking process, while the current level on which a player is playing is not taken into consideration [54]. However, introducing other criteria in matchmaking optimization function would effect in higher waiting time. In Fifa Mobile, the opponents are assigned on the basis of the number of fans one have, no matter what the overall squad rating is [55]. In World of Tanks Blitz, the only criterion taken into account in the matchmaking system is the tank hardware, which means that factors such as personal rating, tank progress, player statistics or class if the vehicle do not influence the matches [56]. It can lead to matches of the gamers playing on quite different levels, which can be confirmed by their opinions on forums and can lead to the feeling of dissatisfaction and frustration among gamers.

5 Discussion

According to the results of conducted research, there are many factors influencing Esports player engagement, and matchmaking is undoubtedly one of the very important ones. It is crucial therefore for game developers to design a proper matchmaking system, and the main encountered problem in doing that is that it should satisfy as many players as possible. At the same time, players have different playing styles and various characters, so it is not easy to measure their skills, and it is even more difficult to match them in a way that satisfies everyone. In matchmaking systems, an optimization function is defined. The objective of the function is to maximize player engagement, which in many models is understood as minimizing the time spent in queue and matching players of the similar skills. According to the players' opinions on online forums, even if the companies try to assure that players with comparable skills are matched together, it can be viewed from gamers' perspective in completely different way. Furthermore, not all players want always to compete with people who are at the same level as they are – sometimes they prefer challenging gameplay, and at other times they want an easy win. If player personality influences their reactions and satisfaction from matches, it should be one of the criteria included in matchmaking systems. The level of emotions and physiological reactions can be tracked as well (using as indicators, e.g., the speed of thumb work), and it could give some hints about when to match a player with considerably worse or better opponents, not always with the ones of the same skills.

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References

1. Deloitte (2018) Technology, media & telecommunications (TMT) trends: predictions, 2018, p 35. https://www2.deloitte.com/content/dam/Deloitte/pl/Documents/Reports/pl_2018_TMT_Predictions.pdf
2. Grohmann K (2018) Olympic Channel boss says ready to explore esports after Pyeongchang. https://www.reuters.com/article/us-olympics-2018-ioc-esports/olympic-channel-boss-says-ready-to-explore-esports-after-pyeongchang-idUSKCN1G30JM. Last Accessed 15 Mar 2018
3. Deloitte (2018) Informacje prasowe. W tym roku przychody z esportu przekroczą po raz pierwszy miliard dolarów. https://www2.deloitte.com/pl/pl/pages/press-releases/articles/W-tym-roku-przychody-e-Sportu-przekrocza-po-raz-pierwszy-miliard-dolarow.html?utm_source=newsletter&utm_medium=email-04-05-2018&utm_campaign=C/RG-AUD-01794-Non-campaign%20related%20press%20releases. Last Accessed 04 Oct 2018
4. Scopus Article Base. https://www.scopus.com/term/analyzer.uri?sid=fe0b046cb4-53ff7f3b754ff62b6d6dc4&origin=resultslist&src=s&s=TITLE-ABS-KEY%28esports%29&sort=plf-f&sdt=b&sot=b&sl=22&count=61&analyzeResults=Analyze+results&txGid=16a3563d1ab2906d8d9b679a53343a50. Last Accessed 19 Mar 2018
5. Hemphill D (2005) Cybersport. J Philos Sport 32(2):195–207
6. Hamari J, Sjöblom M (2017) What is eSports and why do people watch it? Internet Res 27(2):211–232
7. Bornemark O (2013) Success factors for E-sport games. In: Bensch S, Drewes F (eds) Umeå's 16th student conference in computing science. Umeå University, Umeå, pp 1–12
8. Jonasson K, Thiborg J (2010) Electronic sport and its impact on future sport. Sport Soc 13(2):287–299
9. Kauweloa S, Winter J (2016) Collegiate E-sports as work or play. In: Proceedings of the first international joint conference of DiGRA and FDG, 1–5 August 2016. Dundee, Scotland. Digital Games Research Association and Society for the Advancement of the Science of Digital Games
10. Szablewicz M (2011) From addicts to athletes: participation in the discursive construction of digital games in urban China. In: Fragoso S (ed) Selected papers of internet research 12.0. Association of Internet Researchers, Seattle, pp 1–21
11. Weiss T (2011) Fulfilling the needs of eSports consumers: a uses and gratifications perspective. In: Bled eConference, 30
12. Karhulahti VM (2017) Reconsidering esport: economics and executive ownership. Phys Cult Sport Stud Res 74(1):43–53
13. Rose V (2017). The International's prize pool is, once again, the biggest in esports history. In: The flying courier. Polygon. Archived from the original on August 4, 2017. https://www.theflyingcourier.com/2017/7/12/15959890/dota-2-ti7-prize-pool-biggest-prize-pool-esports-history. Last Accessed 19 Apr 2018
14. Google Play Store. https://play.google.com/store. Last Accessed 05 Mar 2018
15. Handrahan M (2017) Critical force: "Mobile will become more and more important to esports". https://www.gamesindustry.biz/articles/2018-02-27-critical-force-mobile-will-become-more-and-more-important-to-esports. Last Accessed 19 Apr 2018
16. Fullerton T (2014) Game design workshop: a playcentric approach to creating innovative games, 3rd edn. CRC press, Boca Raton
17. Dillon R (2010) On the way to fun: an emotion-based approach to successful game design. A K Peters, Ltd, Natick
18. Mayes DK, Cotton JE (2001) Measuring engagement in video games: a questionnaire. In: Proceedings of the human factors and ergonomics society annual meeting, 45(7): 692–696. SAGE Publications, Sage/Los Angeles
19. Biocca F, Kim T, Levy MR (1995) The vision of virtual reality. Commun Age Virtual Real:3–14

20. Csikszentmihalyi M (1997) Finding flow: the psychology of engagement with everyday life. Basic Books
21. Zaichkowsky JL (1985) Measuring the involvement construct. J Consum Res 12(3):341–352
22. Vorderer P, Hartmann T, Klimmt C (2003, May) Explaining the enjoyment of playing video games: the role of competition. In: Proceedings of the second international conference on entertainment computing, Carnegie Mellon University, pp 1–9
23. O'Brien HL, Toms EG (2008) What is user engagement? A conceptual framework for defining user engagement with technology. J Assoc Inf Sci Technol 59(6):938–955
24. Ravaja N, Saari T, Salminen M, Laarni J, Kallinen K (2006) Phasic emotional reactions to video game events: a psychophysiological investigation. Media Psychol 8(4):343–367
25. Charlton JP, Danforth ID (2007) Distinguishing addiction and high engagement in the context of online game playing. Comput Hum Behav 23(3):1531–1548
26. Brusselle R, Bilandzic H (2009) Measuring narrative engagement. Media Psychol 12:321–347
27. Cavadenti O, Codocedo V, Boulicaut JF, Kaytoue M (2016, October) What did I do wrong in my MOBA game? Mining patterns discriminating deviant behaviours. In: IEEE international conference on data science and advanced analytics (DSAA), pp 662–671
28. Oksanen K, Lainema T, Hämäläinen R (2017) Learning from social collaboration: a paradigm shift in evaluating game-based learning. In: Handbook of research on serious games for educational applications. IGI Global, Hershey, pp 41–65
29. Ryan RM, Deci EL (2002) An overview of self-determination theory: an organismic-dialectical perspective. In: Handbook of self-determination theory. University of Rochester Press, Rochester
30. Hodent C (2017) The Gamer's brain: how neuroscience and UX can impact video game design. CRC Press, Boca Raton/London/New York
31. Vallerand RJ, Ratelle CF (2002) Intrinsic and extrinsic motivation: a hierarchical model. In: Handbook of self-determination research, vol 128, pp 37–63
32. Deci E, Ryan R (2014) The importance of universal psychological needs for understanding motivation in the workplace. In: The Oxford handbook of work engagement, motivation, and self-determination theory. Oxford University Press, New York
33. Dysvik A, Kuvaas B, Gagné M (2013) An investigation of the unique, synergistic and balanced relationships between basic psychological needs and intrinsic motivation. J Appl Soc Psychol 43(5):1050–1064
34. Deci EL, Ryan RM (2002) Self-determination research: reflections and future directions. In: Handbook of self-determination theory. The University of Rochester Press, Rochester
35. Freeman G, Wohn DY (2017) Understanding eSports team formation and Coordination. In: Computer supported cooperative work (CSCW), pp 1–32
36. Zoeller G (2010) Development telemetry in video games projects. In: Game developers conference
37. Bernhaupt R (2010) User experience evaluation in entertainment. In: Evaluating user experience in games. Springer, London, pp 3–7
38. Sarkar A, Williams M, Deterding S, Cooper S (2017, August) Engagement effects of player rating system-based matchmaking for level ordering in human computation games. In: Proceedings of the 12th international conference on the foundations of digital games. ACM, New York, p 22
39. Hadiji F, Sifa R, Drachen A, Thurau C, Kersting K, Bauckhage C (2014, August) Predicting player churn in the wild. In Computational intelligence and games (CIG), 2014 IEEE conference on, 1–8
40. Lin J (2013) The science behind shaping player behavior in online games. In: Annual game developers conference
41. Horton E, Johnson D, Mitchell J (2016, November) Finding and building connections: moving beyond skill-based matchmaking in videogames. In: Proceedings of the 28th Australian conference on computer-human interaction. ACM, New York, pp 656–658

42. Herbrich R, Minka T, Graepel T (2007) TrueSkill™: a Bayesian skill rating system. In: Advances in neural information processing systems. MIT Press, Cambridge, MA, pp 569–576
43. Glickman ME (1999) Parameter estimation in large dynamic paired comparison experiments. J R Stat Soc Ser C Appl Stat 48(3):377–394
44. Elo AE (1978) The rating of chessplayers, past and present. Arco Pub, New York
45. Graepel T, Herbrich R (2006) Ranking and matchmaking. Game Dev Mag 25:34
46. Véron M, Marin O, Monnet S (2014, March) Matchmaking in multi-player on-line games: studying user traces to improve the user experience. In: Proceedings of network and operating system support on digital audio and video workshop. ACM, New York
47. Chen Z, Xue S, Kolen J, Aghdaie N, Zaman KA, Sun Y, Seif El-Nasr M (2017, April) EOMM: an engagement optimized matchmaking framework. In proceedings of the 26th international conference on world wide web, International world wide web conferences steering committee, pp 1143–1150
48. Agarwal S, Lorch JR (2009, August) Matchmaking for online games and other latency-sensitive P2P systems. ACM SIGCOMM Comput Commun Rev 39(4):315–326
49. Manweiler J, Agarwal S, Zhang M, Roy Choudhury R, Bahl P (2011, June) Switchboard: a matchmaking system for multiplayer mobile games. In: Proceedings of the 9th international conference on Mobile systems, applications, and services. ACM, New York, pp 71–84
50. Jiménez-Rodrıguez J, Jiménez-Dıaz G, Dıaz-Agudo B (2011). Matchmaking and case-based recommendations. In 19th international conference on case based reasoning
51. Myślak M, Deja D (2014, November) Developing game-structure sensitive matchmaking system for massive-multiplayer online games. In: International conference on social informatics. Springer, Cham, pp 200–208
52. Delalleau O, Contal E, Thibodeau-Laufer E, Ferrari RC, Bengio Y, Zhang F (2012) Beyond skill rating: advanced matchmaking in ghost recon online. IEEE Trans Comput Intell AI Games 4(3):167–177
53. Kozinets RV (1998) On netnography: initial reflections on consumer research investigations of cyberculture. ACR North Am Adv
54. ClashRoyalPedia. https://www.clashroyalepedia.com/The_Clash_Royale_Matchmaking_Guide. Last Accessed 15 Apr 2018
55. FifPlay. http://www.fifplay.com/fifa-mobile-17-vs-attack-matchmaking-system/. Last Accessed 15 Apr 2018
56. WarGaming.net. http://wiki.wargaming.net/en/Matchmaker_(Blitz). Last Accessed 15 Apr 2018

Learning via AI Dolls: Creating Self-Active Learning for Children

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Abstract This research aimed to propose an artificial intelligence (AI) chatbot mobile application for pre-school children engaging in active learning processes. The research tools Microsoft Bot Framework and Azure Bot Service were used to create an AI chatbot doll (AIBD) prototype. With this AIBD, the players simply dragged and dropped items in an intelligent bot builder that could create characters with different identities using a set of customized doll items, for example, genders, dresses, shoes, or flowers. During play, children could either learn about what colors, apparel, languages, or music they liked or communicate their attitudes or thoughts to the dolls. Consequently, the AIBD also learned and collected personal data, such as players' personalities, emotions, attitudes, or behaviors. Finally, the data were stored in a private cloud repository, where only authorized parents could access the reports. In our findings, the average correlation between the capability of the AIBD's learning performance and children's active learning processes was high (support value equal to 0.791 and confidence value equal to 0.853). Moreover, the children playing with the AIBD could not only develop their emotions but they also saw large improvements in their ideas generation.

Keywords AIBD · Artificial Intelligence · Chatbot · Doll · Child · Active learning

1 Introduction

In the past, children, both boys and girls, played with dolls for purposes such as reaction, relaxation, learning, or having friends. They might dress, talk to, teach, or hug their dolls, but these actions could only be considered as a one-way interaction because the dolls could not perceive the feelings or thinking of the playing child. In the twenty-first century, artificial intelligence (AI) plays an important role in education, computer technology, business, and industry because intelligent agents could

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perceive their environments and actions to empower them with the best chances of success for some end goal. This is because the machine mimics human-like functions, such as learning and problem-solving [1].

For example, there exists work studying how an AI robot with simple interaction skills could be used as a teaching device (a 'doll') in autism therapy [2]. In a series of trials among 8- to 12-year-old autistic children, it was found that: (1) the robot was safe for the children to use; (2) a large majority of children was not afraid of the robot; (3) the children were very motivated to interact with the robot over a period of 5–10 min or longer; (4) the children were usually more interested in the robot in 'interactive' mode compared to the robot showing rigid, repetitive, non-interactive behavior; and (5) the children had no problems coping with the robot behaving reactively, but not completely predictably [3, 4].

Traditionally, these robot dolls had shown only a few basic behaviors. The results also indicated that children in the past were generally more interested in robots (in terms of gaze, touch, etc.) and were more engaged in interactions with the robot than with another type of non-robotic doll [3]. Recently, new generations of AI doll have been developed as mobile applications, called AI chatbot dolls (AIBDs), and have become commercially significant in the marketplace [1, 5]. Generally, AIBDs have been designed to perform human-like interactions and exhibit human-like intelligence that could be developed using Android™ or iOS™ software development kits (SDKs) and, additionally, integrated with AI frameworks [6, 7].

In the educational sector, AIBDs have been popularly known as innovative active learning tools to enhance pedagogy approaches, because children who played with AIBDs would not only see emotional improvements but also make friends who knew and understood them very well [8, 9]. From these benefits, researchers have been motivated to contribute to AIBDs research using new features of cutting-edge technology development. In this paper, we propose an AIBD prototype specially designed for pre-school children. This paper is organized as follows: Sect. 2 discusses the exiting literature and related works; Sect. 3 describes the proposed model; in Sect. 4, the results are presented; finally, the conclusions are given in Sect. 5, along with further developments.

2 Literature Review

The history of AI for home assistants has become a part of human life since the mid-eighteenth century [9]. In the past, philosophers had only built experimental machines that test hypotheses about the mechanisms of thought and scientific tasks. René Descartes, Gottfried Leibniz, and Blaise Pascal designed mechanical reasoning devices using rules of logic to calculate complex arithmetic [10]. However, those systems were only studied in the laboratory and have never been made into commercial products, for example, ActivMedia Robotics or RWI's indoor robots, such as B21r, B14r, and Magellan Pro [11].

In the early part of the twentieth century, researchers found significant learning outcomes relative to the usage of robots in education. For example, children's active learning methods with physical robot dolls or robotic devices positively encouraged them to develop eye contact and improve social settings, including body therapy, emotional expression, and mental improvement [11]. However, recent researchers found that the development of physical robot dolls was severely limited in terms of their capabilities and replicated only a small amount of the basic behaviors of human beings to players, for example, arm, voice, and eye movements or vibrations without intelligent features. Therefore, most of the pre-historic robotic products could not successfully enter the consumer market [1].

In 2016, schools spent nearly $160 billion on AI technologies for education and it is forecast that this spending will grow 17% annually through 2020. AI's share in the education market, especially the learning processes, will grow exponentially due to its abilities of providing active learning for each student and interpreting complex human responses, such as emotions, while imparting knowledge on different subjects. AI will also play a key role in recruitment by matching the right person to the right position. A recent study estimated that, by 2025, online AI platforms could enable a benefit as large as $60 million in this educational sector [12].

Since smart devices such as smartphones or tablets became available at an affordable price in the marketplace, the development of AI dolls began to move to the mobile platform and be known as AIBDs. The advantages for AI applications were that it was a virtual (meaning that, before the AI technology carried out a real job, it could be tested in a safe environment), social (meaning that this environment could simulate real life as close as possible for testing), and marketable platform for consumers [7, 8]. The evolution of AIBDs development moved from basic functionalities to complex multimedia applications, and moved from video and audio appearances to human-like versions of AI social simulation [13].

In modernized models, the developers use AI bot SDKs based on AI platforms to accelerate the API economy and ecosystem. SDKs provide developers with a set of tools and emulators that help in code writing or testing, as well as providing high-quality bot frameworks for the design and construction of AI architecture, for example, Visual Studio, Eclipse, libraries, and programming languages like C#, Node.js, Java, PHP, and so on. As a result, modern AI bot applications are more intuitive and appealing, such as Facebook Bot Engine, Dialogflow, Siri™, Alexa, and Microsoft Bot Framework [7, 8, 14].

As an educational tool, AIBDs could better assist, guide, or encourage children to learn at his/her own pace everywhere, with safety procedures in place to protect them. Some schools use AIBDs as an edutainment or pedagogy tool for the method and practice, especially as an academic subject or theoretical concept for children to learn or have active experiences of. Most AIBDs are now designed to mimic real biological systems, such as 'Cute', 'Talent', and 'Good society', as well as to appeal to children's tendencies to play with them [15, 16]. Moreover, modern AIBDs could perform realistic actions with safety precautions, enabling users to communicate and engage with digital personal assistants connected to smart TVs, computers, smart appliances, security cameras, smartphones, smart cars, and so on [9].

Therefore, most of the researchers believe that AI for the cloud education platform with personalized learning such as AIBDs could replace traditional dolls for active learning assistance in the future [14, 17].

3 The Proposed Model

In this section, we develop a prototype of the AIBD application using the Microsoft Bot Framework SDK [7, 8, 18]. Like other software development frameworks, the Microsoft Bot Framework SDK provides resource kits for developers who need to build mobile chatbot applications that can perform human-like interactions. The Bot Framework SDK provides components for developers to help solve problems such as automatic translation to different languages, user and dialog state management, and debugging. The Microsoft Azure service platform (Language Understanding, LUIS) [7] provides intents and utterances with Cognitive Services, which helps to train and test LUIS applications with reduced modification effort [8]. The bot architecture was used to design the interface for user input, such as text format, speech, or images. Moreover, it supports various channels for communication with users, including Slack, Facebook Messenger, Skype, and so on. These intelligent services were enabled in the Azure AI cloud portal, forming the bot brain that understands and reasons with dialog flow in the Microsoft Azure platform, as shown in Fig. 1.

From Fig. 1, the main components of the chatbot framework are as follows:

1. Bot Connector is a service that allows a bot to exchange messages with channels available in the Microsoft Bot Framework by using the REST API and JSON over the secure protocol HTTPS. When a user sends a message, the Bot Connector sends a POST request to the endpoint that was specified during bot registration, and the information from it could be used to create a response to the user when the bot obtains a JSON object [7, 8, 18]. An example of the body of the request is shown below:

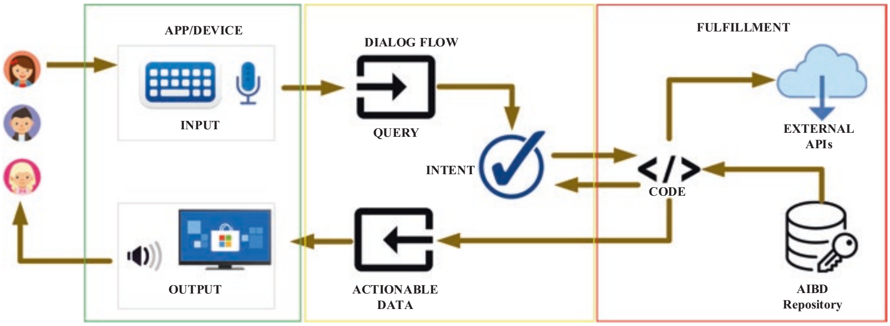

Fig. 1 The dialog flow in the Microsoft Azure platform

```
{
 "type": "message",
 "text": "message text",
 "from": {
 "id": "default-user"
 },
 "locale": "en-US",
 "textFormat": "plain",
 "timestamp": "2018-05-09T00:12:30.174Z",
 "channelData": {
 "clientActivityId": "1420608946838.7637367733445164.0"
 },
 "entities": [
 {
 "type": "ClientCapabilities",
 "requiresBotState": true,
 "supportsTts": true,
 "supportsListening": true
 }
 ],
 "id": "dc12f8svfg9j",
 "channelId": "emulator",
 "localTimestamp": "2018-05-09T00:12:30.174Z",
 "recipient": {
 "id": "96elffmf1d0d",
 "name": "Bot"
 },
 "conversation": {
 "id": "ab34g6dffr1m"
 },
 "serviceUrl": " http://localhost:3978/api/messages"
}
```


```
[Route("api/requests/menu")]
[HttpGet]
public async Task<HttpResponseMessage> MenuResponse()
{
botService botService = new botService();
 var msg = botService.GetdollcaMenu(
 "http://www.test.fi/modules/json/json/Index?testNumber=1111&langu
age=en");
 return await SendMessage(msg);
}
```

2. Bot Builder is an SDK for .NET Framework developers for developing AIBDs using Visual Studio and Windows. The SDK supports the C# and Node.js programming languages. The kit consists of the Bot Application, Bot Controller, and Bot Dialog class templates (`BasicLuisDialog`) which could be developed for the intents of `DollAutomation.TurnOn` and `DollAutomation.TurnOff` inside the `BasicLuisDialog` class. A POST method was used to accept messages and auto-generate a dialog builder in the bot application project to generate the `ShowLuisResult` method in the `BasicLuisDialog` class to round the score, collect the entities, and display the response message in the chatbot, as shown below:

```
    / CONSTANTS
    // Entity
    public const string Entity_Device = "DollAutomation.Device";
    public const string Entity_Doll = "DollAutomation.Doll";
       public const string Entity_Operation = "DollAutomation.
Operation";

    // Intents
    public const string Intent_TurnOn = "DollAutomation.TurnOn";
    public const string Intent_TurnOff = "DollAutomation.TurnOff";
    public const string Intent_None = "None";
    LuisIntent(Intent_TurnOn)]
    public async Task OnIntent(IDialogContext context, LuisResult
result)
    {
        await this.ShowLuisResult(context, result);
    }

    [LuisIntent(Intent_TurnOff)]
    public async Task OffIntent(IDialogContext context, LuisResult
result)
    {
        await this.ShowLuisResult(context, result);
    }
    // Entities found in result by LUIS inside the BasicLuisDialog
class
    public string BotEntityRecognition(LuisResult result)
    {
        StringBuilder entityResults = new StringBuilder();

        if(result.Entities.Count>0)
        {
```

```
            foreach (EntityRecommendation item in result.Entities)
             {
                 // Query: Turn on the [sound]
                 // item.Type = "DollAutomation.Device"
                 // item.Entity = "sound"
                entityResults.Append(item.Type + "=" + item.Entity
+ ",");
             }
             // remove last comma
             entityResults.Remove(entityResults.Length - 1, 1);
         }

         return entityResults.ToString();
     }
```

After the bot packages are completely built (`Build.cmd`), the bots are run on the Microsoft Azure service console in order to test the bot operations, with a terminal window showing the progress and results of the build in the Azure portal. To invoke the intents that operated the AIBD, the children needed to simply type command messages like "turn on the sound" or "turn off my icons" in Web Chat to play with the bot on any mobile device. In addition to automatically generating the results, there was a `ShowLuisResult` method in the `BasicLuisDialog` class to round the score, collect the entities, and display the response message in the chatbot to the specified Slack channel. The `ShowLuisResult` method is shown below (Fig. 2):

```
private async Task ShowLuisResult(IDialogContext context,
LuisResult result)
{
    // get recognized entities
    string entities = this.BotEntityRecognition(result);

    // round number
   string roundedScore =  result.Intents[0].Score != null ? (Math.
Round(result.Intents[0].Score.Value, 2).ToString()) : "0";

  await context.PostAsync($"**Query**: {result.Query}, **Intent**:
{result.Intents[0].Intent},      **Score**:      {roundedScore}.
**Entities**: {entities}");
    context.Wait(MessageReceived);
}
```

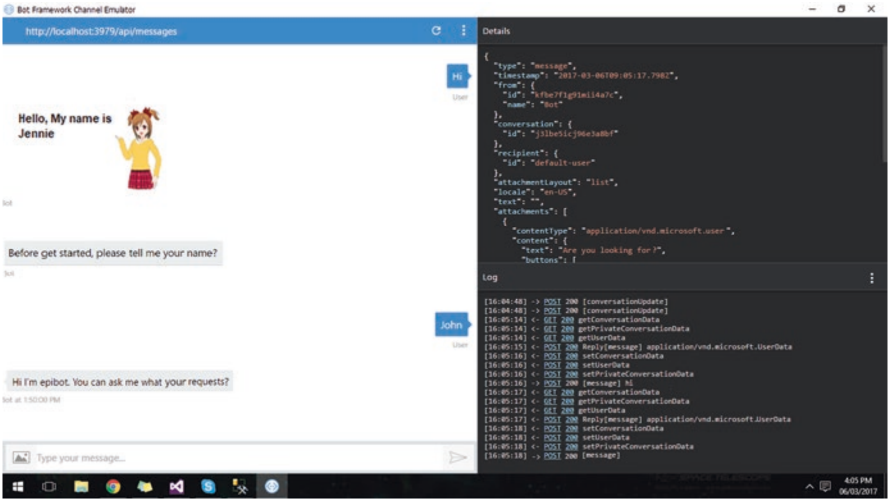

Fig. 2 Microsoft Bot Framework emulator communicating with the Azure Bot Service

4 Data Collection and Data Model

In the data collection process, the data were recorded when children communicated with or created characters using the bot builder with a different set of customized doll items, for example, genders, dresses, shoes, or flowers. During play, children could either learn about what color, apparel, language, or music they liked or communicate their attitudes or thoughts to the dolls.

Consequently, the AIBD also learned and collected personal data, such as children's personalities, emotions, attitudes, or behaviors. Finally, the data were gathered and transferred from the AIBD's memory to the private cloud repository. Using the data, we could assess children's active learning processes by measuring the correlation between children's learning activities and the AIBD's learning performance from these attributes. The data model was designed and built in Microsoft SQL Server for the Azure platform as a database schema (Fig. 3).

5 Results

In the experiment, we included a small group of pre-school children who were in the age range 3–5 years old. They engaged with the AIBD by playing with it and communicating their attitudes or thoughts to it. After providing instructions on using the AIBD, the children could lead and improve on the complexity of play behaviors with developmental abilities. During playing, we gathered the dataset from Bot Framework Emulator that allowed bot developers to test and measure the correlation between the capability of the AIBD's learning performance and the capability of the

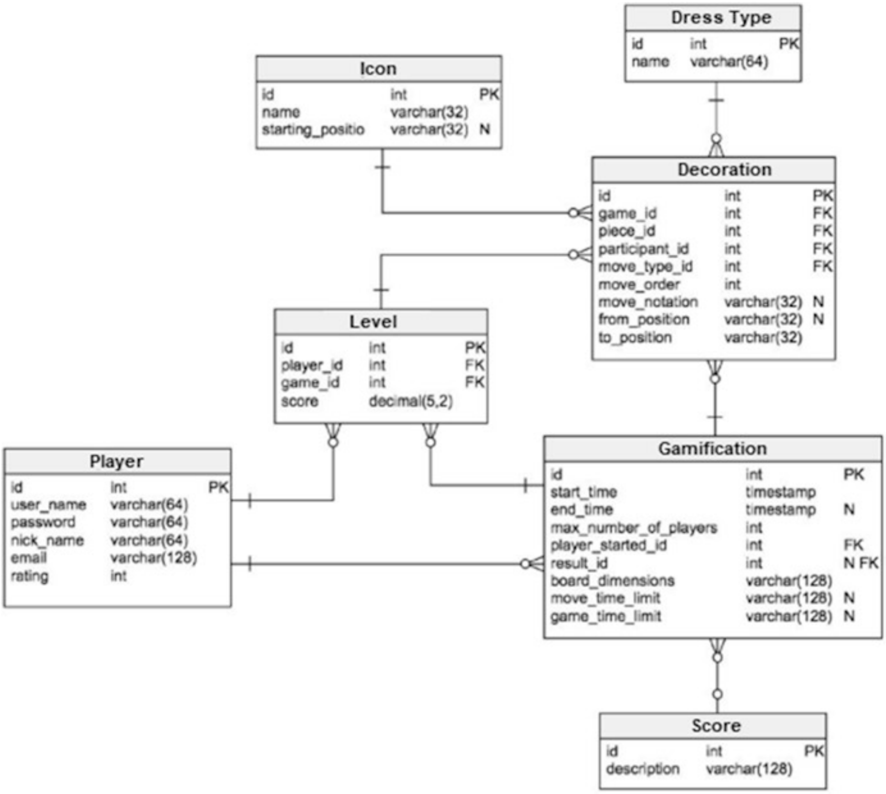

Fig. 3 The design of the data model on the Microsoft Azure platform

children's active learning processes. Using the bot emulator, researchers inspected the response messages that it sent, received correlation results, and evaluated the AIBD's performance by applying the association rule [19]. The support, $s(\mathrm{X} \rightarrow \mathrm{Y})$, to measure the percentage of correlation is shown in Eq. (1) and the confidence of the rule $c(\mathrm{X} \rightarrow \mathrm{Y})$, where X and Y are sequential patterns, is defined as Eq. (2):

$$\text{Support, } \mathrm{s}\left(\mathrm{X} \rightarrow \mathrm{Y}\right) = \frac{\sigma\left(\mathrm{X} \cup \mathrm{Y}\right)}{N} \tag{1}$$

$$\text{Confidence, } c\left(\mathrm{X} \rightarrow \mathrm{Y}\right) = \frac{\sigma\left(\mathrm{X} \cup \mathrm{Y}\right)}{\sigma\left(X\right)} \tag{2}$$

where σ denotes the concatenation operator. The Apriori algorithm used in association rule mining can also be adopted to discover open and contiguous sequential patterns. This is normally accomplished by changing the definition of support so that it is based on the frequency of occurrences of subsequences of items rather than subsets of items [20].

Table 1 The results of children's active learning processes associated with the artificial intelligence chatbot doll's (AIBD) learning performance

No.	Item sets	Support	Confidence
1	Social learning and engagement	0.831	0.925
2	Recreation, relaxation, or having friends	0.825	0.915
3	Logical or systematic thinking development	0.815	0.900
4	Emotion expression and mental improvement	0.801	0.891
5	Communication skills improvement	0.791	0.880
6	Body therapy and eye contact development	0.790	0.850
7	Problem-solving development	0.785	0.840
8	Self-confidence development	0.783	0.830
9	Positive thinking improvement	0.765	0.792
10	Leadership and managerial development	0.731	0.711
The average correlations of the capability of children's active learning processes and the capability of the AIBD's learning performance		0.791	0.853

An association rule is an expression of the form X → Y, where X and Y are disjoint item sets (X ∩ Y = 0). The association rule could be measured in terms of its support (*s*) and confidence (*c*). Support determines how often a rule was applicable to a given dataset (*N*), while confidence determines how frequently items in Y appear in transactions that contain X. Considering the average correlations of the capability of the AIBD's learning performance, as well as the capability of children's active learning processes, the researchers found that the support was equal to 0.791 and the confidence was equal to 0.853, respectively (Table 1).

6 Conclusions

In this work, we aimed to develop an AI doll prototype especially designed as an AI chatbot mobile application for engaging pre-school children in active learning. Using disruptive technologies, the AIBD provided learning functionalities and stored data in a secure, private cloud storage repository. In our findings, correlation of the capability of the AIBD's learning performance and the capability of children's active learning processes achieved high support and confidence values. Besides, we found that children who played with AIBDs could not only develop their emotions but they also saw large improvements in their ideas generation. In the future, work would also involve integrating Internet of things (IoT) technologies and social networking platforms [7, 8] to improve intelligent bot functionalities and empower them with human-like responses in further development.

References

1. Perez JA, Deligianni F, Ravi D, Yang GZ (2018) Artificial intelligence and robotics. arXiv Preprint arXiv:1803–10813
2. Santatiwongchai S, Kaewkamnerdpong B, Jutharee W, Ounjai K (2016) BLISS: using robot in learning intervention to promote social skills for autism therapy. In: Proceedings of the international convention on rehabilitation engineering & assistive technology. Singapore Therapeutic, START Centre: 16
3. Richardson K (2016) The robot intermediary: mechanical analogies and autism. Anthropol Today 32(5):18–20
4. Beccaluva EA, Bonarini A, Cerabolini R, Clasadonte F, Garzotto F, Gelsomini M, Viola L (2017) Exploring engagement with robots among persons with neurodevelopmental disorders. In: The 26th IEEE international symposium on robot and human interactive communication, pp 903–909
5. Thies IM, Menon N, Magapu S, Subramony M, O'Neill J (2017) How do you want your chatbot? An exploratory Wizard-of-Oz study with young, urban Indians. In: IFIP conference on human-computer interaction. Springer, Cham, pp 441–459
6. Doshi SV, Pawar SB, Shelar AG, Kulkarni SS (2017) Artificial intelligence Chatbot in Android system using open source program-O. Artif Intell 6(4)
7. Machiraju S, Modi R (2018) Develop bots using. NET Core. In: Developing bots with Microsoft bots framework. Apress, Berkeley, pp 19–52
8. Machiraju S, Modi R (2018) Conversations as platforms. In: Developing bots with Microsoft bots framework. Apress, Berkeley, pp 1–17
9. Bhaumik A (2018) From AI to robotics: mobile, social, and sentient robots. CRC Press, Boca Raton
10. Davis M (2011) The universal computer: the road from Leibniz to Turing. AK Peters/CRC Press, Boca Raton
11. Dautenhahn K, Billard A (2013) Games children with autism can play with Robota. In: Universal access and assistive technology: proceedings of the Cambridge workshop on UA and AT 2: 179
12. Manyika J, Lund S, Robinson K, Valentino J, Dobbs R (2015) A labor market that works: connecting talent with opportunity in the digital age. McKinsey Global Institute, New York
13. Augello A, Gentile M, Weideveld L, Dignum F (2016) A model of a social chatbot. In: Intelligent interactive multimedia systems and services. Springer, Cham, pp 637–647
14. Stucke ME, Ezrachi A (2018) Alexa et al., what are you doing with my data? Crit Anal Law 5(1)
15. Cath C, Wachter S, Mittelstadt B, Taddeo M, Floridi L (2018) Artificial intelligence and the 'good society': the US, EU, and UK approach. Sci Eng Ethics 24(2):505–528
16. Gini M, Agmon N, Giunchiglia F, Koenig S, Leyton-Brown K (2018) Artificial intelligence in 2027. AI Matters 4(1):10–20
17. Rad P, Roopaei M, Beebe N, Shadaram M, Au Y (2018) AI thinking for cloud education platform with personalized learning. In: Proceedings of the 51st Hawaii international conference on system sciences
18. Sannikova S (2018) Chatbot implementation with Microsoft Bot Framework
19. Chen LF, Chen SC, Su CT (2018) An innovative service quality evaluation and improvement model. Serv Ind J 38(3–4):228–249
20. Fok WW, He YS, Yeung HA, Law KY, Cheung KH, Ai YY, Ho P (2018) Prediction model for students' future development by deep learning and tensorflow artificial intelligence engine. In: The 4th IEEE international conference on information management, pp 103–106

Virtual Reality for Active English Learning in the University Context

Jeffrey D. Wilang

Abstract The use of technology is becoming widespread in science and technology classes due to its overwhelming benefits in learning. Yet many English language teachers lack knowledge of the existing technologies and the "know-how" to use it in the classroom. In this paper, the results of the pilot study are reported concerning the effects of virtual reality (VR) headset onto the language learner's affective variables such as engagement, motivation, and independent learning. It also explores the effectiveness of VR headset onto the language learner's ability to learn vocabularies and to follow instructions. Descriptive reports show very high mean scores of the learner's engagement ($M = 4.63$), motivation ($M = 4.72$), and independent learning ($M = 4.63$). The average mean score concerning their ability to follow instruction was 4.36. With regard to vocabulary test, the average mean score in the posttest was 2.73, higher than the average mean score of 1.18 in the pretest.

Keywords Active learning · English language · Virtual reality

1 Introduction

The use of technology to improve language teaching and learning has been promoted over the years due to its overwhelming benefits. One of the available technologies gaining popularity is virtual reality and/or augmented reality as it allows real-world-like experiences for language learners. For example, in virtual worlds, students could interact with specific situations in a dinner party, a cruise ship, a museum, and so on. In some situations, where language learning could be expensive, virtual reality could bring language learners to places such as international airports.

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Research has shown some evidences that virtual reality has positive effects on the affective and cognitive aspects of language learning. In the affective aspect, learners were found to increase autonomy, engagement, motivation, and interests in language learning [1]. For cognition, learners may enrich their vocabularies.

Having to control the technology with just a click to learn, language learners may review the lesson when mistakes are committed. Immediate feedback could be programmed unlike in textbooks. In some programs where students can create their own virtual world, they can directly communicate or interact with other characters, for example, when asking information to strangers.

Incorporating newer technologies into language learning could be beneficial for the learners [2, 3]. Providing them with affordances that create beyond classroom traditional experiences, for instance, through gamification, could promote active learning. So the use of VR headset, an inexpensive version of VR tools, is utilized in the present study.

2 Background of the Study

Virtual reality is becoming a trend in foreign language learning as realistic situational communication programs can be developed such as greetings, job interviews, ordering foods, or telephone conversations. Accordingly, virtual reality can help overcome constraints of traditional language classrooms by providing learner-centered experiences such as control over the language learning process [4].

VR is one of the most recent technologies utilized in education. Among children who do not complete assignments and were unprepared in class, a technology-supported learning environment altered their negative behaviors onto becoming more engaged in classroom activities [5]. In another study, students who were asked to do some computer-based task exhibited excitement as compared to traditional in-class settings [6]. Assistive technology was also found helpful to solve individual differences, for example, students with learning disabilities [7].

With the use of technology in the classroom, learning could become student-centered. Some authors suggested that the use of virtual learning environment makes students engaged and excited as they can learn at their own pace [8]. It could also be beneficial for the teacher as assessments could be streamlined.

The popularity of Pokemon Go prompted Godwin-Jones [9] to review the existing literature on how games can be utilized by the education community. For instance, creating a personal avatar, which involves physical appearance, could be used to teach sex, dress, and hair color, among others. Participants may also create a digital storytelling book by taking screenshots of scenes they have been into. Students may also want to write a journal of their virtual experiences. Although commercial games are not designed for language learning, teachers may use its popularity and integrate it in language learning. However, teachers must consider its suitability [10].

Cheng, Yang, and Andersen [11] adapted a virtual reality video game called *Crystallize* to teach Japanese language and culture among 68 participants in the university. They were exposed to VR and non-VR versions. Accordingly, half of the participants learnt how to bow. Also, participants were less involved in Japanese culture when non-VR version was used. Qualitative responses of the participants were found promising such as “getting connected with people,” “a real-life experience,” and a “fun talk” with others. Despite the gains, the participants expressed dissatisfaction from technological and interface problems, for example, motion sickness and difficulty in reading words. Although the study noted high level of motivation in the study, there was no instrument used that measured the construct. With regard to vocabulary learning, it was found that there was no significant difference between VR and non-VR conditions. Similar result has been reported by Lin and Wu [12] among junior high school students.

Other studies have reported increase of vocabulary learning in other lesser-known languages such as Filipino and German [13]. By using immediate and delayed posttests to evaluate the effect of AR and non-AR applications, they observed a larger difference of AR as compared with non-AR application, which means that AR resulted in better retention of words among the participants. With user “good” experience as one of the objectives of the study, the use of AR resulted to the reduction of cognitive load, improved attention, and increased attention [13]. Similar positive gains have been reported by Lin and Hsiao [14] in learning Chinese and English. Since commercial games may not be applicable to specific language learning contexts, language teachers may need to adapt based on immediate contextual considerations [15].

In the context of the present study, little has been known on how the use of VR headset is related to motivation, engagement, independent learning, and vocabulary learning among first-year non-English major university students in Thailand.

3 Purpose of the Study

This paper reports the results of the formative study on the use of virtual reality (VR) headset in English language learning. It is a part of a research project that aims to explore the effects of VR technology, specifically, the use of VR headset onto the language learner’s affective variables such as engagement, motivation, and independent learning. Additionally, it explores its effectiveness on English language vocabulary learning as well as the ability of the learner to follow instructions.

4 Methods

4.1 Participants of the Study

Convenience sampling was used in the formative study. Out of 55 freshmen students enrolled in a foundation English course, only 11 students volunteered to take part in the formative study.

4.2 Components of the VR Game

Research instruments include the following: VR headset (VR Box), iPhone 6s, a 360 VR stimulus video (sourced from YouTube), observation sheet (a checklist), survey form (a 5-point Likert scale), vocabulary picture cards (see Fig. 1), and individual interviews. Individual interviews were conducted to know the learners' experiences.

The 360 VR stimulus video is a YouTube-sourced media available online – https://www.youtube.com/watch. Because the researchers are unable to create media resources as well as to save time, the researchers have utilized Learn English in VR – Describing Houses published by LearnEnglishVR on September 21, 2017. The topic was chosen as the students could relate to the topic as compared to other resources which describe places in other countries of which students may not have any background knowledge about it. The clip is 2 min and 16 s long – *not too short and not too long.*

A survey form contains a binary scale with three items focusing on engagement (high engagement to low engagement), motivation (high motivation to low motivation), and independent learning (very independent to highly dependent). The three

Fig. 1 Vocabulary picture cards

items were made as short as possible for the participants to gauge their opinion toward the VR activity accurately. The vocabulary picture cards were derived from 360 VR stimulus video. There were six picture cards including an ironing board, a dining table, a clothes rack, curtains, a sofa, and a coffee table. For the interviews, one question was asked – What do you think about the use of VR in English language learning?

4.3 The VR Game

The following were observed before, during, and after the VR game: (1) the overview of the research project was explained, and the students were given instructions on what to do with the VR headset, the vocabulary tests, and the elicitation of their feedback; (2) each student was asked to name the picture cards; (3) each student was asked to put on the VR headset; (4) iPhone 6s was inserted, and the video stimulus was played; (5) the reaction of each student was recorded; (6) each student was asked about their experience and accomplished the survey form; and (7) each student was asked to name the picture cards again.

Before the use of VR headset, each participant was asked to name the pictures being shown. For a correct answer, each participant has to name the picture in English. Answers were incorrect if it was spoken in Thai and if it was described (e.g., that thing is where people sit *instead* of a sofa).

Upon the use of VR headset, the students were asked to listen to the speaker and follow the instruction given (see Table 1). The speaker starts with *You are now standing in the middle of an apartment. I want to show you some vocabulary and expressions for houses. Find number one, it's near the door. Have you found it? It is an ironing door.*

The researcher used the observation sheet to mark the reactions of each participant (e.g., P1, P2, P3) during the task (see Table 2). A tick (✓) was used for a correct response, while an X mark was used to indicate an incorrect response.

After the task, each participant was given a survey questionnaire to indicate their perceptions toward three affective variables – engagement, motivation, and independent learning (see Table 3). After each participant accomplished the survey

Table 1 List of instructions

Number	Specific instruction
1	Find number one, it's near the door
2	Look left, you'll see number 2
3	To the left of the dining table, you'll see another important object for the home. Can you see number 3?
4	Look left, you will see number 4
5	Now find number five
6	Finally in front of the sofa, you will find number 6

Table 2 Sample observation sheet

Instruction	P1	P2	P3	P4	P5
1	✓	✓	X	✓	X
2	✓	✓	X	✓	X
3	✓	✓	X	✓	X
4	✓	✓	X	✓	X
5	✓	✓	X	✓	X
6	✓	✓	X	✓	X

Table 3 Survey form

Affective variable	Levels							
Perceived level of engagement	Very high	5	4	3	2	1	0	Very low
Perceived level of motivation	Very high	5	4	3	2	1	0	Very low
Perceived level of autonomy	Very high	5	4	3	2	1	0	Very low

questionnaire, they were asked to share their idea(s) about the use of VR in English language learning.

4.4 Data Analysis

SPSS was used to analyze the quantitative data. Mean of scores, standard deviation, and correlations were computed. Qualitative data from the students' insights were coded accordingly.

5 Results

Several interesting results were revealed. Descriptive analysis (see Table 4) showed high level of engagement ($M = 4.63$, $SD = 0.80$), high level of motivation ($M = 4.72$, $SD = 0.64$), and high level of independent learning ($M = 4.63$, $SD = 0.67$). Moreover, participants were able to follow the instructions ($M = 4.36$, $SD = 0.80$). For the vocabulary tests, posttest indicated an increase of vocabulary knowledge ($M = 2.73$, $SD = 1.48$) than the pretest ($M = 1.18$, $SD = 0.39$).

Further analysis on the relationships of the affective variables (see Table 5) revealed a strong significant relationship between motivation and independent learning ($r = 0.87$, $p < 0.01$). Nonsignificant relationships were revealed between engagement and motivation ($r = 0.55$, *n.s.*) and engagement and independent learning ($r = 0.46$, *n.s.*). For language vocabulary learning, there was a significant difference on the students' vocabulary performance before and after the use of VR, $t(10) = 6.70$, $p = 0.000$). However, the sample population is small to claim significant results.

Table 4 Descriptive analysis

No.	Variables in the study	Mean of scores/*SD*
1	Level of engagement	4.63, *0.80*
2	Level of motivation	4.72, *0.64*
3	Level of independent learning	4.63, *0.67*
4	Ability to follow instructions	4.36, *0.80*
5	Vocabulary test 1	1.18, *0.39*
6	Vocabulary test 2	2.73, *0.80*

Table 5 Relationships of affective variables

	Engagement	Motivation	Independent learning
Engagement	–	0.55	0.46
Motivation	–	–	0.89**

*******Correlation is significant at the 0.01 level (two-tailed)*

Individual insights indicated negative comments concerning the clearness of the pictures in the 360 VR stimulus video and their inability to remember the words. Students positively said things such as “it was fun,” “it looks like the real thing,” and “I was moving instead of sitting down.”

6 Discussions and Conclusions

The use of VR in language learning motivates students to increase, for example, their vocabulary repertoire. This finding likely supports the enormous literature indicating the advantages of using technology in the classroom [2, 3]. Thus, it possible to conclude that technological integration could increase motivation in language learning. This, however, should not be taken for granted as Ciampia [10] insinuated that appropriate technology should be used. When teachers carefully select technology suitable for the students, it is more likely that students get motivated and engaged in learning [13]. This is also related to another important finding, which confirms previous studies that the use of VR increases student engagement in language learning. Further, in the present study, the researchers have taken into account the context of stimulus video into the required task. When students can relate with the learning material to their immediate context, the task becomes more meaningful to them.

As shown in the preliminary findings, motivation and independent learning are significantly correlated. Giving students control over their language learning cultivates autonomy in language learning. Though the findings are from a formative study, it lends support to massive empirical evidence showing positive gains of independent learning in the language classroom. When students make mistakes, they can always go back and redo the task until they get the right answer. Like in

Mulrine's study [8], students got excited and more engaged when they can take charge of their learning process. It would be interesting in the final study to delve deeper insights as to how motivation affects independent learning as well as how the interplay of the two variables plays a role in language acquisition. In the final study, the individual interviews may include two or more probing questions related to the topic above.

Since this paper reports the formative study, the final study must incorporate the following observations. Firstly, participants must be familiar with the VR headset to avoid negative comments as indicated above. Familiarity of the tool may also let the participants more focused on the language task. In fact, during the interview, some of the participants complained about the clearness of the video. When students are familiar on how to use the tool, they might be able to adjust clearness accordingly. Secondly, a bigger population sample is necessary in the final study to have more meaningful interpretations of results. The more participants, the stronger claim of significance will be. Next, pilot studies should always be conducted to be prepared in the data collection of the final study. At present where learners are tech-savvy, future studies may explore the effects of neo simulation and gaming onto the language learning processes. Considering an experimental study could provide convincing results.

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References

1. Stockwell G (2013) Technology and motivation in English-language teaching and learning. In: Ushioda E (ed) International perspectives on motivation. International perspectives on English language teaching. Palgrave Macmillan, London. https://doi.org/10.1057/9781137000873_9
2. Keengwe J, Schnellert G, Mills C (2012) Laptop initiative: impact on instructional technology integration and student learning. Educ Inf Technol 17(2):137–146. https://doi.org/10.1007/s10639-010-9150-8
3. Li SC, Pow JWC, Wong EML, Fung ACW (2010) Empowering student learning through tablets PCs: a case study. Educ Inf Technol 15(3):171–180. https://doi.org/10.1007/s10639-009-9103-2
4. Jung HJ (2017) Virtual reality for ESL students. Internet TESL J. http://iteslj.or/Articles/Jung-VR.html
5. Francis J (2017) The effects of technology on student motivation and engagement in classroom-based learning. All theses and dissertations, 121
6. Heafner T (2004) Using technology to motivate students to learn social studies. Contemp Issues Technol Teach Educ 4:42–53
7. Floyd KK, Judge SL (2012) The efficacy of assistive technology on reading comprehension for postsecondary students with learning disabilities. Assistive Technol Out Benefits 8:48–64
8. Mulrine CF (2007) Creating a virtual environment for gifted and talented learners. Gift Child Today 30(2):37–40
9. Godwin-Jones R (2016) Augmented reality and language learning: from annotated vocabulary to place-based mobile games. Lang Learn Technol 20(3):9–19

10. Ciampa K (2014) Learning in a mobile age: an investigation of student motivation. J Comput Assist Learn 30(1):82–96. https://doi.org/10.1111/jcal.12036
11. Cheng A, Yang L, Adersen E (2017) Teaching language and culture with a virtual reality game. https://dl.acm.org/citation.cfm?id=3025857
12. Lin CC, Wu YC (2013) The effects of different presentation modes of multimedia annotations on sentential listening comprehension. In: Proceedings of the 21st international conference on computers in education
13. Santos ME, Lubke A, Taketomi T, Yamamoto G, Rodrigo M, Sandor C, Kato H (2016) Augmented reality as multimedia: the case for situated vocabulary learning. Res Pract Technol Enhanc Learn 11(4):1–23. https://doi.org/10.1186/s41039-016-0028-2
14. Lin CC, Hsiao HS (2011) The effects of multimedia annotations via PDA on EFL learners' vocabulary learning. In: Proceedings of the 19th international conference on computers in education
15. Derboven J, Geerts D, Grooff DD (2017) Appropriating virtual learning environments: a study of teacher tactics. J Vis Lang Comput 40:20–35

Research on User Experience in Risk Management: Alternate Reality Game

Michał Jakubowski

Abstract This paper describes the user experience research of an educational game that covers risk management issues. Creating such information systems as serious games requires them to be tailored for learning purposes. The first phase of research focused on questions about the feasibility of the tool and its usability in terms of learning outcomes. The study was undertaken with use of an already existing online tool for user experience research and additional open-ended questions to obtain deeper insights into the quantitative data. Analysis of the results is provided. Readers can also find here a detailed design process description. This paper can be of interest for those who want to compare their own designs of mobile-tailored software, especially when it has an educational angle.

Keywords Game design · Serious games · Design evaluation · Gamification · Design science · Risk management · User experience

1 Introduction

Nowadays, game-based learning is becoming a leading trend in education on every level. It can be discussed on many layers, such as improving engagement [7], leveraging better problem-solving [10], or enhancing higher order thinking [14]. Games can help to translate complex problems into visualized forms of interaction that are more attractive and interesting to investigate and understand. This is an aim not only for games that are designed for educational purposes but also for video games which are available off-the-shelf [5, 13]. Even in casual settings, video games are becoming a tool that is responsible for such benefits as language skills improvement. In this article, the author will try to present his own vision of how to design such a game with user experience in mind. This paper also describes the evaluation phase of the first iteration of the game designed by the author.

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When the use of games in education is under discussion, there can be some misconception regarding the use of the term 'gamification' in that context. During the last several years, the definition of gamification has evolved. This doesn't mean that the old definition is incorrect but, rather, it shows how the term has matured into more universal and empirical-based information. One of most often used definitions states that gamification is the use of game design elements in non-game contexts [4]. The problematic part of this is the 'game design elements'. Because games are some form of medium, it is hard to distinguish which elements are unique to them or how many of them should be combined in order to think about it as 'game' elements. Does adding points change the classroom experience into an engaging one or does it just transform grading into a more sophisticated or complicated system? That and other questions bothered researchers when searching for the essence of what gamification can be. The definition of Huotari and Hamari seems to have it right: "Gamification refers to a process of enhancing a service with affordances for gameful experiences in order to support users' overall value creation" [6]. That leads us to start from the user experience side and then move on to the game elements and mechanics that can make that experience valuable. The authors distinguish three parts of the gamification process: the motivational affordance and the resulting psychological outcomes and behavioral outcomes. This seems to have more universal meaning and reduces the burden of using 'game elements' as a defining term. That view on the concept leads to focusing on the final users of gamified solutions and delivering them compelling and attractive experiences which lead to psychological and behavioral changes.

The author of this paper argues to treat games-based learning as one of the components that can gamify the classroom. The core idea should focus on the learning (and teaching) experience. How it will be executed is up to the facilitator of the course and his or her capabilities or resources. Focusing on experience resulting from using gamification and games in learning might be the solution for boosting learning outcomes for the students. At least this theory works in software and web development, where user experience research is the core step for improvement and leads to the enlargement of user counts, amount of time spent, and revenue. Using computer-based or mobile games in an educational context should, then, take some inspiration from related areas of software design and transfer good practices, such as creating and maintaining user (learner) experience throughout the whole time spent playing games in class. This paper will present the author's game design and an evaluation of its role as part of risk management classes.

2 Blueprint Conspiracy – Game Background

The idea behind the game was to prepare an interactive exercise that will explain issues connected to risk management. There were no limitations other than the budget of the project and the requirement of using that product in larger groups (30–50 people). Having some practice in using simulations and educational games in the classroom, the author concluded that a common feature is the lack of fun and entertainment, such as that which can be found in video games. This led to the idea of developing a mobile game which will engage users because more effort has been put into creating an experience similar to what can be found in off-the-shelf production games. So, the most important points of design were related to the good look and feel of the game, easy to understand navigation of the interface, and an engaging hook, such as the storyline. To deliver such experiences, the design work was based on the spirit of design science so that current as well as further research can be based on design science research (DSR) frameworks (e.g., Hevner's information systems research framework) [8] (Fig. 1).

Blueprint Conspiracy (BPC) is a game that can be placed in the alternate reality games (ARG) genre [1]. Characteristic of ARG is that the gameplay is placed in a real-world environment and the player's physical activity is needed to complete tasks. Making an ARG can be a good platform or genre for educational purposes [2, 15]. In BPC, that mechanism is used to unveil the task description and open the possibility to input answers – players must find special codes hidden around the area of gameplay (e.g., building, park, forest, etc.) and then they can start the challenge. The core part of the game is a web application designed using the responsive web design [11] methodology, which means that it scales itself to fit on various screen sizes and screen resolutions. The app is accessible through any web browser. It is treated as a 'control panel' of the game for each player. Inside, players can find task descriptions, their status and progress statistics, the virtual trophies collection, and the leaderboard. Risk management is based on the virtual currency distribution and

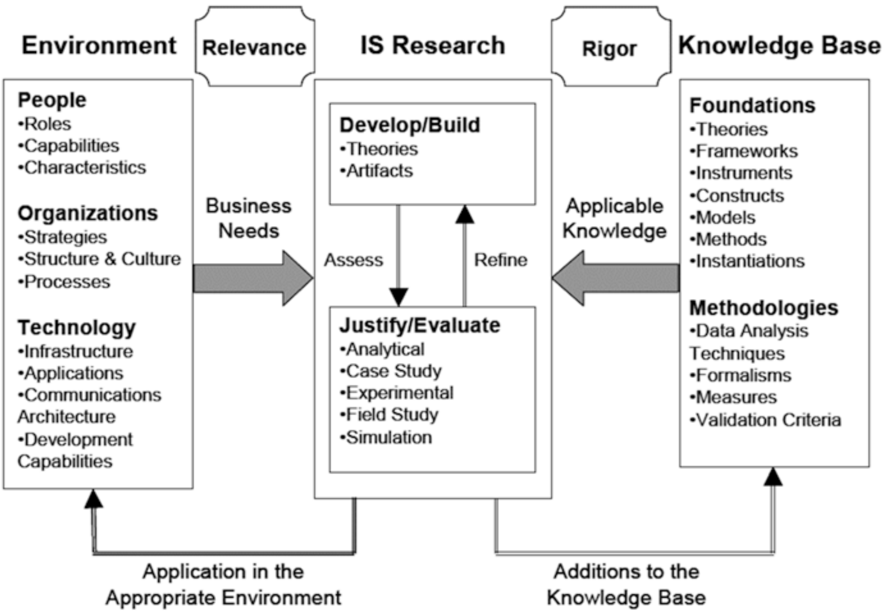

Fig. 1 Information systems research framework

insurance mechanism – players have to decide upon the order of task solving. There is only one chance allowed for each task but buying insurance can increase the number of answer attempts. Players also need to carefully manage their resources – in case of risky currency points distribution, they can get stuck during the gameplay. A typical game starts with the briefing and short introduction to the rules. Then, after the time is up, the facilitator sums up the game and provides a debriefing discussion about what happened during play. The debriefing part is one of the most important elements of educational games and, if done right, can generate useful knowledge from the game's players [3].

2.1 Game Design and Gameplay

The design of the game was based on the MDA framework [9], where MDA stands for mechanics, dynamics, and aesthetics. It shows how players are using and perceiving games and how it relates to detailed implementation of the mechanics into the dynamic system of the game. From the perspective of the designer, it is about choosing the right set of game elements that will create specific dynamics which will generate certain aesthetics. That creates the player experience which is appropriate for the player aesthetics. The authors mention seven types of aesthetics. The following game design description is based on this and it was aimed to deliver all of them in the final game.

The facilitator of the game needs to prepare it before the start. Preparations are focused on the creation of user accounts and supervision of physical cards with codes placement around the play area. The narrative structure of the game situates players as engineers whose blueprints were stolen by a hacker who calls himself Thales (as the very first engineer in history). The blueprints data can be retrieved by gathering mixed chunks of it in the form of so-called blueprint points. One can obtain blueprint points by solving short riddles and quizzes that are scattered around the physical space of the play area. Thales has released a special web application for his victims (players) so that they can localize and unlock trails that will eventually help them to recover the lost data.

There are two kinds of points in the game:

- Blueprint points (BP) – points for collecting rewards; they indicate the player's progress in the game and also define the way that the players leaderboard looks;
- Action points (AP) – required for starting missions and also required for the purchase of an insurance (Fig. 2).

At the beginning, each player possesses an equal amount of action points (AP). The completion of each task is rewarded with a certain amount of both BP and AP (the harder the task, the bigger the reward).

To start a task, the player receives a part of its content and a hint about the other part's whereabouts. The exact location of the second half of the content of the task is communicated through a riddle or a mini-quest, which is down to the facilitator's creativity (e.g., one of the mini-quests was to approach the cloakroom at the univer-

Fig. 2 Tutorial leaflet of the Blueprint Conspiracy (BPC) game

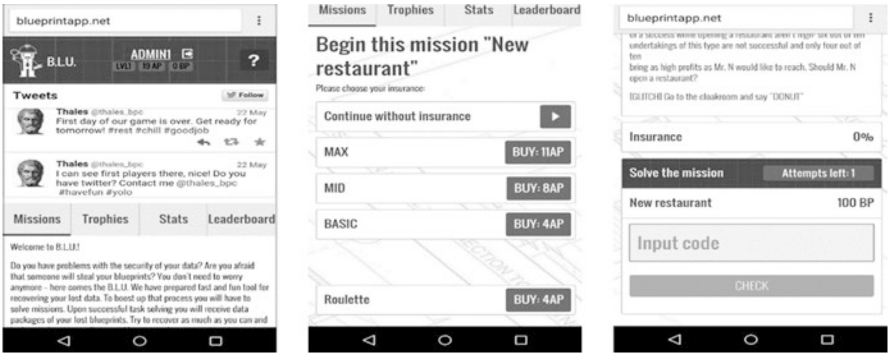

Fig. 3 Screens from the final game

sity and ask about a sleeveless coat; once the player did this, the cloakroom service would hand him or her an access code that would unlock the missing part of the content) (Fig. 3).

The tasks and riddles themselves can be shaped freely, although as for now when played on courses about risk management, most of them somehow touch upon that area. They also took on the shape of logical riddles. After finding the missing part of the question, the player may attempt to resolve it. Each quest/task may be approached only once. A wrong answer means less BP and lost AP committed to approaching the task. Each player can, however, protect himself or herself from such loss by acquiring ‘an insurance package’ at the beginning of the game. There are three types of insurance packages and also a possibility to randomly pick one of them (random selection is cheaper than the most expensive package but more expensive than the cheapest, so it is priced at the level of the moderate insurance package). Insurance gives another attempt(s) with the chosen mission. The completion of each task is bounded by a time limit. If the full amount of time elapses before a correct answer is given, the result is the same as when giving a wrong answer.

The winner is the player who, by the end of the game, collects the highest number of BP, which is translated into an amount of retrieved blueprint data (on the narrative level). The winner receives the final letter from Thales and is faced with the last dilemma of choosing between two available finales: (1) the winner is informed that Thales was her or him and can admit that in front of the group (meaning that all of his or her points are distributed among the others and he or she stays with zero bonus points for the course grade) or (2) he or she can stay silent and receive all of the bonus grade points just for their own sake.

3 Design Science Research

Based on Hevner’s DSR framework, it can be stated that the design of the artifact (which is the BPC game design) is built upon environmental properties and preferences (on the layer of people, organizational, and technological needs) and the existing knowledge base (foundations and methodologies of experiential learning, risk management, and game design). The next step would be the first iteration of the assessment and refinement cycle with the use of a working prototype of the game. That step was done with a group of 104 students of Business University in Warsaw, Poland. These were mostly participants of a risk management course, so the teachers could justify using the game in classes and could observe and deliver feedback towards future development of the game. The game was played with six different groups of students and, for each of them, they were asked to fill in a questionnaire that contained two parts: the official User Experience Questionnaire (UEQ) and a couple of in-depth questions about the game’s design flaws.

The UEQ is a tool created to gather data about the user experience of interactive products. The authors of the UEQ suggest that it can be applied to test whether a digital product has adequate user experience and determine areas of improvement [12]. Users (or players) can quickly describe their post-activity feelings, impressions, and attitudes about the product. The questionnaire contains six scales with 26 items covering basic usability aspects (efficiency, perspicuity, dependability) and user experience aspects (attractiveness, novelty, stimulation). The UEQ contains six scales with 26 items in total:

- Attractiveness: Overall impression towards the product. Do users like or dislike the product? This scale is a pure valence dimension. Items: annoying/enjoyable, good/bad, unlikable/pleasing, unpleasant/pleasant, attractive/unattractive, friendly/unfriendly.

- Efficiency: Is it easy to interact with the software? Is the interface readable and easy to understand? Items: fast/slow, inefficient/efficient, impractical/practical, organized/cluttered.
- Perspicuity: How easy is it to understand how the software works? Items: not understandable/understandable, easy to learn/difficult to learn, complicated/easy, clear/confusing.
- Dependability: How quickly can users understand the software functionality? Items: unpredictable/predictable, obstructive/supportive, secure/not secure, meets expectations/does not meet expectations.
- Stimulation: Does the software make it easy to build a bond with users? How strong is engagement and motivation to come back to the software? Items: valuable/inferior, boring/exciting, not interesting/interesting, motivating/demotivating.
- Novelty: How does the design of the software look and feel in terms of innovative experience? Items: creative/dull, inventive/conventional, usual/leading edge, conservative/innovative.

The authors of the UEQ structure those scales in the following way: attractiveness is a pure valence dimension with branches of pragmatic quality, goal-oriented scales (perspicuity, efficiency, dependability), and hedonic quality, not goal-directed scales (Fig. 4).

The first tested area is related to having sufficient user experience in designing and developing the game. It is possible to do this with the UEQ data analysis tool, which offers a benchmark with the data of 246 product evaluations (with 9905 users in total). The results of the user experience test are presented Table 1.

That led the author to the conclusion about the pragmatic quality of the game. The first step with future work should be taken by analyzing how the game rules and mechanics are explained and how readable they are from the user's perspective. This is important because, after the briefing phase of the game, the users are let out into the play area and they may need help with remembering some of the rules or be shown how to use the game interface. However, good results in hedonic quality scales and overall attractiveness of the game give a positive sense of proper game design, at least in that area. Players seems to be interested, stimulated, and attached while playing BPC.

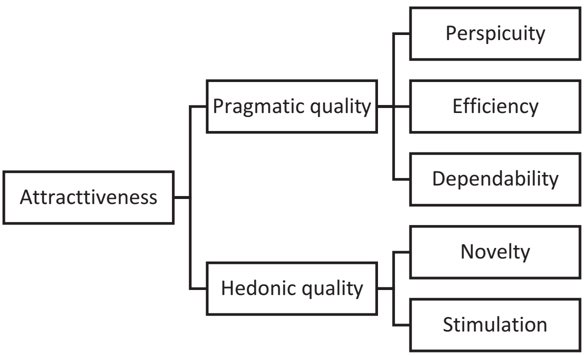

Fig. 4 Scales of the User Experience Questionnaire (UEQ)

Table 1 Results of the User Experience Questionnaire (UEQ) research

Scale	Mean	Comparison to benchmark	Interpretation
Attractiveness	1.256957929	Above average	25% of results better, 50% of results worse
Perspicuity	0.410194175	Bad	In the range of the 25% worst results
Efficiency	0.881067961	Below average	50% of results better, 25% of results worse
Dependability	0.834142395	Below average	50% of results better, 25% of results worse
Stimulation	1.303398058	Above average	25% of results better, 50% of results worse
Novelty	1.122168285	Good	10% of results better, 75% of results worse

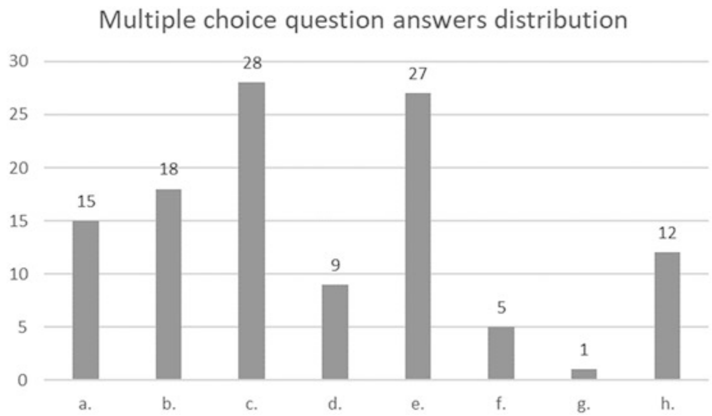

Fig. 5 Results of the qualitative research

Some more in-depth questions were also asked. This is an additional method of determining areas of improvement, which is also suggested by the authors of the UEQ. There were just two questions. In the first, the users were asked about various elements from the game's design that were unclear. Respondents were given multiple choices and could also leave a comment with further explanation of their choice. A translation of the questions and answers is as follows: "Please choose the game element which was unclear for you during the gameplay" (Fig. 5):

(a) Interface,
(b) Rules (goal, game mechanism),
(c) Tasks and missions formulation,
(d) Solving missions,
(e) Insurance mechanism,
(f) Scoring system,

(g) Leaderboard position,
(h) Unlocking missions.

It is clear that the biggest problem was with two elements: tasks and missions formulation (24% of answers) and insurance mechanism (23%). The rules of the game, interface, and unlocking (using codes) mechanism are also things that have to be improved in the next iteration. Those results are obscured by the qualitative part of the research and, using knowledge of the distribution of the answers, the author can give now priorities for further design and development.

The second question targeted absent features that, from the user's point of view, would enrich the game. The author has grouped this in similarity to the UEQ scale's main categories. In terms of attractivity, the users suggested an anti-cheating mechanism or regulation (some of the cards with codes were ripped off walls to stop other players from solving certain missions), possibility to play in teams on one account (reading descriptions from one smartphone was a pain), and solving some errors in the general development code (warnings and other unexpected bugs were appearing during the game). Pragmatic quality contained statements such as improving the insurance mechanism, implementing an additional acceptance question before sending the answer (right now, there is only one step in the answer process), and improvement in readability (bigger buttons, larger fonts, shorter text descriptions). At the least, the hedonic quality can be improved by better tasks and missions within the game (e.g., practical tasks) and using media other than text in tasks and missions.

4 Conclusions

The first iteration of the design process can be considered as complete. Multiple valuable points were discovered to implement in the next version of the educational game for learning risk management. Most of them are related to better presentation of the overall rules of the game, as well as some of the mechanics that were already in existence. There is also quite a large potential for implementing new gameplay solutions, such as team play or different ways of challenging the player. All of this will be implemented in the following months, so there is a chance that it will be ready for the next academic semester and further testing phase.

Based on the research described in this paper, the author can state that the UEQ is a valuable tool for finding flaws in designed software. Using it during such an early stage of development should result in a better game which students already find fun to learn from but, because of some weak points, they cannot enjoy it fully. The same thing can be related to the learning outcomes of the game. The current state of user experience seems to be impacting learning from the BPC. The learning outcomes of using that game will be the author's next research project.

References

1. Bonsignore E et al (2013) Alternate reality games as platforms for practicing 21st-century literacies. Int J Learn Media 4(1):25–54
2. Chess S, Booth P (2014) Lessons down a rabbit hole: alternate reality gaming in the classroom. New Media Soc 16(6):1002–1017
3. Crookall D (2014) Engaging (in) gameplay and (in) debriefing. Simul Gaming 45(4–5):416–427
4. Deterding S et al (2011) From game design elements to gamefulness: defining gamification. In: Proceedings of the 15th international academic MindTrek conference: envisioning future media environments. ACM
5. Gee JP (2014) What video games have to teach us about learning and literacy. Macmillan, New York
6. Huotari K, Hamari J (2016) A definition for gamification: anchoring gamification in the service marketing literature. Electron Mark:1–11
7. Hamari J et al (2016) Challenging games help students learn: an empirical study on engagement, flow and immersion in game-based learning. Comput Hum Behav 54:170–179
8. Hevner AR, March ST, Park J, Ram S (2004) Design science in information systems research. MIS Q 28(1):75–105
9. Hunicke R, LeBlanc M, Zubek R (2004) MDA: a formal approach to game design and game research. In: Proceedings of the AAAI workshop on challenges in game AI, vol 4, no. 1, pp 1–5. AAAI Press San Jose, CA
10. Hwang G-J, Hung C-M, Chen N-S (2014) Improving learning achievements, motivations and problem-solving skills through a peer assessment-based game development approach. Educ Technol Res Dev 62(2):129–145
11. Kim B (2013) Responsive web design, discoverability, and mobile challenge. Libr Technol Rep 49(6):29–39
12. Laugwitz B, Held T, Schrepp M (2008) Construction and evaluation of a user experience questionnaire. In: Holzinger A (ed) USAB 2008, LNCS 5298. Springer, Berlin/Heidelberg, pp 63–76
13. Minnery J, Searle G (2014) Toying with the City? Using the computer game SimCity™ 4 in planning education. Plan Pract Res 29(1):41–55
14. Sánchez J, Olivares R (2011) Problem solving and collaboration using mobile serious games. Comput Educ 57(3):1943–1952
15. Whitton N et al (2014) Alternate reality games as learning environments for student induction. Interact Learn Environ 22(3):243–252

Part VI
S&G to Facilitate Consensus Building

Rights-Conversion Type Urban Redevelopment Game Considering Financial Risk Management

Toshiyuki Kaneda, Takayuki Mizuno, Ryuhei Ueda, and Mingji Cui

Abstract In this research, an Urban Redevelopment Project Game prototype version is developed as a game that concisely represents the tasks and issues in a private-initiated redevelopment project based on the rights-conversion approach. In Urban Redevelopment Project Game, gaming deals with drawing up plans to ensure project profitability and reaching consensus under conditions of uncertainty. Additionally, it analyzes the results of test play and the risk-return attitudes of the plans which the players agreed. The validity of the game as a decision-making analysis tool is also discussed.

Keywords Rights conversion · Private redevelopment project · Urban Redevelopment Project Game · Consensus building · Project profitability

1 Introduction

The Rights-Conversion Type Redevelopment Project described in this paper is considered to be a system originating in Japan, primarily from the reorganization of arable land and the Land Readjustment Project System, and refers to a project

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scheme institutionalized as the Category I Urban Redevelopment Project under the 1970 Urban Renewal Act of Japan [1]. These kinds of redevelopment projects include a concept known as “rights conversion” in which the rightful claimants of lands and buildings in a site exchange the composition of the rights before a project for new rights issued in accordance with the implementation and completion of an agreed project plan. The claimants take the initiative to organize the project implementation body and proceed with the project.

To put it briefly, the advantages of this type of system is that as compared with the “public expropriation” approach which a public sector purchases the whole site of district on the strength of the right of eminent domain, the approach based on “rights conversion” has little reliance on any public authority and minimizes any monetary transactions, and for these reasons, it is now drawing attention in developing countries as a useful approach for urban development projects. In recent years, as the Urban Redevelopment Project System originating in Japan, it has spread in the large cities of developing countries along with the Land Readjustment Project System by the Japan International Cooperation Agency (JICA) [2].

The system does have disadvantages such as the need to develop appropriate social systems including a legal system to serve as a foundation for rights conversion and official valuation. In addition, since decision-making for the project is entrusted to an ad hoc group of individual landowners, this raises other issues concerning the competence of the project implementation body and the need for consensus building among the landowners. These issues bring up the importance of human relations, and gaming simulation offering “learning by doing” is an effective tool [3, 4]. A gaming prototype with a focus on the Land Readjustment Project System has also been reported in past studies [3, 5].

This paper explains the Urban Redevelopment Project Game (URPG hereinafter) used for the simulation of collective reconstruction projects in urban centers in Japan. URPG has been developed on an experimental basis by taking into account the technology transfer support available in the Redevelopment Project System. URPG is a game simulating a group of landowners who are required to cooperate to ensure the profitability of a single construction project; they must draw up a redevelopment plan by consensus building and manage the project. The game incorporates a degree of uncertainty concerning key elements and is a realistic representation of the problems and risks facing redevelopment project management in an urban area of twenty-first-century Japan.

The following sections describe the outline of the URPG prototype version and analyze the results of test play and the risk-return attitudes of the plans, which the players agreed through gaming. The validity of the game as a decision-making analysis tool is also discussed.

2 Modelling of URPG

The theme of gaming is consensus building to complete a project plan exposed to risk. Accordingly, we modelled URPG by paying attention to the following three points.

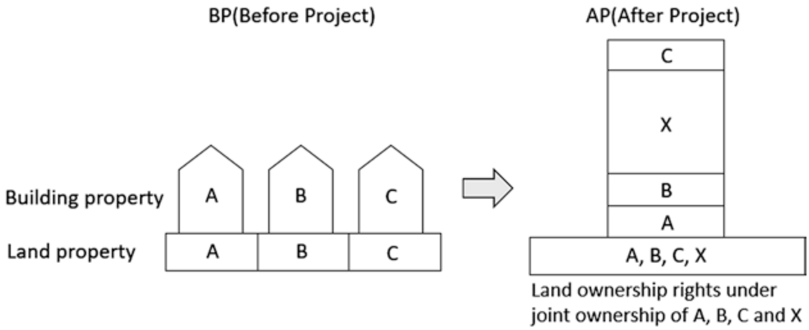


Fig. 1 Rights conversion between before and after the project

2.1 Characteristics of Typical Rights-Conversion Type Redevelopment Projects Led by Private Landowners

Figure 1 explains the outline of a project scheme assuming a typical Japanese Category I Urban Redevelopment Project (hereinafter, "legal redevelopment") and undertaken on the initiative of private landowners, in which a local government is not a rightful claimant.

The project implementation body consisting of all private landowners internally prepares a rights-conversion plan based on the law and has a business scheme in which the main revenue items are sale of reserved floors and public subsidy and the main expenditure items are research design/land improvement costs and construction costs. It is a mandatory condition that at the completion of any single project, there must be no deficit.

If there is no purchase of the land due to a landowner moving for the project implementation body, the land purchase costs will not be included in the expenditure items, and in many cases where a public subsidy is provided, the site survey, physical planning, and land improvement costs in the expenditure items will often be set off against the public subsidy in the revenue items. For the above reasons, the scheme can be simplified so that the revenue from the sale of the reserved floors covers the expenditure of the construction costs; however, this is exposed to a risk resulting from a time delay between the expenditure and the later revenue. This is the greatest feature of recent redevelopment projects in Japan.

2.2 Gaming Assignment: The Profitable Completion of a Small-Scale Redevelopment Project by Three Private Landowners

Assuming legal redevelopment by private initiative, URPG deals with the situation of a relatively small-scale redevelopment project by three private landowners as a gaming assignment (Figs. 2 and 3).

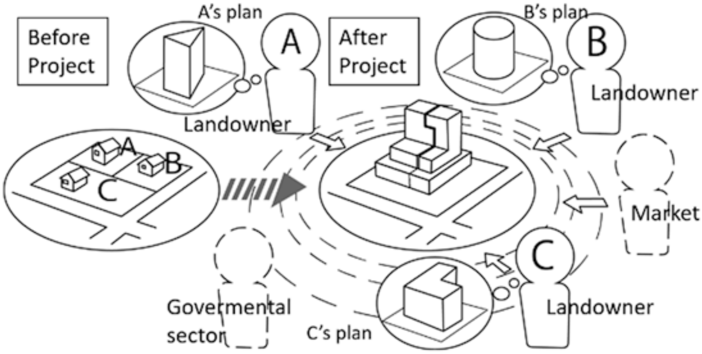
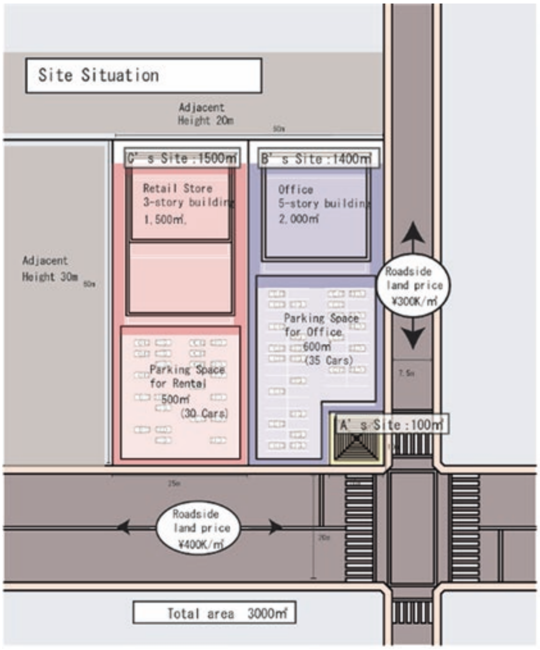


Fig. 2 Private sector-led redevelopment



Assumption Condition

Project area	3000m²
Zoning Regulation	Commercial districts are (80/500)
Building ratio	35%
FAR	120%
Floor use	Rightful floor: Residence, Retail, Office Reserved floor Option: Residence, Retail or Office
Structure	Building: RC, Parking Space: S
Owners	3 (A, B and C)

Fig. 3 Gaming assignment

However, to simplify by playability, it was decided not to have an option allowing any landowners to withdraw in the middle of the project. In other words, this scenario means that all landowners gain similar profits or losses depending on the success or failure of the project.

Simplification was also ensured again by designing URPG not to incorporate any dynamic processes of the project, and to eliminate phased consensus, which is a distinctive feature in actual redevelopment projects.

During the gaming, any "requests" to be included in a plan and any "risks" to which the project is exposed are symbolized and represented by cards. A request card shows an additional item that a landowner player wants to have incorporated into the project plan, and it has no market exchange value. However, since a request card also represents a "value in use," e.g., some requests might provide a motivation for participation in the redevelopment. Moreover, pursuit of profits is not necessarily the prime motivator; consequently, request cards have been introduced as an additional feature for each landowner player.

The risk cards concisely represent project risks resulting from time delays; more specifically, fluctuations to the construction costs, land prices, and reserved floor market. When drawing up a project plan, all cards are disclosed, and before the assessment of success or failure of the plan in the final stage, they are randomly selected from the card deck.

2.3 Agreed Plan as a Composition of Players Individual Plans: Key Concept for Post-play Analysis

We focus on a post-play analysis of URPG. This is the formation of an agreed project plan; at the beginning of gaming, each landowner player prepares their own desired project plan (hereinafter, an "individual plan"), and then, through negotiation and consensus building, they draw up an agreed project plan (hereinafter, an "agreed plan").

From the viewpoint of systems theory, this situation is a dance-type negotiation in the three-player hypergame situation, because each individual plan reflects personal preferences, but does not recognize other players' preferences accurately [6]. Note that, in actual cases of a redevelopment project, march-type negotiations based on multiphase consensus become common practice; therefore, overall the simplified game represents a fictional scenario that is rarely seen in reality.

Although how players build their consensus will vary, for both the individual plans and agreed plan, by conducting risk simulation using the information on the risk cards disclosed during gaming, it becomes possible to analyze the risk-return attitudes incorporated in the plans.

All plans are required to satisfy the Project Profitability condition, namely, estimated project revenue will be higher than the expenditure, but because of the simplified gaming with a focus on consensus building among the landowners, additional requirements were set, which were to satisfy the following conditions: Inner Equality condition (the property ratio among the landowners remains the same) and Post-project Property Improvement condition (for all landowners, the post-project property will not decrease). Moreover, to check the project profitability, dedicated Excel sheets were prepared.

3 Outline of URPG

In this game, three landowner players collaborate to draw up an agreed group plan for a redevelopment in the midtown area of Nagoya City and then proceed with the project based on this created plan. URPG mainly consists of Lego blocks, game tools, and Excel worksheets operated on a notebook computer. This URPG assumes a Category I Urban Redevelopment Project through voluntary enforcement.

The key gaming concept dealt with is a redevelopment plan, comprising the following three items: (1) development plan (floor-area ratios, intended use of the reserved floors, building areas, unoccupied land ratios, number of floors, and construction contract); (2) incidental facilities (car and bicycle parking lots, public squares, and sidewalks); and (3) building performance (security, disaster prevention, and aesthetic performance).

The game flow has the following five stages.

- Step1. Presentation of the pre-project site conditions:

Within the site, three buildings, a “residence,” an “office building,” and a “retail store” are located in close proximity. Each player owns one building (Fig. 2). This game condition is a fiction but considers Nayabashi-higashi, Nagoya, case study [7].

- Step2. Creation of an individual plan:

Each player creates an individual plan based on the “conditions around the site,” the “situation for their type of building,” and “their own ideal scenario for the development.” Before creating their plan, they select five of the prepared request cards and incorporate them in their individual plan. However, during the plan creation, if a player assesses a request is redundant, or may prevent project profitability, the card is discarded. Players are also informed of possible risks in the form of risk cards while drawing up their plans.

- Step3. Creation of an agreed plan:

The three players now hold discussions to form a consensus. Players must take into account the occurrence possibility of risks on the risk cards while drawing up the agreed plan.

- Step4. Occurrence of risk events:

The facilitator randomly selects risk cards and informs the players of any economic change event, such as fluctuations in land prices and construction costs, and the likelihood of reserved floor sales.

- Step5. Assessment of project success or failure:

Finally, judgment is made for whether the agreed project plan satisfies the profitability criteria. If it is satisfied, the project is a success, if not, the project has failed, and the game is ended.

4 Analysis of the Plans

After the game has ended, it is possible to analyze and evaluate the plans created during the play. The probabilities of the agreed plan and initial individual plans showing a deficit were calculated by risk simulation applying the Monte Carlo method; the risk-return attitude included in each plan was analyzed.

4.1 Analysis Summary

In order to evaluate the business feasibility of the project decision, now we focus the expected value of the surplus/deficit rate (surplus or deficit amount/total project costs), or Profit Rate. Probability distribution pattern of these rates of both the individual and agreed plans can be drawn by Monte Carlo simulation, and differences in the risk-return attitudes observed in the plans are examined.

Ten thousand trials were conducted using random numbers for the values of economic changes occurring during the gaming; expected values (return) of the surplus/deficit rate and the standard deviations (risk) representing their variation were found. When considering the nature of commercial transactions, it is often said that returns entail risk; therefore, it can be stated that returns and risk have a positive correlation. For this reason, the axes crossing the 2nd and 4th quadrants show commercial success or failure, and the axes crossing the 1st and 3rd quadrants orthogonal to the 2nd and 4th can be considered commercially indifferent (Fig. 4). Based on these premises, the analysis results were examined.

4.2 Individual Plan Analysis

The average was assumed as the origin. Figure 4 shows the simulation results for 18 individual plans in 6 test plays.

Characteristics were found from the differences in the number of requests incorporated in each plan. In the 1st quadrant of successful business projects, three out of the seven plans had only three requests, and in the 4th quadrant of low performing business projects, three out of the four plans included all five requests.

These results confirm that some players included fewer requests in order to realize secure and highly profitable plans, while other players, by including all requests, created insecure and low-profit plans. The higher number of requests incorporated in a plan not only affected its business success or failure but also demonstrated the difference in player risk-return attitudes.

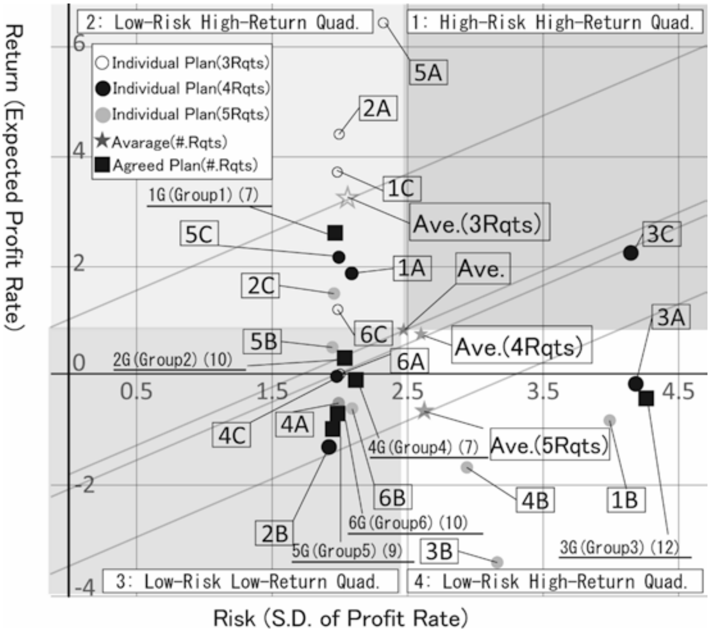


Fig. 4 Risk-return planar plots of the project plans

4.3 Agreed Plan Analysis

When a focus was given to the agreed plans in Fig. 4, just like the individual plans, a plan with fewer requests had higher security and profitability; in contrast, as requests increased, uncertainty rose, and profitability fell. These results as well confirm the number of requests in a plan relates to its commercial success or failure and shows players' risk-return attitudes.

There was an exception; just like Group 1 (1G), Group 4 (4G) had seven requests, the lowest number, but despite this similarity the return was a deficit. Although the requests were fewer, this case resulted in poor business performance. Interestingly, a survey separately conducted after the gaming revealed a very low level of satisfaction with this agreed plan; it could be considered that this unsatisfactory consensus building had an adverse effect on the project feasibility of the agreed plan.

4.4 Consensus Building Analysis

The relationship between the initial plans of landowners and their agreed plan were arranged on a risk-return plane, and analysis carried out to assess consensus building.

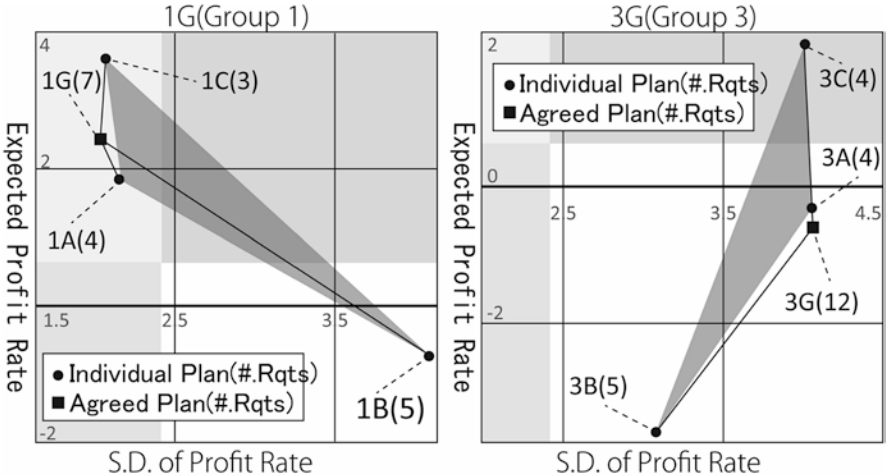


Fig. 5 Consensus building analysis

Figure 5 shows the transition of the returns and risks of the G1 and Group 3 (G3) plans, both of which had a distinctive consensus building process. In G1, during the discussion, landowners A and C focused on profitability and persuaded landowner B, who emphasized requests. The final agreed plan is positioned to the left side of the A, B, and C triangle and was developed to further reduce risk. This indicates that the consensus building process worked favorably. In contrast, G3 is a case where discussion is centered on landowner A, who strongly stuck to their plan; as a result, the agreed plan is positioned slightly to the right of the A, B, and C triangle. The group's discussions resulted in a decline of both risks and returns, indicating that consensus building worked in a negative way.

5 Conclusion

In this research, a URPG prototype version was developed as a game that concisely represents the tasks and issues in a collective reconstruction situation, which is a typical example of a private redevelopment project based on the rights-conversion approach. In URPG, gaming involves drawing up plans to ensure project profitability and reaching consensus under conditions of uncertainty.

URPG is a playable game that deals with one "ideal (simplified)" type of consensus building among landowners in a rights-conversion type redevelopment project led by private initiative.

Regarding the plans during URPG play, planar plotting of the risk-return attitudes enabled analysis of decision-making after the conclusion of the gaming. In addition, plotting of the individual and agreed plans of landowners allowed analysis of consensus building.

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References

1. Ministry of Land, Infrastructure and Transport (2014) Urban redevelopment project by association/individual enforcement. National Urban Redevelopment Association (in Japanese)
2. Japan International Cooperation Agency (2016) Signing of record of discussions on project for the capacity development for management of Kabul City Road improvement and project for development service for land readjustment and urban redevelopment projects for Kabul Municipality in Islamic Republic of Afghanistan. https://www.jica.go.jp/afghanistan/english/office/topics/160718.html. Last accessed July 18 2016
3. Kaneda, T (2005) Simulation & gaming for societal design. Kyoritsu Publisher, Tokyo (in Japanese)
4. Meier RL, Duke RD (1966) Gaming simulation for urban planning. J Am Inst Plann 32(1):3–17
5. Sadiq AR, Kaneda T (2016) A feasibility study of land readjustment projects in Afghanistan by developing and applying gaming simulation. In: Kaneda T, Kanegae H, Toyoda Y, Paola R (eds) Simulation and gaming in the network society. Springer, Singapore, pp 309–322
6. Raiffa H (1982) The art and science of negotiation. Belknap Press of Harvard University Press, Cambridge, MA
7. Miyano Y, Yamasaki T, Suzuki T, Ohta A, Kaneda T (2016) A study on risk management to prospect of project profit from 'appropriate size' redevelopment project. In: 4th SIG-BI, JSAI (in Japanese)

Impact Finder: Board Game as a Tool for Social Impact Assessment Knowledge Transfer

Siyanee Hirunsalee and Chanya Punyakumpol

Abstract This chapter introduced Impact Finder, gaming, and simulation invented in order to support a transfer of complicated knowledge of social impact assessment (SIA). Impact Finder has proved to be a useful tool for beginners who are new to SIA to gain basic understanding of two of the most important tools for measuring impact, namely, Theory of Change and Impact Value Chain.

Keywords Gaming simulation · Social impact assessment · Knowledge transfer

1 Background

Confirmed by previous research, gaming and simulation can play an important role as communication tool to transfer knowledge, leading to better understanding of the knowledge. The research also concluded that players have tendency to change their behavior according to the knowledge learnt throughout the game [1]. In light of this, the Impact Finder is invented in order to support a transfer of complicated knowledge of social impact assessment (SIA). Impact Finder is portrayed to be used along with the prior lecture educating SIA. Impact Finder is suitable for those who are interested in learning about SIA and welcome active learning, which allows the discussion among players. Players are to learn how to classify output, outcome, and impact of both intended and unintended social consequence and then realized how to start, manage, and monitor social impact in action. Impact Finder is repeatable and yet enjoyable; it encourages players to revisit the game when SIA knowledge is fade away or even just to have fun with a group of friends.

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2 Overview of Social Impact Assessment

One social impact assessment (SIA) refers to an action of evaluating social outcomes and impacts of a social project or activities of social-purpose organizations to demonstrate results in addressing social issues. It is becoming more and more popular due to the demands of funders to see the results of their "investments." More importantly, as Ebrahim and Rangan [2] have stated, as the sector is professionalized, it is but a natural development of administrative norms for social-purpose organizations which claim to work for social changes in one way or another.

Unlike financial accountings and auditing, there is no standard practice that is recognized globally for measuring the social performances and auditing social impacts of social-purpose organizations. Yet, certain concepts and tools have emerged at the forefront as common practices, especially among nonprofits and social enterprises. In particular, two concepts are important for discussing Impact Finder, as a tool for social impact assessment knowledge transfer, namely, Theory of Change and Impact Value Chain (IVC). Traditionally, "Theory of Change" is a way to comprehensively describe the desired changes that an organization want to achieve, how such desired can come by, and in which ways the organization is contributing toward such changes. Figure 1 shows an example of a Theory of Change of Elm Harbor, a program designed to improve learning for children and families [3]. The desired outcome is "improved learning for children and families," and the necessary condition for this outcome to occur is that "stakeholders in the Elm Harbor Region come together to create the pack initiative," while boxes in the middles are exactly how the program aims to contribute toward the change.

On the other hand, another major tool used by social-purpose organizations is called Impact Value Chain or logic model, which has a setup similar to Fig. 2. Impact Value Chain has been developed for the purpose of evaluating programs or projects, originally by the US Agency for International Development (USAID) around the 1960s [2]. The key components of Impact Value Chain as shown in Fig. 2 are inputs, activities, outputs, outcomes, and impacts. The framework helps evaluators and organizations alike in walking through their activities and make connections to the desired impacts.

A lot of the inspirations for developing Impact Finder come from our direct experiences working in social innovation and social enterprise field in Thailand. Particularly, we have done some social impact assessment projects and organized workshops relating to social impact assessment. Although social impact assessment is yet to be a mainstream practice among social-purpose organizations or social projects in Thailand, it is gaining more and more momentum and interests from various groups of people, especially among potential funders and investors who would like to fund social enterprises and social projects, as evidenced from the active participation of the Stock Exchange of Thailand and other listed companies, as well as the government.

Even though social impact assessment is being recognized in Thailand, a lot of social enterprises and social projects still lack knowledge and resources to conduct

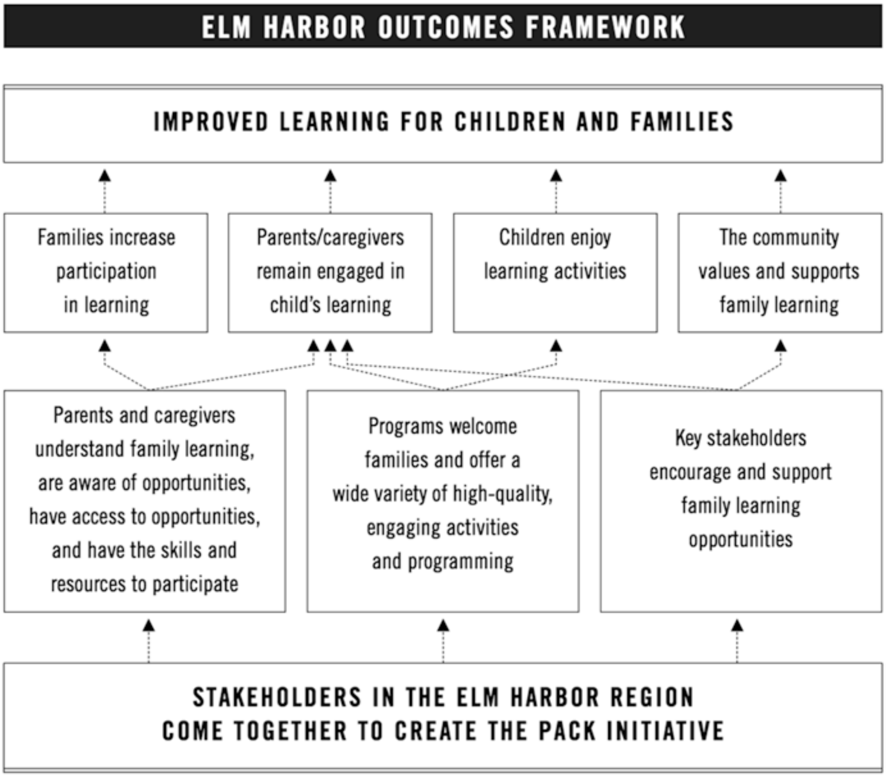

Fig. 1 An example of a Theory of Change of Elm Harbor. (Source: Anderson [3]: 12)

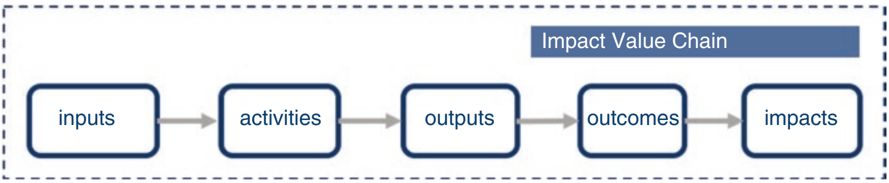

Fig. 2 Impact Value Chain template. (Source: Author adapted from Ebrahim and Rangan [2]: 121)

social impact assessment. One of the main issues among social entrepreneurs is that they do not understand how to make connections between their actions and their goals. This could be done by using Theory of Change and Impact Value Chain described above.

Achavanuntakul and Yamla-or [4] have proposed a modified version of Theory of Change for ease of use. Instead of drawing conceptual map similar to Fig. 1, Achavanuntakul and Yamla-or simplify the format into "if…., then …" statement. In a sense, this emphasizes the main idea of Theory of Change. It forces evaluators to figure out, in the simplest form, how the social-purpose organization or the social project under evaluation contributes to the desired changes. The detailed breakdowns will be done through drawing Impact Value Chain instead.

3 Impact Finder's Mechanism

Impact Finder is resource management board game, which aims at transferring knowledge of social impact assessment (SIA) and demonstrating how the public react after results of the impacts are announced. Impact Finder can be played individually with groups of 4–8, taking 90–120 min (depend on number of players). Impact Finder is planned to be entertaining to capture player's attention; game accessories are then designed as colorful and playful.

3.1 Scenario

The scenario set in Impact Finder is a rural community with population of 930. There are local farmers who rely on farming activity to feed their families. Most population only graduated from primary school; thus 14% of the population are illiterate. Moreover, most of the population are senior citizen and people with disability. More than 70% migrated from other communities and have stayed in a community not more than 5 years. Interaction among community members is less active. A small group of shamans is well known for their medical knowledge. The main source of income in this community is selling local herbal medicine, and its effectiveness attracts more senior population to constantly come to the community. However, formal education is needed to improve knowledge other than medical. The closest school that offers formal education is 100 m away. This discourages children to access to alternative disciplinarians. Since community is remotely situated, community leader has his supreme power to manage and rule the community. "She" has been in her position for 30 years and counting.

3.2 Instruction

There are seven steps to play Impact Finder. (1) Impact Value Chain (IVC) board game is A1 size, and a dice is a main part of this board game for the players to play on. (2) Three Theory of Change cards, one Stakeholder cards, and Money card of 500 IF are to distribute to each player. The player can choose to keep all three Theory of Change cards or to drop any, but at least one card is to be remained. There are 12 Theory of Change and 12 Stakeholder cards in total. (3) All Stakeholder cards left in the stack are up for bidding. Each player can propose money to trade

Fig. 3 IVC board and Stakeholder, Theory of Change, and Money cards. (Source: Authors)

with the stakeholders that are most likely to be linked with Theory of Change cards in hands. (4) Five Resource cards (Fig. 3), input, output, outcome, and impact cards, are distributed to each player. The less of Resource Cards are placed at the stack to be drawn. There are a total of 60 Recourse cards and are divided equally for each type of the cards (15 cards for each type). (5) Roll the dice to decide play order of each player. (6) Start the game. The first player can decide to put one Resource card in hands that is similar to the column indicating on IVC board and then draw one more Resource card from the stack. Other players take turn, respectively. Players

(Source: Authors)

Fig. 4 Resource cards. (Source: Authors)

can also pay 50 IF to swap three pairs of cards. (7) The player who is able to fill in the last box of the chain must reveal the Theory of Change and Stakeholder cards to all players and explain the reason why the chain is complete. If majority of the players agree with the reason, the player who urges the claim can roll the dice twice to get score.

The game is over when all Resource cards are drawn. The player with Theory of Change cards left in hands will be asked to deduct 5 scores for each card. The winner is one with the highest score. Money cards can only help fuel opportunities to boost the process in the IVC but are not the key to winning this game. This is to be mentioned in the debriefing phase (Fig. 4).

3.3 Golden Rule

There is a Golden Rule for the player to learn to master Impact Finder. There are four Discount cards hidden in Resource cards stack. The player who gets the card from the beginning or draws the card from the stack can use these four cards against the player who urges the claim. The player who urges the claim can first roll the dice twice, and the one who holds the Discount cards can then roll the dice twice. Any who has more score can get the different of the score. However, if the player who urges the claim also holds the Discount cards, he/she can use the cards to prevent the attack and can continue to roll the dice with no effect. When using Discount card, players must draw a new card from the stack to remain the original number of the cards in hands.

With this rule, players will understand how social impact is discounted in four different situations:

1. Attribution: there is another who shares the impact.
2. Deadweight: the situation is better organically without your intervention.

3. Displacement: your intervention cannot improve the situation; just that existing of your intervention replaces the other function who used to do the job
4. Drop-off: your impact is declining each day; you cannot always claim the impact. The discount phenomena known as base case scenario in SIA is to be mentioned during debriefing.

4 Feedbacks of the Game

After finishing the game, their Impact Finders were demonstrated six times within a team of designers and played twice with actual players, who are participants in a workshop series called SE 101, held by Stock Exchange of Thailand, aiming at incubating social enterprise in Thailand. SIA class is outlined as one out of ten classes in aforementioned workshop series. The lecture about SIA was delivered from 09:00 to 12:00, and Impact Finder was played from 13:00 to 15:00, following with the debriefing for a half hour. Debriefing phases of Impact Finder are designed to contribute to learning by doing approach. It will first stimulate players to exchange difficulties in winning the game. The facilitator will then ask all players to refer the aforementioned difficulties with the real-world problems in making or assessing social impact. There are a total of 50 players (24 and 26 for the first and second batch, respectively), who experienced Impact Finder.

4.1 SIA Knowledge Learnt Before and After "Impact Finder"

Post-questionnaires were distributed to every workshop participant after class. The results display that participants agreed that Impact Finder can enhance understanding of SIA and the average score if how much it helps is indicated at 3.98 out of 5.0. The satisfaction in learning improvement of SIA class is the highest among other nine classes in the workshop series. Ninety percent of participants (45 participants out of 50) clearly mentioned that Impact Finder can elaborate their learning from theory to practice. Moreover, 80% (40 participants out of 50) mentioned that Impact Finder affects their thought of how to create social impact and has tendency to change their behavior to scale the impact in the future. Seventy-six percent (38 participants out of 50) agreed that Impact Finder is worth spending time and money on. An average of 3 h is the maximum hour that participants are willing to spend with Impact Finder and participant are willing to pay up to 250–500 THB (8.03–16.07 USD) to play Impact Finder for 3 h. One hundred percent expressed introducing Impact Finder to others who have difficulties in understanding SIA.

4.2 Feedbacks and Future Outlooks of "Impact Finder"

Most feedbacks received from 50 participants are as follows: (1) Impact Finder is hard to play and takes much time (at least 15 min) for players to learn how to play the game, and it may cause frustration. This challenge can be avoided by giving clearer instruction and small demonstration round before beginning the game. (2) It is hard to convince other players to agree with the reason given when the player urges to claim the IVC. Since the current version of Impact Finder set to let the discussion flow naturally and they are all competitors, no one tend to agree with anyone. Impact Finder should consider adding the closed-ended answers to explain the IVC. (3) Maximum players set for the current version are from 4 to 8 players. From playing it eight times, four players are the best number for the game. Impact Finder can also be played in team; thus 8, 16, and more players can be added to the original 4 teams. (4) Interplayer negotiations such as swapping their cards, buying and selling cards, etc. were found often during the game and should be allowed. It can bring up the fun element of the game and relieve stress from strategic thinking.

5 Conclusion

In Thailand, measuring social impact will become a crucial factor in securing financial and other in-kind supports in the future. While many social entrepreneurs, as well as other social-purpose organizations, are aware of the need to start measuring their own impacts, there is a clear lack of practitioners who know how to do so. Combined with the highly conceptual nature of Theory of Change and Impact Value Chain, connecting the dots between the desired outcomes and the activities of the organizations is a crucial step and yet the most difficult step for practitioners who are not familiar with social impact assessment to go through. Therefore, we have devised a board game mechanism to turn highly conceptual ideas into a more tangible explanation with examples.

Impact Finder has proved to be a useful tool for beginners who are new to social impact assessment to gain basic understanding of two of the most important tools for measuring impact, namely, Theory of Change and Impact Value Chain. It translates conceptual ideas into tangible examples, enabling practitioners to gain basic understandings easier. However, it also comes with limitations. Most notably, Impact Finder can only provide basic introduction to learners. The situation presented in the game does not necessarily cover the complexity that comes with actual applications of the concepts. The main recommendation gained from feedbacks and observations of Impact Finder implementation is thus how to improve the situations included in the game so that it reflects more actual applications of measuring social impacts. Oftentimes, suggestions on improving and expanding realistic examples in the game come from practitioners who have tried to measure social impacts themselves. Therefore, one way to do so could be interviewing various practitioners from different fields to exact more examples.

References

1. Hirunsalee S, Promsaka Na S, Kanegae H (2011) The utilization of 4R, gaming simulation in bridging the gap of town & gown and instilling enthusiasm of college students to participate in disaster volunteerism activities. In: Proceeding book of the 3rd international ThaiSim conference: ThaiSim 2011-TS'10 Quality, life-long learning through simulation/gaming, Ayutthaya, Thailand, 24–26 March 2011
2. Ebrahim A, Rangan VK (2014) What impact? A framework for measuring the scale and scope of social performance. Calif Manag Rev 56(3):118–141
3. Anderson AA (2004) Theory of change as a tool for strategic planning. http://www.wallace-foundation.org/knowledge-center/Documents/Theory-of-Change-Tool-for-Strategic-Planning-Report-on-Early-Experiences.pdf. Last Accessed 2018/03/05
4. Achavanuntakul S, Yamla-or P (2017) Handbook for social impact assessment and social return on investment. The Thailand Research Fund, Bangkok (in Thai)

A Study About the Changes of Participants' Impressions Through a Brainstorming Group Work

Kohei Ito, Shinobu Kitani, Shin Oyamada, and Takafumi Hanamatsu

Abstract We designed a group work (GW) for university students based on the KJ-method as a frame game. The goal of the GW is to create the concept of the "ideal rural area" collaboratively. To evaluate the impact of this, we send out the questionnaires using both the Likert and the SD scales before and after the GW and compared these results. The results of the Likert questionnaire suggest that students' interests in rural areas and so on had been increased. The result of the SD questionnaire shows that students' impressions of both "agriculture" and "rural area" changed and became similar after the GW. On the other hand, there were little correlations between the changes of interests and impressions. These tentative results suggest that students had rethought the relation between rural areas and agriculture through creating the concept. In addition, the changes in participants' attitudes that cannot be grasped by only the Likert questionnaire might have occurred.

Keywords KJ-method · Frame game · Semantic differential method · Participants' impressions

1 Introduction

The productive-age population in Japan turned to decrease in 1995, as did the total population in 2008. The populations in most of prefectures, excepting Tokyo, Okinawa, etc., are estimated to continue to decline. Now, many local governments, especially in rural areas, are at stake.

Against the background of the above problems, we have designed and implemented gamings focusing on the attitudes of residents and outsiders of local

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communities such as university students, with the theme of “rural community building” and considered the way to evaluate them. Especially, we have been focusing on the changes of participants’ attitudes due to their “awareness” in a free-form gaming where “unexpected events” for even the designers may occur.

During policy-making process for the rural area development, it is important to reveal the problems facing the communities and make future vision. We assume that such effort not only helps to rural development but also may make people in the country change their attitudes or consciousness through its process. In this study, we regard the KJ-method as a kind of frame game and design group work (GW) for university students based on its procedure. Then, we make students work on creation of the vision of the “ideal rural area.” To evaluate the impact of the GW, changes of their attitudes before and after the GW are examined by both Likert and SD (semantic differential) scale questionnaires. Through the comparison between those results, we also consider the applicability of the measurement of participants’ impressions by SD method to evaluate gamings.

2 Designing the GW and Its Evaluation

2.1 Brainstorming GW Based on the KJ-Method

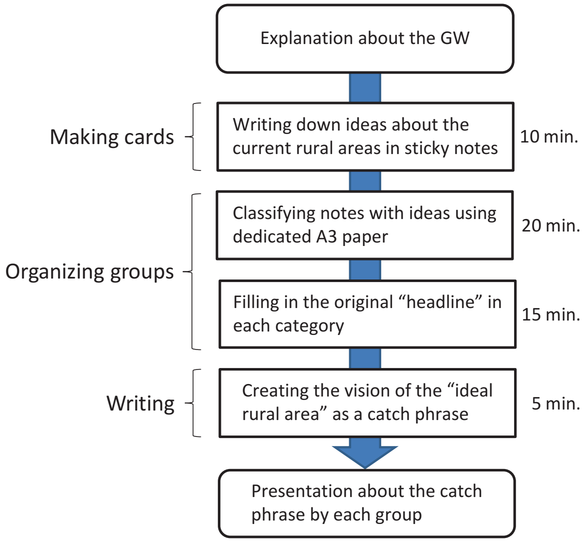
In this study, based on the procedure of the KJ-method, we design a brainstorming GW that can help students to think about current and future Japanese rural areas cooperatively.

The KJ-method (also known as the affinity diagram) was designed and integrated by Jiro Kawakita, a Japanese geographer and cultural anthropologist, to organize data and obtain new ideas [1]. Today, the KJ-method is regarded as the technique which can help students to learn actively, so this is often used for group discussion in classes. In addition, this is also used to analyze free descriptions in studies. In broad terms, the procedure of the KJ-method consists of the following four steps. (1) Making cards: Briefly write down ideas in cards (one idea per card). (2) Organizing groups: Sort cards into several groups by their “affinities,” and caption each group. (3) Illustration: Focusing on the interrelations of the organized groups, arrange them spatially. Based on the arrangement, illustrate it with circles and bars. (4) Writing: By writing (or speaking verbally) based on the illustration, make up a story.

The participants of this GW are freshmen in university, and they are divided into some groups consisting six to seven members. In each group, one member is assigned to a facilitator, who is instructed not to express own opinions in the discussion.

This GW is conducted through the following steps (Fig. 1). Firstly, according the subject of the “ideal rural area,” use red and blue sticky notes ($1.5 \times 5\ \mathrm{cm}^2$) to write down “the good aspects or what you want to keep unchanged in the current rural

Fig. 1 Flowchart of the GW



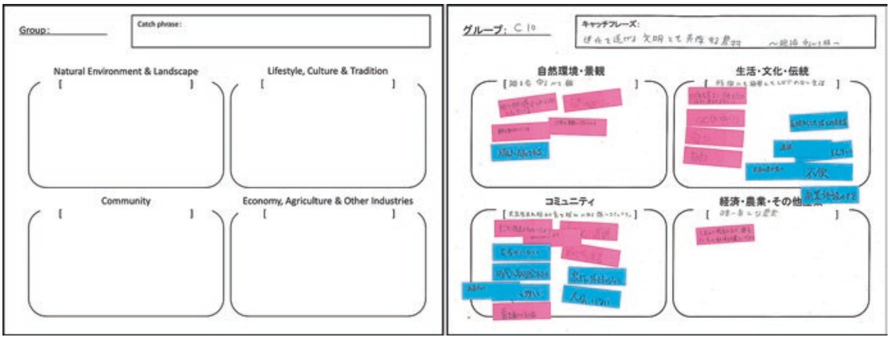


Fig. 2 Left: Dedicated paper for classifying notes (translated). Right: Sample of the paper after the GW

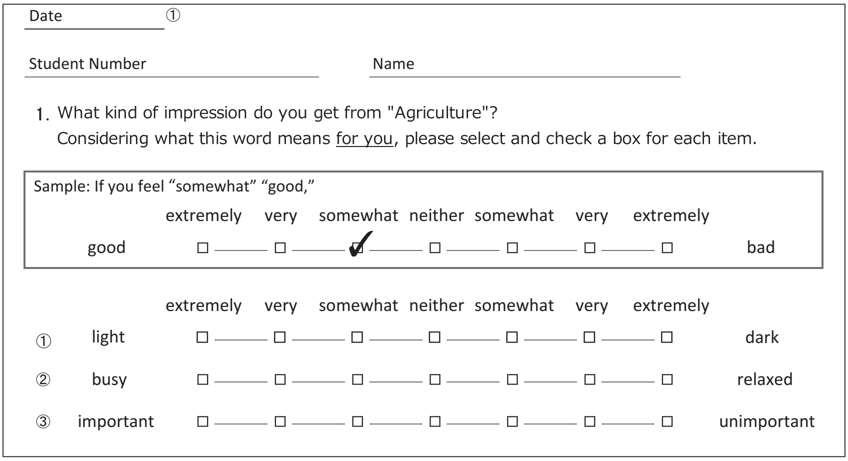
areas” and “the bad aspects or what needs to be improved in the current rural areas,” respectively. Secondly, each member puts the notes to dedicated A3 paper where categories for classifying notes are described (Fig. 2). What is the most different step in this GW from the original KJ-method is this “organizing groups” that is expected to require much time in original way. The A3 paper has the following four categories: “natural environment and landscape;” “lifestyles, culture, and tradition;” “community;” and “economy, agriculture, and other industries.” Participants put each note with idea considering which categories the idea fits in. If there are conflicting opinions among members, use yellow note and write down an agreement idea in it through consultation. Also, there is a blank space under each category name to fill in the “headline.” Participants create the original headline for each category based on the contents of classified notes (Note: Kawakita said that setting categories to classify ideas in advance is the "wrong way" [1], so this procedure is against the original spirit of the KJ-method. However, because of using the KJ-method rigidly demands much time and training, we altered the procedure as above in order to simplify its process and finish the GW in time). When the "headline" for the four categories is completed, integrate them and create the vision of the "ideal rural area" as a catch phrase. After all groups finish all the above steps, the facilitator of each group makes a presentation about the catch phrase they made.

2.2 Evaluation by Impressions

When focusing on the new ideas obtained through its process, the KJ-method is positioned as a method of getting ideas. On the other hand, it is also known for its educational effects and used in order to enhance participants' discussion skills, creativities. Like the above, if focusing on participants' learnings and attitude changes through the process, the KJ-method can be considered as a kind of frame game.

In a free-form game with a loose rule structure, the result may not match designer's intents or may exceed his/her expectations [2]. In other words, when using a free-form game for educational purposes, it may not be possible to measure the impacts of the game on participants in terms of only whether the learning goal has been achieved. Regarding this, Kitani [3, 4] attempted to evaluate a gaming by focusing on "emotions" of participants in the gaming from the standpoint of the "inner measurement." In these studies, participants' emotions are analyzed by extracting emotional words appearing in the free descriptions after gaming or freely selecting emotional words from a word group. However, both methods have a disadvantage that it is difficult to quantitatively compare. Therefore, in this study, we design a brainstorming GW based on the KJ-method and evaluate it from the standpoint of participants' "impressions," using the SD method which enables quantitative comparison among concepts and individuals and before and after the GW.

The SD method, developed by American psychologist C.E. Osgood in the 1950s, is for measuring the "affective meaning" of concepts using pairs of adjectives [5]. Until now, it has been used to evaluate of impressions or images of various things such as people, colors, sounds, music, goods, landscapes, and environments and used for class evaluations, sensory evaluations, and attitude evaluations. Also, the SD method is used for evaluating gamings. For example, Nakamura [6] evaluated the change in participants' perceptions of gaming simulations before and after the course during which gaming simulations were conducted. The SD method uses some pairs of adjectives to evaluate a concept (Fig. 3). These adjectives must be the representation of the range in which the meaning of the concept changes [7], so the preparations such as extraction of adjectives related to the concept by free association are needed. When the representativeness is ensured, the broad range of attitude changes could be evaluated by the SD method. In this study, we regard the changes of one's impressions before and after GW as an indicator of attitude change and use the SD method in order to evaluate players' impressions of GW theme: "agricul-


Date ①

Student Number Name

1. What kind of impression do you get from "Agriculture"?
Considering what this word means for you, please select and check a box for each item.

Sample: If you feel "somewhat" "good,"

	extremely	very	somewhat	neither	somewhat	very	extremely	
good	☐	☐	☑	☐	☐	☐	☐	bad

	extremely	very	somewhat	neither	somewhat	very	extremely	
① light	☐	☐	☐	☐	☐	☐	☐	dark
② busy	☐	☐	☐	☐	☐	☐	☐	relaxed
③ important	☐	☐	☐	☐	☐	☐	☐	unimportant

Fig. 3 Part of the SD questionnaire used in this study (translated)

ture" and "rural area." Also, we compare the results of the SD questionnaire to the results of a Likert questionnaire designed according to the expected results. Through this comparison, we expect to find the "unexpected" changes of participants' attitudes.

2.3 Analysis Items

The analysis items are the following. Firstly, the Likert questionnaire is used to evaluate whether the GW worked. Three questions are asked after GW: "Was this GW meaningful to you?," "Did you deepen understanding of your own way of thinking?," and "Did you deepen understanding of other group members' way of thinking?" Next, to evaluating the changes of students' interests, three questions are asked before and after the GW: "Do you want to participate in any farming experiences?," "Are you interested in growing crops with your own hands?," and "Would you like to visit any rural areas?" Each question is on a five-point scale and calculated "strongly agree" as 5 and "strongly disagree" as 1.

Secondly, using the SD questionnaire, we examine the change in students' impressions of "agriculture" and "rural area" before and after GW. Twenty pairs of adjectives are selected based on the adjective words associated with "agriculture" and "rural area" extracted from students' free description texts in pre-survey and used in previous studies [8, 9]. Regarding the 20 pairs of adjectives used in this survey, see Table 1 which summarizes the results. The purpose of this questionnaire is to examine the changes in each pair before and after GW, to grasp the impression structures by the exploratory factor analysis and to analyze the change in the factor scores. In addition, the correlation between changes in factor scores and interests in

Table 1 Means in the before and after GW and the results of paired *t*-test

	"Agriculture"		"Rural area"	
	Pre-GW	Post-GW	Pre-GW	Post-GW
light-dark	4.04 (0.91)	4.60 (1.00)***	3.97(1.13)	4.57 (1.17)***
busy-relaxed	3.89 (1.43)	3.29 (1.26)***	2.57(1.16)	2.89 (1.27)***
important-unimportant	5.95 (1.13)	5.58 (1.03)***	4.32(1.09)	4.96 (1.07)***
competitive-cooperative	4.14 (1.49)	3.42 (1.43)***	2.54(1.14)	2.90 (1.40)***
artificial-natural	3.45 (1.52)	2.90 (1.41)***	2.42(1.08)	2.68 (1.28)**
plain-fancy	5.24 (1.05)	4.87 (0.95)***	5.41(0.89)	4.95 (0.97)***
warm-cold	5.30 (0.94)	5.47 (1.06)*	5.46(1.10)	5.54 (1.13)
open-closed	4.83 (1.28)	4.32 (1.41)***	4.16(1.71)	3.94 (1.60)
rigid-flexible	3.61 (1.02)	3.80 (1.05)	3.92(1.31)	3.79 (1.21)
clean-dirty	3.45 (1.01)	3.94 (1.20)***	3.99(1.12)	4.14 (1.14)
small-big	3.17 (1.12)	3.99 (1.18)***	5.10(1.30)	4.58 (1.34)***
kind-severe	3.89 (1.39)	4.68 (1.48)***	4.99(1.19)	5.14 (1.21)
common-unique	4.41 (1.05)	4.51 (1.19)	4.58(1.11)	4.53 (1.18)
free-bound	4.25 (1.30)	4.49 (1.32)*	4.45(1.40)	4.51 (1.32)
stable-unstable	2.73 (1.07)	3.16 (1.19)***	3.54(1.14)	3.39 (1.19)
modern-traditional	2.51 (1.15)	2.70 (1.12)*	2.07(0.83)	2.46 (1.08)***
bustling-quiet	3.19 (1.07)	3.46 (1.24)**	3.16(1.37)	3.36 (1.36)
enjoyable-tough	3.64 (1.05)	4.05 (1.05)***	4.19(1.02)	4.53 (1.05)***
strong-weak	4.90 (0.89)	4.47 (1.00)***	4.04(1.10)	4.26 (1.13)**
near-far	3.76 (1.19)	3.77 (1.18)	3.14(1.21)	3.67 (1.18)***

Mean (SD)
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

"farming experiences," "cultivation," and "visit rural areas" examined by Likert questionnaire is examined to discuss the relationship between interests and impressions.

Thirdly, to confirm that the differences in directions of discussion affect participants' attitude changes, we focus on the proportions of classified notes numbers in categories in the A3 paper. In this study, we regard that the numbers of classified notes represent the characteristics of discussion in the group indirectly. According to the proportions of classified notes in the above four categories and the margin area (unclassified notes), we conduct group clustering. Then, the differences of the factor scores between the clusters are examined.

3 Results and Discussion

We implemented the GW in the class of the "Science of Decision-making" in Tohoku University (Fig. 4). There were 231 students (including 40 facilitators who were not subjects of analysis in this study) who participated in the GW, and the

Fig. 4 Students in the GW

number of students per group was four to seven. Of these, the number of valid responses was 166 (86.9%).

3.1 Evaluation of the GW and the Changes of Interests

The results of Likert questionnaire after GW are as follows. For the question of "Was this GW meaningful to you?," 88.6% of respondents said "very meaningful" or "somewhat meaningful." For the question of "Did you deepen understanding of your own way of thinking?," 75.9% of respondents said "deepened so much" or "slightly deepened." Likewise, 95.2% of respondents said "deepened so much" or "slightly deepened" for the question of "Did you deepen understanding of other group members' way of thinking?"

In the questions asking about the degrees of interest in "farming experiences," "crop cultivation," and "visit rural areas" conducted before and after the GW, the means increased after the GW, respectively (3.30–3.50, 3.52–3.84, 3.10–3.51). Also, as results of the Wilcoxon signed-rank test, the null hypothesis that the median of the difference is 0 was rejected in any question ($p < 0.01$, two-sided test).

3.2 Results of the SD Method

3.2.1 Changes in Each Pair of Adjectives

Table 1 shows the mean of each item measured by the seven-point SD scale questionnaire. Each response was converted to values from 1 to 7 such as:

	extremely	very	somewhat	neither	somewhat	very	extremely	
light	7	6	5	4	3	2	1	dark

The change of each item before and after GW was tested by paired t-test. As a result, there are significant differences between before and after GW in 17 items in “agriculture” and 11 items in “rural area” ($p < 0.05$, two-sided test). Also, the correlation coefficient between each mean of item in “agriculture” and “rural area” increased from 0.53 to 0.93 before and after GW.

Therefore, although the impressions of “agriculture” and “rural area” were somewhat different initially, these seem to become similar through the GW. In addition, the result that both the total amount of change and number of items showed significant change in “agriculture” are larger than “rural area” suggests that the impression of “agriculture” was reconstructed in the context of an “ideal rural area.”

3.2.2 Factor Analysis and Changes of Factor Scores

To grasp the structures of impressions of “agriculture” and “rural area,” and the changes of each impression before and after GW, the result of SD questionnaire was analyzed using exploratory factor analysis (maximum-likelihood method, promax rotation). Table 2 shows the result. Here, to compare the results of each concept before and after GW using factor scores, factor analysis was conducted using all results before and after GW of “agriculture” and “rural area” together. According to the scree plot, three factors were extracted. When choosing items, which has factor

Table 2 Result of factor analysis

	Factor1	Factor2	Factor3
enjoyable-tough	0.636	0.170	0.084
kind-severe	0.600	0.143	−0.209
stable-unstable	0.555	−0.151	0.201
clean-dirty	0.459	0.062	0.130
open-closed	0.099	0.642	0.042
flexible-rigid (inverted)	0.117	0.629	−0.040
warm-cold	0.188	0.538	−0.331
important-unimportant	−0.335	0.442	0.228
strong-weak	−0.038	0.432	0.237
free-bound	0.396	0.411	−0.175
modern-traditional	0.147	−0.118	0.627
artificial-natural	−0.179	−0.062	0.573
bustling-quiet	0.218	0.116	0.466
busy-relaxed	−0.290	0.149	0.461
fancy-plain (inverted)	0.241	−0.047	0.434
Factor correlation	**Factor1**	**Factor2**	**Factor3**
Factor1	1	−0.131	0.171
Factor2		1	0.124
Factor3			1

Maximum-likelihood method, promax rotation

Table 3 Factor scores before and after GW and the result of the Wilcoxon signed-rank test

	"Agriculture"		"Rural area"	
	Pre-GW	Post-GW	Pre-GW	Post-GW
Evaluation	−0.58 (0.95)	0.14 (0.99)***	0.32 (0.72)	0.44 (0.82)*
Potency	0.43 (0.95)	0.09 (0.86)***	−0.24 (1.36)	−0.22 (0.94)
Modern sociality	0.33 (1.03)	0.25 (1.02)	−0.29 (1.11)	−0.07 (1.05)***

Median (IQR)
***$p < 0.001$; *$p < 0.05$

loading less than |0.4| on any factor or more than |0.4|, multiple factors were removed. As a result, 15 items are left. In addition, the scales of values of the following two items "rigid-flexible" and "plain-fancy" which show negative loadings were inverted.

Looking at each factor, items such as "enjoyable-tough" and "kind-severe" show large loadings in the first factor, so the first factor is considered to be related to the participants' value consciousness. Therefore, the first factor was named "evaluation (factor E)." In the second factor, items related to the properties of the concepts such as "open-closed," "flexible-rigid," and "warm-cold" show large loadings. Therefore, the second factor named "potency (factor P)". In the third factor, items such as "modern-traditional," "artificial-natural," and "bustling-quiet" show large loading. These items seem to relate to a contrast between modern cities and idyllic rural areas. Therefore, the third factor was named "modern sociality (factor M)". Looking at the correlation between factors, the correlation is less than |0.2| between any factors, so it is considered that these factors are almost orthogonal.

Table 3 shows the factor scores (medians and interquartile ranges) of each factor before and after GW. Using Wilcoxon signed-rank test, each median of the difference between before and after GW was tested. In "agriculture," the factor score of "evaluation" showed significant increase, and the factor score of "potency" showed significant decrease before and after GW. On the other hand, both the factor scores of "evaluation" and "modern sociality" showed significant increase in "rural areas" ($p < 0.05$, two-sided).

From the above, it suggests that students' impressions of "agriculture" and "rural areas" are composed of the following three axes: "favorability," "potency," and "modern or idyllic." The result of changes of the factor scores through the GW suggests as follows: (1) students' impression of "agriculture" and "rural area" become better, (2) their perceptions of the evaluation of potency of "agriculture" become lower, and (3) the impression of "rural area" shifts from idyllic to somewhat modern.

3.2.3 Correlations Between the Interests and Impressions

The relationship between the changes of the interest in "farming experiences," "crop cultivation," and "visit rural areas" and the change in the factor scores of the three factors of both "agriculture" and "rural area" before and after GW was tested using Spearman's rank correlation. The results are shown in Table 4. The correlation between

Table 4 Correlations between the changes of factor scores and degrees of interest

	"Agriculture"			"Rural area"		
	Factor E	Factor P	Factor M	Factor E	Factor P	Factor M
Farming experiences	0.08	0.10	0.07	0.07	0.07	0.02
Cultivation	−0.11	0.13	−0.08	0.07	0.06	−0.05
Visit rural areas	0.07	0.18*	−0.13	0.19*	0.07	0.02

Table 5 Group clustering according to the proportions of classified notes

	Number of groups	Number of students	The proportion of classified notes in each category				
			Category 1 (%)	Category 2 (%)	Category 3 (%)	Category4 (%)	Unclassified (%)
Cluster 1	16	65	21.4	20.4	33.5	20.7	3.9
Cluster 2	18	76	23.2	34.7	30.3	10.4	1.4
Cluster 3	6	25	20.2	27.6	12.3	28.3	11.6

Ward's method

the changes of interest and factor scores was less than |0.2| in any combination. This suggests that the changes of impressions have little relation to the changes of interests.

3.2.4 The Differences of the Factor Scores Between Groups Focusing on the Proportions of Classified Notes

Table 5 shows the result of clustering by Ward's method according to the proportions of classified notes in four categories and margin of the paper. For ease of interpretation, three clusters were extracted. Cluster 1 has a higher proportion of notes in Category 3 "community," and these groups seem to have discussed about the issue of rural communities such as human relationships and their closed nature especially. Cluster 2 has a higher proportion in Category 2 "lifestyles, culture, and tradition" and a lower proportion in Category 4 "economy, agriculture, and other industries." It is thought that they had interest in such as unique traditions, customs or environments, accessibility issues, and inconveniences in rural life. On the other hand, they seem to have little interest in agriculture and other industries in rural areas. Cluster 3 shows a lower proportion in Category 3 and somewhat a higher proportion in Category 4. Also, they have a lot of unclassified notes. They seem to have discussed about such as the issue of lack of opportunities for employment or revenue instability. Incidentally, even with the note of similar content (such as the issue of aging population), it could be different where it was classified depending on the group. This indicates that there is more than one way to think the problems.

Table 6 shows the differences of changes of the factor scores between the clusters. In the factor scores before GW, there are no significant differences between the

Table 6 The differences of changes of the factor scores between the clusters (median)

	"Agriculture"			"Rural area"		
	Factor E	Factor P*	Factor M	Factor E*	Factor P*	Factor M
Cluster 1	0.60	**−0.54**	−0.06	0.16	**−0.03**	0.28
Cluster 2	0.69	**−0.22**	−0.07	0.16	**0.19**	0.22
Cluster 3	0.45	−0.38	−0.11	−0.13	0.05	0.57

Kruskal-Wallis test, $^*p < 0.10$

clusters. As the results of Kruskal-Wallis test, significant differences in factor P of "agriculture" and factors E and P of "rural area" between clusters were confirmed. The results of multiple comparisons using Bonferroni's correction show that there are differences between cluster 1 and cluster 2 in factor P of both "agriculture" and "rural area" ($p < 0.033$). Regarding factor P of "agriculture," the factor scores show a decrease in all clusters. Among them, the score largely decreased in cluster 1. Also, only cluster 1 shows a decrease in the score of factor P of "rural area." These might have been caused by focusing on the closed nature of rural areas especially. On the other hand, discussion about the appeal of rural areas such as traditions or environments may increase the potency evaluation of rural areas.

3.3 Summary

From the results of the Likert scale questionnaire, it was confirmed that students deepen the understandings of own and others' thought through GW, and their interests in agriculture and rural areas increase. On the other hand, the result of SD method shows that the impressions of "agriculture" and "rural area" became a bit better, the potency evaluation of "agriculture" shows reduction, and the image of "rural areas" shifts to somewhat modern. These results suggest that the SD method can be available for evaluation of the participants' attitude changes in a free-form game. However, there was little correlation between these interests and impression changes. And, the results of clustering suggest that the differences of discussions between each group may affect these impression changes.

These above results suggest that the GW made participants change their attitudes, and the changes could not to be grasped from the evaluation framework that focuses on only their interests.

4 Conclusion

In this study, focusing on participants' impressions, we designed and implemented a brainstorming GW for university students based on the KJ-method and evaluate it using both the Likert and the SD scale questionnaires. As a result, it was suggested that the attitude changes that could not be grasped from only the Likert questionnaire may have occurred to students. From the above, the SD method might be available to evaluate gamings where the unexpected events may happen. These results may help in evaluating the impact of gamings or other instructions in future study.

However, it is not clear what the meaning of the "impression" itself is and how it relates to one's decision-making and so on. Also, it is unclear what kind of factors is affecting the formation and change of the impression. Further study is needed to identify the factors that determine the impression by using path analysis, etc. as well as discuss the meaning and the definition of the impression.

References

1. Kawakita J (1967) The method of abduction. Chuokoron-Sha, Tokyo. (in Japanese)
2. Arai K, Deguchi H, Kaneda T, Katoh F, Nakamura M (1998) Gaming simulation. Nikkagiren, Tokyo. (in Japanese)
3. Kitani S (2009) A new attempt on evaluating a cross-cultural understanding simulation based on an inner measurement theory —how to grasp emotions and attitude against unexpected events. Simul Gaming 19(1):61–71. (in Japanese)
4. Kitani S, Hasebe T (2014) The influence of formal mindsets on decision maker attitudes when confronted with difficult problems: a view of gaming simulation "lost in space" using inner measurement. In: Kriz WC, Eiselen T, Manahl W (eds) The shift from teaching to learning: individual, collective and organizational learning through gaming simulation. W. Bertelsmann Verlag, Bielefeld, pp 212–223
5. Iwashita T (1983) Measurement of image by SD method: its understanding and implementation guidance. Kawashima-shoten, Tokyo. (in Japanese)
6. Nakamura M (2016) Participants' perceptions of gaming simulation. In: Kaneda T, Kanegae H, Toyoda Y, Rizzi P (eds) Simulation and gaming in the network society. Springer, Singapore, pp 53–63
7. Saito S (1978) Semantic differential method. Jpn J Ergon 14(6):315–325. in Japanese
8. Inoue M, Kobayashi T (1985) The research domain and scale construction of adjective-pairs in a semantic differential method in Japan. Jpn J Educ Psychol 33(3):69–76. (in Japanese)
9. Miura T, Tobioka J (1993) A study on the psychological function and estimation method of the green environment. J Jpn Inst Landsc Archit 56(5):235–240. (in Japanese)

Eliciting Requirements of a Knowledge Management System for Gaming in an Organization: The Role of Tacit Knowledge

Bill Roungas, Julia C. Lo, Rachele Angeletti, Sebastiaan Meijer, and Alexander Verbraeck

Abstract Games used by organizations generate a wealth of valuable output in terms of knowledge. In order to maintain the produced knowledge, such as the explicit, e.g., logging and questionnaires, and implicit/tacit knowledge, e.g., experience from game sessions, a knowledge management system (KMS) should be employed. This paper starts by giving a brief description of the building blocks for a KMS and then proposes a methodology that combines three different methods, namely, semi-structured interviews, causal maps, and the Q-methodology, to illustrate how tacit knowledge from principal stakeholders (game designers and project team members) can be extracted as part of building a KMS. The proposed methodology is applied in a case study related to the railway sector.

Keywords Knowledge management system · Game requirements · Tacit knowledge

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1 Introduction

Gaming simulations (hereinafter referred to as games) used for decision-making have developed into a powerful tool for corporations [1]. Irrespective of their size, corporations have been increasingly using games in order to evaluate and ascertain impactful business decisions and strategies. Despite their proven added value to the decision-making process, there is still a lack of research on whether, and if so how, games can be used by researchers and practitioners to build evident on systems' behavior, as part of a larger scheme [1], in other words, whether and how knowledge acquired through games can be managed and reused and particularly how can implicit, also known as tacit, knowledge can be elicited, managed, and disseminated within an organization.

The management of both explicit and implicit knowledge from games is not, and should not be, of academic interest only. The effectiveness of a corporation depends heavily on how it manages this knowledge [2] or, in layman terms, how in the first place it obtains and thereafter maintains the so-called know-how. As a corporation acquires and builds up on knowledge obtained through games, it improves its know-how and thus sustains or even increases its competitive advantage [3].

The authors aim to propose a knowledge management framework (KMF) and subsequently build a knowledge management system [4] (KMS) for games. In this paper, the part of the framework pertaining particularly to the elicitation and reuse of tacit knowledge is analyzed. The specific selection of tacit knowledge for further analysis in this paper is due to the fact that tacit knowledge is an integral part of the decision-making processes of organizations yet one that has hardly been explicitly operationalized [5].

In Sect. 2, a brief description of the complete KMF is given as for the reader to see the bigger picture and the role of tacit knowledge within this picture. In Sect. 3, a methodology to capture and disseminate tacit knowledge within an organization is proposed. In Sect. 4, preliminary results from three case studies are illustrated. Finally, in Sect. 5, the future steps of this research are identified, and final remarks are made.

2 Knowledge Management in Games: The Building Blocks

With regard to knowledge, a distinction should be made about explicit and implicit, or tacit, knowledge. Explicit knowledge can be seen as academic, technical data, or information that is communicated in a formal language and/or shared digitally or in print, such as manuals [6]. On the other hand, tacit knowledge is cognitive or technical and consists of mental models, beliefs, insights, and perceptions. An example of an application of technical tacit knowledge is conducting train traffic operations [6].

Games generate a wealth of output depending on their application [7]. Games can be focused on training, design, research, and policy intervention, to name a few.

In Table 1, the different applications of games are shown based on two criteria: the type of knowledge generated by the game and the person or persons who are the beneficiaries of this knowledge. With regard to the type of knowledge generated, the authors distinguish between two categories: (1) generalizable, meaning that the knowledge acquired during the game provides for broad insights beyond the scope of a particular game scenario, and (2) contextual, meaning that the knowledge acquired during the game provides for deep insights closely related to a particular game scenario. With regard to the beneficiary of the generated knowledge, the authors again distinguish between two categories: (1) the participant, meaning that the beneficiary of the knowledge acquired during the game is the person or persons who play the game, and (2) the principal, meaning that the beneficiary of the knowledge acquired during the game is any stakeholder or stakeholders other than the participants, like decision-makers, researchers, or game designers.

The aim of this research as a whole is to build a complete KMF for games and particularly for games in engineering systems in which the knowledge type is contextual and the knowledge beneficiary is the principal. While this paper only focuses on the tacit knowledge produced by games, a brief description of the complete framework is deemed necessary for readers to understand the bigger picture and how tacit knowledge of involved stakeholders fits into the complete framework.

Regardless of the organization or the specific games they use, a KMF consists of some common building blocks that eventually contribute toward building a KMS. Namely, these blocks are:

- The type of the KMS. Currently there are two distinct types of KMS, *codification* and *personalization* [8]. *Codification* stores and makes available for reuse any acquired knowledge, which is in reality isolated from its source. On the other hand, *personalization* is the exchange of knowledge that has been acquired in the past through one-to-one conversations and brainstorming sessions; it is a way to promote discussion and exchange of ideas and knowledge between people in a more personal manner, and it is usually where most of the tacit knowledge is exchanged. The framework associated with this paper is a hybrid approach that combines *codification* and *personalization*, in order to harness the advantages of both methods and provide for a more formal way of capturing and reusing tacit knowledge.

Table 1 Canonical applications of gaming methods

	Knowledge beneficiary	
Knowledge type	Participant	Principal
Generalizable	Teaching	Research
	Experiential learning	Hypothesis generation and testing
	Dangerous tasks	Artifact assessment
Contextual	Policy	Design
	Organizational learning	Interactive visualization
	Policy intervention	Collaborative design

- The purpose of the KMS. A KMS can be used for one or more purposes, like root-cause analysis, own-project improvement, cross-project improvement, and network improvement. The proposed KMS will incorporate all these purposes, depending on the users.
- The intended users of the KMS. Any individual or group employed or even associated with the organization is a potential user of the KMS. In the proposed KMS, the potential users are individuals and groups related one way or another to games built or used by the organization.

3 Tacit Knowledge

In this section, first the different methods on how to capture tacit knowledge are examined, and then a comprehensive methodology that is used throughout the case studies is proposed.

3.1 State of the Art

One of the most common techniques for capturing tacit knowledge is "cognitive maps," which facilitate the representation of individuals' view of reality [9]. There are different types of cognitive maps, one of which is causal maps [10]. Causal maps are interpretations of individuals' or groups' beliefs about causal relationships [11]. Causal maps have been proven to be an effective tool for the elicitation of tacit knowledge for a variety or reasons, e.g., allowing to focus on action, eliciting context-dependent factors, etc. [10].

Semi-structured interviews are another tool that can help elicit tacit knowledge. While the purpose and structure of such an interview are predetermined, the essence of the "semi-structure" lies on the fact that interviewees are encouraged to answer questions by telling stories [10]. The storytelling nature of those kinds of interviews allows people to manage the collective memory of an organization [12], frame their experiences [13], and reflect on the complex social web of an organization [14].

Tacit knowledge encompasses a large amount of subjectivity and a research method to study its Q-methodology [15]. In a nutshell, in Q-methodology the interviewee sorts a series of items/statements throughout a continuum (e.g., from strongly disagree to strongly agree) that is approximately normally distributed, in the sense that more of these statements are placed close to the neutral area than in the two edges of the continuum.

Various scholars argue that the use of metaphors can serve to transmit tacit knowledge [10, 16], and since metaphors allow different ways of thinking, people may be able to explain complex organizational phenomena [17]. The term metaphors connotes the transfer of information from a relatively familiar domain to a relatively unknown domain [17].

Social media have become prominent on how people interact not only in a personal but also in a professional level. While research is still relatively poor in this area, the use of social media sounds indeed promising in tacit knowledge sharing, since they encompass interactive and collaborative technologies [18].

3.2 Methodology

The current study aims at capturing the tacit knowledge of principal stakeholders, mainly that of game designers, through a combination of semi-structured interviews, causal maps, and the Q-methodology. The interviews enable to capture knowledge (e.g., experiences, insights, etc.), and in turn causal maps are used to build the list of statements required by the Q-methodology. Then, using the Q-methodology, the interviewees sort these statements in accordance to their relevance.

In more detail, the interviews are partitioned in two sets. The first set of interviews is used to build the list of statements and subsequently the causal maps that are then used by the Q-methodology. For building a comprehensive list of statements for games, on average, the amount of interviews needed is between three and five. The second set of interviews actually uses the Q-methodology to sort the list of statements defined by the first set of interviews.

These three methods, i.e., interviews, causal maps, and Q-methodology, are stand-alone methods and thus could have been used on their own to approach the problem of eliciting tacit knowledge. Nevertheless, combining all three is expected to create a more robust methodology. The reasons that these particular methods were selected are the following:

Semi-structured interviews: Structured interviews have the risk of resulting in biased, on behalf of the interviewer, statements due to the lack of flexibility. Hence, providing a setup for the interviewees to expand on their answers, and not just answer closed or very structured questions, allows for more rich responses from which the statements for the Q-methodology are expected to be more descriptive.

Causal maps: The richness provided by the semi-structured interviews increases the risk for statements to overlap or to have strong causal relations (1 to 1, 1 to *n*, or *n* to 1). Hence, using causal maps enables the grouping of such statements and thus reducing, among other things, the effect of what in statistics is known as multicollinearity.

Q-methodology: Knowledge, and particularly tacit knowledge, is characterized not only by its subjectivity but also by its almost completely nonquantifiable nature. Therefore, using a methodology like Q seemed to be the most appropriate way forward with this research.

4 Case Studies

In this section, the methodology proposed in Sect. 3.2 is put into action. The full study includes three games that were conducted at ProRail. These games were selected based on a number of criteria, such as the technology used to build them (analog/digital), the degree to which they were considered to be successful, and the number of principal stakeholders involved. All games were multiplayer, varying from 3 to 23 participants.

The research is still ongoing, in which only the first game has been analyzed. For this game, called "OV-SAAL" [19], four interviews have been conducted, which have served as the first set for building the list of statements for the Q-methodology. OV-SAAL is an analog game, and its game design requirements are shown in Table 2.

The interviewees were principal stakeholders in the game with different roles: two game designers from academia and a game and an infrastructural designer from ProRail. Three out of four interviewees attended the main game session as observers. The interviews consisted of more than 20 questions, of which more than half aimed at understanding the game characteristics, the role of each stakeholder, and the input and output data. The last seven questions were concerned with the tacit knowledge produced in, and by, the game. These questions aimed at identifying the challenges each stakeholder faced, the lesson learned from the game, as well as whether and how they would do things differently if they were to repeat the game. Results from the initial interviews reveal a varying level of tacit knowledge by each of the principal stakeholders. For instance, each interviewee found certain challenges of the game session memorable, like the time pressure that was a consequence of the amount of conditions that were tested, the dynamics of the game in which the participants changed the game rules by adapting the speed of each round, and the extent to which the debriefing should be structured. Also, for the game designers from academia, the application of the game in a railway domain contributed to a better understanding of the train traffic operations. These four interviews resulted in building a list of 40 statements for the Q-methodology.

5 Conclusion and Future Work

In this paper, the building blocks for a KMF for games of engineering systems were first introduced. Then, the paper focused on the role of tacit knowledge and particularly on how to elicit this knowledge. In order to tackle the complex task of eliciting tacit knowledge, well-established methods from the literature were adopted and used in a case study involving three games from the railway sector. These methods included semi-structured interviews, causal maps, and the Q-methodology. The study is still ongoing, in which the first set of interviews has resulted in an extensive list of 40 statements required by the Q-methodology.

Table 2 Game design requirements of OV-SAAL game

Core aspects	Description
Purpose	Exploring the impact of different infrastructural expansions
Scenario	1. No infrastructural expansion
	2. Four additional tracks at Almere station
	3. Additional haul tracks at Weesp station
	4. Four additional tracks between Duivendrecht and Weesp station
	5. Implementation of European Rail Traffic Management System (ERTMS) in all four infrastructural layouts
Simulated world	Railway infrastructure on two trajectories: Amsterdam Central Station – Lelystad and Amsterdam Zuid – Hilversum, co-location of operators occurred by seating arrangements (each table was a control center). Current time table
No. of participants	8
Roles	Train traffic controller (TTC) (2), regional network controller (RNC) (2), national network controller (NNC) (1), regional passenger traffic monitor (RPTM) (2), national passenger traffic controller (NPTC) (1)
Type of role	Similar to own (5), prior experience in role (3)
Objectives	Determining own decisions for the next 15 min given the status of the system at paused moment
Constrains	Separation of train traffic regions: one regional train (2) and passenger traffic center (2) each versus other remaining regional train traffic center (2), exclusion of roles outside the defined infrastructure area, exclusion of train driver
Load	Four types of disruptions:
	1. Local train delay (+5 min)
	2. Freight train delay (+10 min)
	3. Corridor train (intercity) delay (+10 min)
	4. Disruption as chosen by participants themselves
Situation (external factors)	Presence of observers and video cameras. At the end of the day results were discussed with invited stakeholders
Time model	Step-wise (per time periods of 15 min)

With regard to future work, the list of 40 statements will be grouped using causal maps and then used in the remaining 15 interviews as part of the Q-methodology. That would result in obtaining an overview of the tacit knowledge possessed by the principal stakeholders, which in turn will be the cornerstone for building a KMS for games. Two additional case studies will be conducted to strengthen the generalizability of the KMS. The end goal of this research is to build a complete KMS combining explicit and tacit knowledge under one roof.

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References

1. Stephenson W (1953) The study of behavior: Q-technique and its methodology. The University of Chicago Press, Chicago
2. Boje DM (1991) Consulting and change in the storytelling organisation. J Organ Chang Manag 4(1):7–17
3. Smith EA (2001) The role of tacit and explicit knowledge in the workplace. J Knowl Manag 5(4):311–321
4. Roungas B, Meijer S, Verbraeck A (2018) Knowledge management of games for decision making. In: Simulation gaming. Applications for sustainable cities and smart infrastructures. ISAGA 2017, Lecture notes in computer science, vol 10825. Springer, Cham
5. Dixon NM (2000) Common knowledge: how companies thrive by sharing what they know. Harvard Business School Press, Boston
6. Martin J (1982) Stories and scripts in organizational settings. In: Hastorf AH, Isen AM (eds) Cognitive social psychology. Elsevier, New York, pp 255–305
7. Hansen MT, Nohria N, Tierney T (1999) What's your strategy for managing knowledge? In: Woods JA, James C (eds) The knowledge management yearbook 2000–2001. Butterworth-Heinemann, Boston, pp 1–10
8. Eden C, Jones S, Sims D, Smithin T (1981) The intersubjectivity of issues and issues of inter-subjectivity. J Manag Stud 18(1):37–47
9. Grogan PT, Meijer SA (2017) Gaming methods in engineering systems research. Syst Eng 20(6):542–552
10. Markus LM (2001) Toward a theory of knowledge reuse: types of knowledge reuse situations and factors in reuse success. J Manag Inf Syst 18(1):57–93
11. Markíczy L, Goldberg J (1995) A method for eliciting and comparing causal maps. J Manag 21(2):305–333
12. Alavi M, Leidner DE, Alavi John M (2001) Knowledge management and knowledge management systems: conceptual foundations and research issues. MIS Q 25(1):107–136
13. Lo JC, Meijer SA Participatory design in large-scale railway infrastructure using gaming simulations: the role of shared mental models. Under Review
14. Brockmann EN, Anthony W (1998) The influence of tacit knowledge and collective mind on strategic planning. J Manag Issues 10(2):204–222
15. Tsoukas H (1991) The missing link: a transformational view of metaphors in organizational science. Acad Manag Rev 16(3):566–585
16. Wilkins AL, Thompson MP (1991) On getting the story crooked (and straight). J Organ Chang Manag 4(3):18–26
17. Panahi S, Watson J, Partridge H (2012) Social media and tacit knowledge sharing: developing a conceptual model. In: World Academy of Science, Engineering and Technology (WASET). WASET, Paris, pp 1095–1102
18. Brown JS, Duguid P (1991) Organizational learning and communities-of-practice: toward a unified view of working, learning, and innovation. Organ Sci 2(1):40–57
19. Ambrosini V, Bowman C (2001) Tacit knowledge: some suggestions for operationalization. J Manag Stud 38(6):811–829

Community Forest Board Game for Learning Interactions Among Ecosystem Components in Community Forest with Local People

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Abstract A "community forest" board game was created and used with local villagers and teachers for collective learning about the community's forest ecosystem components and services. The game was composed of a gameboard and set of photo cards. In the field workshop, two or three representatives from seven villages and two teachers from Lainan Subdistrict, Nan Province, Northern Thailand, were invited to participate in the gaming session. After playing, a debriefing session was conducted, and players were asked to share their ideas about conserving their community forest. The results showed that players could discuss and match the photo cards and the clues on the gameboard. They also shared their own knowledge about the diversity of organisms, especially mushrooms, plants, and animals, and how to use them. Moreover, improvements and future use of this game were discussed between the players and authors.

Keywords Interactions · Gaming and simulation · Non-timber forest products · Northern Thailand

1 Introduction

A community forest plays an important role for the local people, especially in a rural area. In Northern Thailand, nowadays, rapid land use change has created a reduction of a community's forest cover, as the forest edge has been usually taken

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over by cash crops resulting in a smaller size of the forest. In the long term, this might reduce the quality of the forest's ecosystem. Based on the literature review from the ThaiLIS database (http://www.tdc.thailis.or.th/tdc/basic.php), the authors found that most of the research studies focused on social and economic issues, e.g. the establishing process for rules and regulations, involvement of the local people to create a management action plan, and value of non-timber forest products. However, there is a lack of research on ecosystems and the integration of the socio-economic and ecosystem aspects. For sustainable natural resource management, understanding the interactions among the ecosystem components is important [1]. Moreover, knowledge sharing about the importance of natural resources among stakeholders is also essential because the value of each resource is different among each stakeholder [2]. To create shared learning and increase the level of understanding among the stakeholders, a game is a suitable tool because it has been proved to be an effective tool for facilitating shared learning and discussion among diverse groups of stakeholders [3–6]. In this case study, the authors aimed to create a simple game based on scientific studies and to use it with local stakeholders in Lainan Subdistrict, Nan Province, Northern Thailand. It was expected that this simple game with key components could improve the stakeholders understanding on the interactions among the key components in the community's forest ecosystem and facilitate discussion on future community forest management.

2 Methods

2.1 Game Design and Construction

The main objective of this game was to facilitate the understanding on the interactions among ecosystem components and ecosystem services provided by a community forest ecosystem. Therefore, a conceptual diagram representing the concept of this game was created (Fig. 1). The information used to create the game was extracted from previous studies in the study site, including non-timber forest products [7], carbon storage change and diversity of trees [8], diversity of mushrooms [9], diversity of soil and fauna [10], diversity of fish [11], diversity of birds [12], and distribution of bamboo rats [13]. Some components were selected, including mushrooms, trees, soil fauna, birds, fish, mammals, and carbon dioxide, which represented greenhouse gas. This aimed to keep the game simple but with enough representation of the ecosystem components and interactions.

The authors designed this game to make the players remember both the components and relationships among the components in the community forest as well as provide opportunities for players to exchange their knowledge. The authors also attempted to make this game cheap and attractive and contain simple features that were easy to replicate for educational purposes because many community forests in Thailand are located in rural areas. Thus, the game was developed as a "matching board game" format with some open-ended questions.

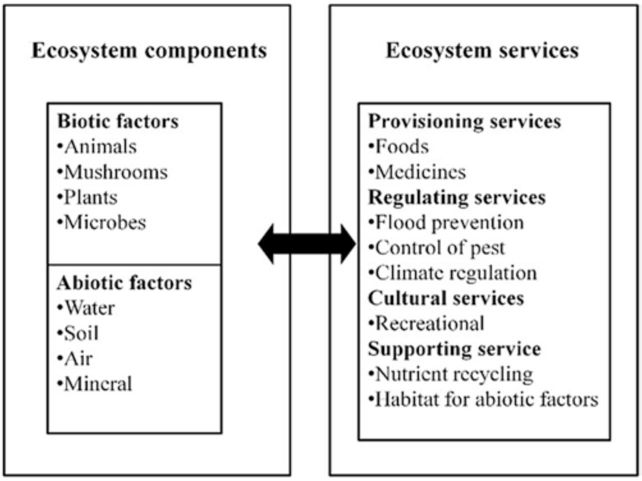

Fig. 1 Concept of the game showing the linkage between the ecosystem components and ecosystem services

An A3-sized gameboard was produced as a prototype. It contained several boxes and links representing the interactions among the components. The ecosystem components were depicted by images printed on small cards. During the gameplay, players had to match the cards with a specific description or hint in the boxes on the gameboard. By doing this, players could learn about the ecosystem components and interactions among the components.

The gaming session was separated into three main phases: introduction, matching game, and debriefing. After the gaming session, the players were asked to assess their knowledge obtained from the game. The game was tested with undergraduate students at Chulalongkorn University before using with the local stakeholders. After some minor improvements, such as the wording, text size, and colour, ten sets of the game were produced. They were then used with the local stakeholders in the field workshop.

2.2 *Field Workshop*

The field workshop was conducted with local stakeholders, including 16 villagers from Lainan Subdistrict, 5 Lainan Subdistrict Administrative Organisation representatives, and 1 teacher from a nearby school, namely, the Ban Tha Li School. Before the game, the authors introduced the participants to the local biodiversity and field research carried out in the site. Then, the participants were separated into five groups of two to three players to play the game. During the gaming session, workshop staff observed the behaviour of the players and overall environment. After each group completed the game, a debriefing session was conducted by a presentation and comparison of the results from each group. Finally, self-assessment was conducted on three aspects: community forest components, interaction between the components and importance of the community forest, and ecosystem services of the community forest. Moreover, participants were asked to provide some suggestions for the game and workshop improvement.

3 Results and Discussion

3.1 Community Forest Board Game Description

The game consisted of two main components: the cards and the gameboard. For the cards, a set of the game was composed of 51 cards of 3.5 cm × 2.5 cm (refer to http://gg.gg/ai90c). A deck of cards could be divided into 39 picture cards and 12 blank cards. The picture cards represented images of the components and services from the community forests of Lainan Subdistrict, which were used to play in the matching game part. They included pictures of trees, soil fauna, mushrooms, fish, birds, bamboo rats, some non-timber forest products, carbon dioxide, and food. The remaining 12 blank cards were prepared for players to answer open-ended questions.

The gameboard was a printed A3-sized paper containing white boxes and a background (Fig. 2). Each box contained a hint or phrase for players to find a specific card. The boxes were grouped by types of components or services and annotated by a line and colour. The interactions among the components were shown in the gameboard by arrows. The gameboard was divided into two main sections: ecosystem components and ecosystem services. The ecosystem components section was located in a two-third area on the left side of the gameboard. It contained 7 groups of ecosystem components (36 white boxes), including trees (dark green), soil and fauna (orange), mushrooms (yellow), fish (light blue), birds (light green), bamboo rat (dark blue), and non-timber forest products (transparent). The ecosystem services section appeared on the one-third area on the right side containing 15 white boxes in three groups. The "direct benefits" group (brown) contained three hints for matching with the cards and answering the questions. The "indirect benefits" group (purple) was created for players to think about this aspect from the community forest. The "our community forest" group (grey) was created for players to collaboratively think about forest conservation methods. Two white boxes in the lower right corner were used for players to provide reasons why they must conserve their community forest and provided details of the game designer.

One set of the game was designed for collaborative playing in a group of two to five people. To play with many players, a competitive setting can be conducted by distributing multiple sets of the game to the groups. The first group that completely matches the cards with the hint boxes will be the winner. The number of groups depended on the number of participants. The game was divided into two steps: card matching and brainstorming. In the card matching step, players discussed and

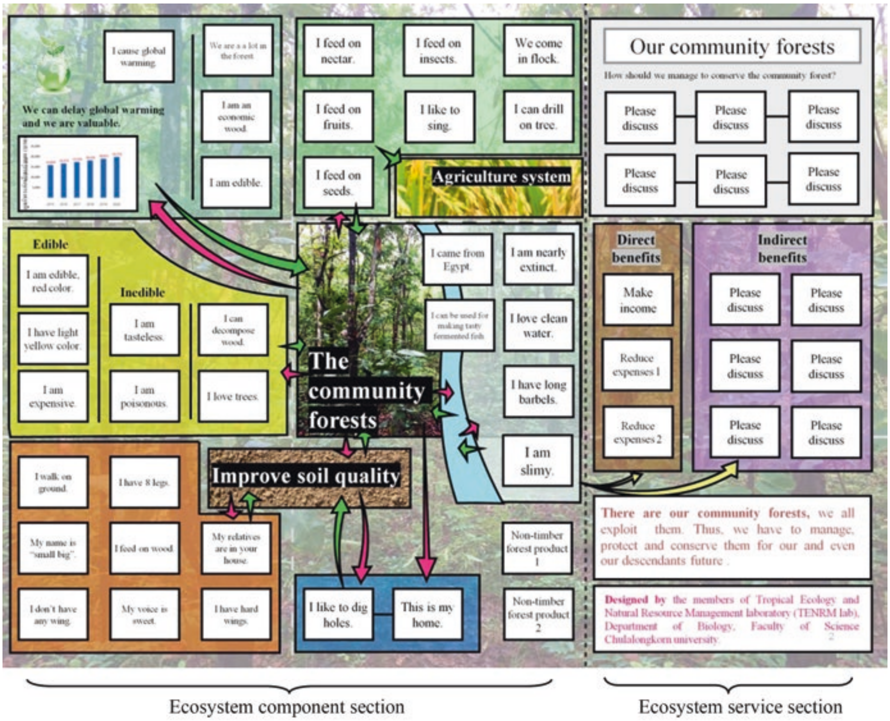

Fig. 2 The gameboard represents the two main parts of the Lainan community's forest ecosystem (components and services) with arrows representing the interactions

attached 39 photo cards to match the hints in 36 boxes from the ecosystem components section and three boxes in the direct benefits group in the ecosystem services section. Players could play the next step after correctly completing the card matching. In the brainstorming step, players used 12 blank white cards to play by discussing and writing down their opinions based on the topics. The results from the brainstorming step were shared among all participants. To make the game run smoothly, adhesive putty was required to attach the cards on the gameboard, as well as a pen for writing the opinions on the blank paper cards.

3.2 Results from Gaming Session

During the gaming session, the players understood the gaming features. Although the hints were short, the players attempted to discuss and share opinions in the group to match the cards with the hints on the gameboard (Fig. 3). The players spent around 30 min to complete the card matching to the gameboard. Most of the groups started by matching the easier cards that they knew the answer from the hints first,

Fig. 3 Participants discussed and shared their knowledge during the card matching session

Fig. 4 Examples of completed gameboards

while they left the harder ones behind and discussed in a group to make a final answer together. Some of the completed gameboards are shown in Fig. 4. The authors observed that rather than compete to beat the other groups, each group tried to exchange their knowledge with each other on the organisms that they had in mind based on the hints. They also attempted to explain within the group how each group of components on the gameboard was linked to each other.

During the plenary discussion and briefing session, each group presented their results of the ecosystem components, direct and indirect benefits obtained from the community forest based on their points of view, and ideas to improve the current community forest management practices (refer to Fig. 5). The authors summarised the results of the gaming session again by focusing on the ecosystem components, as well as their interactions and benefits to humans. As a result, knowledge about the community forest was shared among the participants, and a future community forest management plan was provided.

Regarding self-assessment, the results are shown in Table 1. The authors found that the scores were increased when compared with the pre-activity, including understanding about the community forest components (+2.3 pts), interaction between the components and importance of the community forest (+2.1 pts), and ecosystem services of the community forest (+1.4 pts).

Fig. 5 Players shared their knowledge and discussed about the community forest management practices during the debriefing step

Table 1 Participants' self-assessment score before and after gaming session

Assessed subject	Average score (max = 10 points)		Change (points)
	Before game	After game	
Community forest components	5.9	8.2	+2.3
Interaction between components and importance of community forest	6.8	8.9	+2.1
Ecosystem services of community forest	7.3	8.7	+1.4

Moreover, during the debriefing session, some players said that their community would be better in the future if all villagers understood the importance of the community forest. They also wanted to have more villagers play this game in order to provide more feasible and appropriate management strategies. The authors could infer that the game could improve the understanding of players when they played by the rules and analysed and discussed about its content [14, 15].

3.3 Limitations of the Game

Limitations of this version of the game were both observed by the authors and suggested by the players. After the workshop, players explained that the cards were too small for them to see. They suggested that the authors enlarge the size of the cards. Moreover, they suggested authors to provide longer hints because many villagers did not have a biological background. Therefore, to improve the effectiveness of this game, the card size and gameboard would be enlarged. For future study, the authors have taken into account the suggestions from the players that they want more villagers to play. Hence, the improved game would be tested with more stakeholders.

4 Conclusions

Understanding the interactions among the ecosystem components and increasing the level of understanding about the importance of natural resources among stakeholders are important factors for sustainable natural resource management. This study created a simple game from the existing results from scientific studies of community forests and used it with local villagers. Based on the results from the self-assessment, discussion during the gaming session, and request to conduct more sessions with more villagers, it was concluded that this game could be used to increase understanding on the interactions among the key components in the community forest ecosystem in a fun atmosphere.

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References

1. Chapin FS III, Kofinas GP, Folke C (2009) Principles of ecosystem stewardship: resilience-based natural resource management in a changing world. Springer, New York
2. Étienne M (2013) Companion modelling: a participatory approach to support sustainable development. Springer, Dordrecht
3. Khaemmani T (2009) Pedagogy: knowledge for organizing the effective learning processes. Chulabook, Bangkok
4. Salvini G, Van Paassen A, Ligtenberg A, Carrero GC, Bregt AK (2016) A role-playing game as a tool to facilitate social learning and collective action towards climate smart agriculture: lessons learned from Apuí, Brazil. Environ Sci Pol 63:113–121
5. Mostowfi S, Mamaghani NK, Khorramar M (2016) Designing playful learning by using educational board game for children in the age range of 7–12: (a case study: recycling and waste separation education board game). Int J Environ Sci Educ 11:5453–5476
6. Naivinit W (2014) Risk analysis using participatory modelling with stakeholders: case study on the interactions between seasonal flooded forest management and food security. Thailand Research Fund, Bangkok
7. Dumrongrojwatthana P, Wimolsakcharoen W, Punyawong K, Huaihongthong I (2017) Estimation of economic values of non-timber forest products in the area of Plant Genetic Conservation Project under the Royal initiative of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG), Wiang Sa District, Nan Province
8. Tungsukruthai S (2016) Above ground carbon changes in community forests at Lainan Subdistrict, Wiang Sa District, Nan Province. Chulalongkorn University
9. Punyawong K (2016) Species diversity of mushrooms in community forests at Lainan Subdistrict, Wiang Sa District, Nan Province. Chulalongkorn University
10. Khunnala N (2016) Diversity of soil fauna in community forest at Lainan Subdistrict, Wiang Sa District, Nan Province. Chulalongkorn University
11. Huaihongthong I (2016) Species diversity of fishes in community forests at Lainan Subdistrict, Wiang Sa District, Nan Province. Chulalongkorn University
12. Pinmaneenopparat S (2016) Species diversity of birds in community forests at Lainan Subdistrict, Wiang Sa District, Nan Province. Chulalongkorn University

13. Jumsri P (2016) Distribution of lesser bamboo rat *Cannomys badius* in community forests at Lainan Subdistrict, Wiang Sa District, Nan Province. Chulalongkorn University
14. Everitt BS, Howell DC (2005) Game theory. Wiley, Chichester
15. Leemkuil H, De Jong T, Ootes S (2000) Review of educational use of games and simulations. University of Twente, Twente

For Gaming-Based Consensus Building: Problem Formulation of Snowfall Disaster Mitigation in a Japanese Rural Area

Satoru Ono and Michinori Kimura

Abstract This research contributes to building consensus and making social decisions about disaster mitigation, especially in districts of heavy snowfall. From the existing research, the hypothesis model of snowfall disaster problem formulation has been developed, which includes the snowfall disaster phase, software phase, and hardware phase. Next, interview surveys in Takashima city were conducted among the various stakeholders: officers of the social welfare council, community leaders, public health nurses, welfare commissioners, and government officers. As a result of the surveys, the causal relationship and trade-off relationship among the phases have been observed. Especially, information asymmetry among the stakeholders in snow removal and elderly persons watching and health-checking activity is extracted as one of the problems in the snowfall disaster problem structure.

Keywords Snowfall disaster · Disaster mitigation · Stakeholder analysis · Problem formulation

1 Snowfall Disaster Mitigation as a Rural Problem in Japan

1.1 Research Background

Weather disasters, such as flooding, drought, and snow disasters, are regarded as a problem not only for the government but also for communities. In disaster mitigation research, mutual aid in the community in a disaster situation is often discussed, especially in the disaster mitigation planning context. In addition, while the discussion of climate change adaptation becomes more active, public participation in the

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climate change adaptation policy-making process is becoming a more focused topic for developing community-based adaptation strategies. Policy-making for climate change has been regarded as the best mix of 'mitigation' and 'adaptation', and decision-making for adaptation to reduce the impacts of climate change to the local economy and society has been attempted based on impact assessment and consensus building among local stakeholders.

On the other hand, the Japanese society, especially local communities, has been confronted by high aging conditions and the amount of human resources available for mitigation/adaptation is rapidly declining, especially in mountainous villages. According to the National Institute of Population and Social Security Research's (IPSS) simulation results [1], it is estimated that the elderly population in 2048 will increase from the current number of 34 million to 39 million. This means that the aging rate will increase from 28.2% to 37.2%. Especially in districts of heavy snowfall, snow removal is a form of hard labor for elderly people. On the other hand, it is important for surviving and living in a snowfall environment, avoiding house collapse due to the weight of snow, allowing shopping for daily necessities, and also maintaining the possibility to call upon the medical/nursing services.

Population decline in Japanese rural areas itself is not new problem and people living in such districts have overcome the difficulties by purchasing and sharing machinery (wheel loaders and so on), installing snow-melting systems under major roads, and cooperating with each other to conduct snow removal and, especially, to keep elderly people healthy in their community. However, while the number of communities which have 40% or more local elderly people is increasing, it can be seen as a problem for community-based snowfall disaster mitigation that the number of young community leaders is decreasing and delocalizing.

1.2 Existing Research

In the Japanese context, the decision-making process of snowfall disaster mitigation and climate change adaptation has been discussed previously [2–4]. Ichihashi et al. [2] report the problems facing local municipalities in planning and implementing their climate change adaptation policy by introducing the 'interactive approach' concept. Shirai et al. [3] analyzed the causal relationship model between people's adaptation behavior for climate change and 'awareness of the effect' of climate change. As pointed out in their study, promoting awareness of the effect through environmental seminars and dialogs is essential for consensus building for adaptation. Also, Baba et al.'s research [4] formulated people's attitudes to climate change and risk perception.

As these studies showed, behavioral analysis proceeded from the 'top-down' perspective. However, to find the optimized adaptation to heavy snowfall in rural areas, not only psychological factors, such as risk/benefit perception and belief of the government, but also social, economic, and cultural factors must be considered. McLaughlin et al. [5] discussed adaptation and vulnerability to environmental change from the biophysical, human ecological, political economy, constructivist, and political ecology perspectives. Also, Eriksen et al. [6] attempted to describe the decision-making process of adaptation as the interaction among 'contest', 'authority', 'subjectivity', and 'knowledge'. From these studies, which applied a political approach, the decision-making process can be understood as the interaction between top-down and bottom-up approaches, and the bottom-up process in which the various stakeholders participate is expected to output a feasible community adaptation plan.

On the other hand, there are a limited number of existing researches about the concrete target of community-based decision-making concerning adaptation to heavy snowfall in Japan. Kuriyama [7] described the problem structure of snowfall disaster, defining 'snowfall disaster type 1' and 'snowfall disaster type 2' in respect to the physical properties of snow. However, mitigation systems for snowfall disaster have been developed step-by-step in Japanese national, prefectural, municipal, and community level areas, and there is a pressing need to develop the latest problem structure of snowfall disaster reflecting the current situation of communities.

1.3 Research Goals

This research aims to formulate the snowfall disaster problem by describing the causal relationship among natural scientific factors, community cultural factors, and stakeholder collaboration factors based on focus group interviews in Takashima city, Shiga, Japan. This city is located in the west midland of Japan and near the Sea of Japan. This area is often deeply enveloped in snow and Takashima city is confronted with a population that is decreasing as well as aging.

This research is oriented to consensus building among community stakeholders that have different backgrounds, knowledge, skills, values, and so on. The existing researches discuss the meaning of a gaming-based approach in decision-making in community problems such as shelter management [8] and health emergency management after large earthquakes [9]. This research should be one of the bases of gaming design if there is the need to solve the trade-off problem or conduct stakeholders' learning based on gaming simulation.

2 Research Questions

2.1 Physical Properties of Snow and Software/Hardware in the Community

According to the existing research [7], snowfall disasters can be classified into type 1, caused by the physical properties of snow/snowfall, for example damage to agriculture and health damage, and type 2, caused by the interactions among human activity and snow/snowfall, for example transportation disturbance and sluggishness of the economy. This problem formulation can be understood as focusing on the fundamental factors of snowfall disasters.

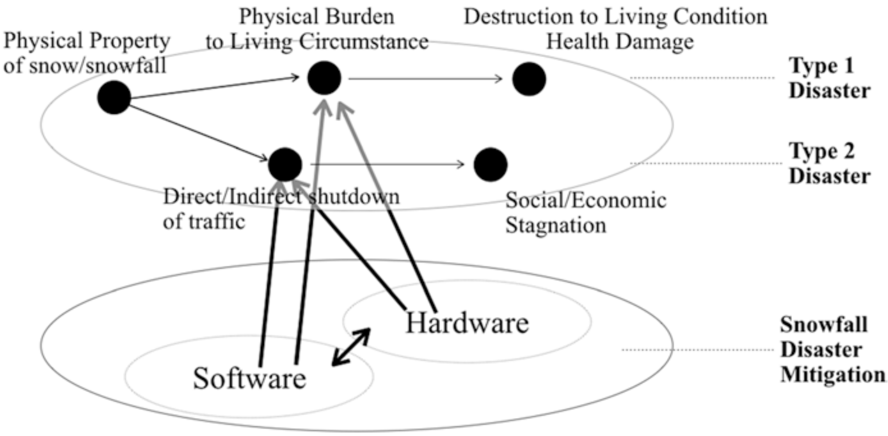

Fig. 1 Conceptual description of the two types of snowfall disaster and mitigation system

On the other hand, the 'coexisting' system among human activities and snowfall has been developed in and adapted to each community's conditions (not only in Japan but also all over the world). For example, in Japanese rural areas, community groups have collaborated to remove snow not only around the houses themselves but also the pavements to assist children's commute to school. If there are elderly people who depend highly upon medical care, community members habitually or systematically look out for such people to ensure their health and wellbeing. The municipalities maintain and manage the melting system under the main road and operate snow plows for the removal of deep snow. In addition, while the software to adapt to snowfall disasters has made progress in the communities' history, the hardware has also been developed corresponding with software changes and technical innovations. As explained previously, melting systems built into the main roads in snowfall regions. To dispose of the snow after removal, ditches for snow discharging have been constructed. To discuss the problem structure of snow disasters, the software's (culture and system) and hardware's (infrastructure) function and dysfunction should be observed from the community movements.

Figure 1 describes the conceptual description of the research framework for snowfall disaster formulation. There can be two phases in the problem formulation: causal relationships of snowfall disasters and mitigation for disasters in the community. As noted in the existing researches, the two types of snowfall disaster derive from the physical properties of snow/snowfall, and the difference is whether there is intervention by human activities or not. Also, the software and hardware as the mitigation factor for snowfall disasters can be regarded as the obstructive factors to physical burden to living circumstances and the shutting down of traffic. In addition, the software and hardware should be interactive with each other, because effective sharing (software) of wheel loaders (hardware) can be thought of as a positive factor (from software to hardware) and operation failure of the melting system (hardware) can be

Table 1 Hypothesis of interviewees' roles in the snowfall mitigation

Name	Position title	Health problem	Snow removal	Resources
A	Council of social welfare	✓		✓
B–E	Community leader	✓	✓	✓
F–H	Public health nurse	✓		
I–L	Welfare commissioner	✓		
M–O	Government officer		✓	✓

regarded as an obstructive factor to snow trashing collaboration (software). Based on this conceptual framework, the research method will be discussed in the next section.

2.2 Research Method

In this research, two research questions were posed in order to achieve the goal, as set out below:

(RQ1) What kinds of factors are there in real snowfall disaster mitigation?
(RQ2) What are the promotional/obstructive factors to the disaster causes and the disaster mitigation factors?

To discuss these research questions, stakeholder interviews were conducted. The interviewees were asked questions as follows: (1) whether he/she looked after elderly people with health problems in the real snowfall disaster (type 1 snowfall disaster), (2) whether he/she attempted to remove the snow that was obstructing traffic (type 2), and (3) whether he/she managed the human resources and goods to overcome the snowfall disaster.

From these focus points, 15 stakeholders were investigated, as described in Table. 1. The council of social welfare in Japan promotes collaboration between the community and welfare businesses, and the interviewee (A) conducted health-promoting activities during snowfall situations. In addition, the interviewee managed the activities of volunteer members too. The community leaders (B–E) acted upon information gathering of elderly people's situations, snow removal, and the management of various resources to help those activities, such as wheel loader sharing. The public health nurses (F–H) are government officers who have a medical license to check on health conditions. There are 163 welfare commissioners in Takashima city, who are appointed the role from the government to check on the health conditions of elderly people, low-income earners, people with disabilities, and social withdrawals. In this research, the interview surveys of four welfare commissioners (I–L) were conducted. As managers of snow removal in the public arena, three government officers were selected as the interviewees. They oversaw the programming of snow plow vehicle operation and contracted with the National Silver Human Resources Center to promote snow removal during emergencies.

3 Results

3.1 Disaster and Software

The results of the interview surveys can be described as the problem formulation in Fig. 2. The upper part describes the set of factors which cause types 1 and 2 disasters and the lower part expresses the sets of causal factors, categorized into ‘hardware’ and ‘software’. As A, G, H, and I pointed out, the efforts to check on the elderly people’s health made positive impacts by decreasing physical burdens and advising them on how to stay healthy. On the other hand, there can be four obstructive factors to watching and checking for health. The first is traffic shutdown. All interviewees carrying out checks on health problems indicated traffic obstructions as a problem during the checking of health.

The second factor, which is related to the first, is the problems deriving from outsourcing the contract of snow removal. G, H, and L analyzed the fundamental problem of health-checking difficulties during the unpredictable operation of snow plows. They agreed with the usefulness of outsourcing the snow removal contract but were unable to find out information on the operation and location of snow plow vehicles, meaning that they couldn’t form a health-checking plan because no information was shared among the government, operations company, or citizens.

The third and fourth factors are about information asymmetry. The community leaders (B, D, and E) and welfare commissioners (J and L) listed enforcing privacy

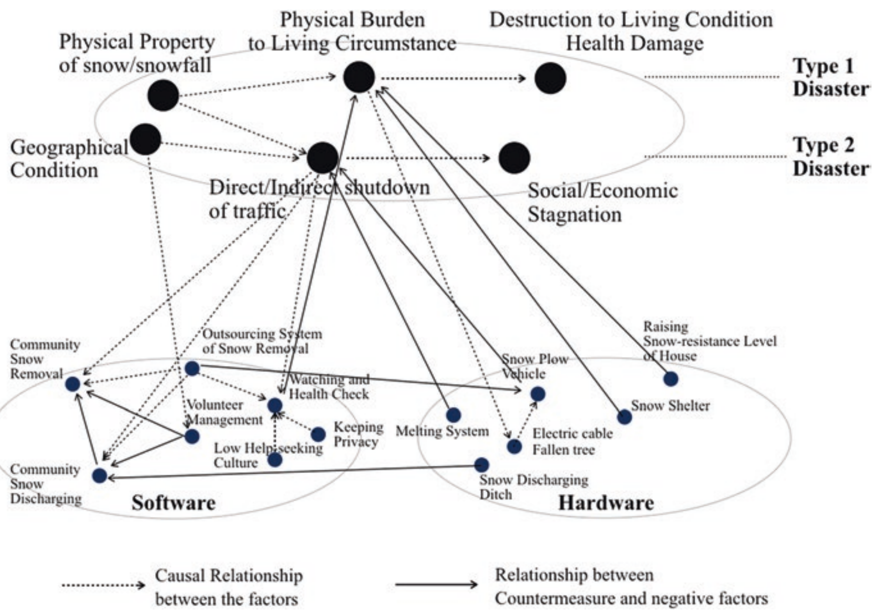

Fig. 2 Problem formulation of snowfall disasters in Takashima city

as an obstructive factor. Because of the shortage of information gathering about health conditions, they felt that their health-checking activities were limited by community members. In addition, the community culture which regards 'help-seeking' action as a kind of opprobrium lead to health information being hidden (by B, C, I, and L). Because of this culture, these community members could access health information only as secondhand information.

3.2 Disaster and Hardware

The government officers (M–O) evaluated the effect of outsourcing from community leaders (B and C). Especially, there is the strength of relying upon a professional company in their ability of snow removal in difficult situations. On the other hand, they explained that fallen electrical cables and trees often cause interruption of snow plow vehicle operation. This is also indicated by the community leaders (B, D, and E) as an obstructive factor to traffic shutdown.

3.3 Software and Hardware

In respect to interactive factors between software and hardware in snowfall disaster mitigation, snow discharging can be mentioned. Snow needs to be disposed of after removal but there is a great difference in whether there are sufficient snow discharging provisions or not, as C, D, and E explained. In densely populated areas, there is insufficient discharging infrastructure when there is a great need for snow removal to keep pedestrians and vehicles moving. Insufficient snow discharge causes 'wall-forming' in front of house entrances and stagnation of social/economic traffic.

4 Discussion

4.1 Problems of Snow Removal Systems

As discussed in Sect. 3, improper snow removal causes stagnation of social traffic, especially the watching and health checking of elderly people. There is a kind of information asymmetry among community leaders, government officers, and private companies in the background of the problem.

How could they optimize the snow removal system? Information sharing among these stakeholders, especially about the location of the snow plow vehicle itself, is a fundamental solution. Some municipalities are implementing GPS-based online mapping systems to share the snow plow vehicle position and operation; therefore, that solution is feasible even if there is not a sufficient budget to implement it. However, according to the results of the interview survey among the community leaders (B and C) and government officers (M, N, and O), the operation program of snow plow vehicles is designed to promote commutation, not to meet social welfare objectives. Adaptation to heavy snowfall situations should include discussion about "what is optimization of snow removal?"

4.2 Communication Between the Elderly People and Community Leaders

In the previous section, the information asymmetry problem was indicated as the obstructive factor of health-checking activities. To overcome that problem, maintaining privacy and help-seeking actions are fundamental factors.

According to the interview survey among the welfare commissioners (J, K, and L), the mutual trust relationship is an obstacle to gathering the health information from elderly people. The population sizes of small communities are in the range 10–100; therefore, the residents in such communities are familiar faces to each other. On the other hand, that relationship is different from the mutual trust relationship for sharing health information, which grows by the experience-sharing history and long family commitment. For example, respondent K is working for a company in Kyoto city (out of Takashima city) and is regarded as a community resident but does 'not' having experience-sharing history.

This problem can be thought of as a mutual understanding of life style. There is the need to discuss what the welfare commissioner's role should be, as well as the collaboration system between them and the elderly person's family.

5 Conclusion

This research has attempted to describe the problem structure of snowfall disasters in Japanese rural areas. Especially through the framework of the disaster, the hardware/software relationship, causal relationship, and trade-off relationship were among the factors found. In conclusion, the benefits and facilitation of gaming-based consensus building can be summarized as below:

- Medical affairs are an essential factor of type 1 disasters caused by snowfall. On the other hand, direct/indirect shutdown causes stagnation of medical treatment and health checking in snowfall situations.
- From this viewpoint, the trade-off relationship can be found between health-checking activity as the mitigation method of type 1 disasters and social workers' risk of encountering traffic or martial accidents as examples of type 2 disasters.

- On the other hand, reconsideration of the collaboration system and application of a kind of information system can help solve the trade-off problem. This is a key-point to building a gaming simulation model of the problem.

This research was conducted based on qualitative methodology and empirical study using quantitative methods will become the future research problem. To understand the problem structure in detail, we should conduct additional surveys, especially in respect to public administration systems and implementations. And, after those quantitative studies, system dynamics and gaming simulation will need to be conducted to implement this research theme in the social arena. Especially, the trade-off relationship among the factors has been described in previous investigations. However, their strength could not be proved in this research. Therefore, the gaming experiment will be an essential problem to investigate in order to achieve the goal of this research.

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References

1. IPSS (2018) Population projections for Japan – a supplement to the 2017 revision. Popul Res Ser 337:1–147
2. Ichihashi A, Baba K (2015) Challenges and solutions of implementing climate change adaptation measures in local government – verifying an interactive approach and practice of a workshop. Environ Sci 28(1):27–36
3. Shirai N, Baba K, Tanaka M (2014) Relation between the awareness of the effects of climate change and actions concerning mitigation/adaptation – an analysis of Iida City residents. Environ Sci 27(3):127–141
4. Baba K, Sugimoto T, Kubota H, Hijioka Y, Tanaka M (2011) Relation between the awareness of the effects of climate change and actions concerning mitigation/adaptation – an analysis of Iida City residents. J Jpn Soc Civil Eng 67(6):II_405–II_413
5. McLaughlin P, Dietz T (2008) Structure, agency and environment: toward an integrated perspective on vulnerability. Glob Environ Chang 18:99–111
6. Eriksen SH, Nightingale AJ, Eakin H (2015) Reframing adaptation: the political nature of climate change adaptation. Glob Environ Chang 35:523–533
7. Kuriyama H (1982) Casualties in the 1980/81 heavy snowfalls. Bull Glaciol Res 44(2):83–91
8. Hayashi K (2015) The effect of shelter management game ~with respect to improvement of within the community. J Community Des Stud 3:21–34
9. Kurose T (2016) Effective use of gaming simulation for health emergency management in Kumamoto Prefecture. Stud Simul Gaming 26(2):64–68

Wadakamari Gaming Which Promotes Players' Viewpoint Switching in Consensus Building

Shin Oyamada, Ryohei Ishikawa, Shun Kumagai, and Shinobu Kitani

Abstract The term "wadakamari" in this paper means to switch one's own viewpoint one after another without seeing it as perfect. We design and carry out "wadakamari gaming" which promotes players have wadakamari in consensus building process and make proposals for a better consensus building way. In this research, we focus on the concept of contingency as a factor that causes wadakamari. The contingencies concerning both the dilemma structure of the consensus building problem and differences of viewpoints between people seem to promote subjects have wadakamari. Therefore, in this research, we design wadakamari gaming in which players deal with a dilemma problem with compact city as the theme and aim for consensus building. We evaluated players' behavior by preparing six indicators concerning wadakamari. As a result, it became clear that the players tend to have wadakamari by confronting the emphasized dilemma structure or facing differences between the players' viewpoints. In addition, consistency was confirmed between the wadakamari indicators.

Keywords Consensus building · Wadakamari · Contingency · Gaming

1 Significance of Wadakamari in Consensus Building

In consensus building process, if each actor sticks to one's own viewpoint, interactive dialogue cannot be achieved. Adachi [1] analyzes a case of public project in which the government does not try to "dialogue" with the opponents and attempts to unilaterally "explain" the public nature of the project. This is not a problem occurring only between governments vs residents. Even if the residents discuss

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between themselves, if each people stick to one's own viewpoint, "dialogue" will not be achieved because expressing opinions from a biased viewpoint can be an "explanation" rather than "dialogue." In gaming research, standing at other players' viewpoint through role exchange has been regarded as a major function of gaming [2, 3]. On the other hand, viewpoint switching emphasized in this research is to consider a problem by perpetual switching viewpoint one after another without seeing his/her original viewpoint as perfect. In this article we express the viewpoint switching on a problem by Japanese word "wadakamari." In Japanese-English dictionary, "wadakamari" is translated as grudge or lingering sense, but these do not express nuances of the word well. If you translate the explanation of "wadakamari" in a Japanese dictionary *Shin Meikai kokugo jiten* into English, it becomes "a shikori that sticks in one's throat." Shikori has the pathological meaning of lump, or the mental meaning of bad after taste. In this research, we would like to emphasize the nuance related to the difficulty of seeing the whole of "lump that sticks in one's throat." By doing this, we use this Japanese word with a positive meaning as "a mode of thinking deeply." There are many gaming simulations for consensus building or negotiation process between stakeholders [4, 5], but most of them do not directly deal with this kind of ambiguous mentality. Although Kitani et al. [6] deal with players' psychological reaction in a simulated intractable problem and their approach is similar to this paper, they do not make indicators of that reaction which make it possible to sufficiently evaluate players' notions and actions in consensus building process. In this research, "wadakamari gaming" is designed and implemented as a gaming that promotes wadakamari in consensus building process. The objective of this research is to make a proposal for "better consensus building" through evaluation of this wadakamari gaming.

2 "Wadakamari" and Japanese Mentality

Doi [7], a psychiatrist, indicates the peculiarity of Japanese people's mind by considering the meaning of a Japanese word "amae." Then, he mentions the word "wadakamari," which relates to "amae." Doi explains that "amae" is an expectation for passive love, which means although someone does not request for help from other people, he/she expects them to do so. The model of this relationship is mother and baby relationship. There's no verbal communication in that relationship, but a mother helps the baby by nonverbally noticing its need. Similarly, people help other people, and the other expects someone's help without verbal communication in "amae" relationship. On the other hand, "wadakamari" is a discomfort for failure in making the "amae" relationship and having hostility to other people in the back of his/her mind.

Here, "in the back of his/her mind" is an important point especially in the context of consensus building. In Japanese traditional villages, the residents did not discuss freely their community problems but expected for unanimous approval because discussion tends to result in losers and it might destroy the villages' intimate relationships

[8]. So, the community leaders must do behind-the-scenes work, which means persuading the opponents before decision-making. This is a traditional wisdom, and it reduces obstacles for "amae" relationship in the village. However, if this behind-the-scenes work is not enough, the residents might have "wadakamari," because making "amae" relationship is difficult in this situation. Modernization made these traditional villages things of the past, but Japanese people still have "amae" in their mind as Doi indicates. On the other hand, ties between Japanese people which made it possible to achieve unanimous approval have become weak because of modernization. So, in consensus building process, Japanese people today are likely to fail in having "amae" relationship and having "wadakamari."

If "wadakamari" is disregarded in consensus building, it might cause serious conflict someday in the future. However, with adequate care in the consensus building, "wadakamari" is not necessarily a bad thing. Because people with "wadakamari" see a problem not only from verbal level but from nonverbal level, it can be said that they deal with the problem from various perspectives. In consensus building, people have various backgrounds and values. People may have difficulty in representing their positions verbally because their notions are too unusual or original or emotional even if those notions have potential to make a breakthrough in consensus building. In order to solve creatively a consensus building problem, we should not pay attention only to verbal level. People with "wadakamari" are key persons who can deal with problems with various perspectives.

3 Contingency That Causes Wadakamari

In this chapter, we clarify the meaning of viewpoint switching through a famous dilemma, "trolley problem." In trolley problem, the rail is divided into two at the end of the runaway truck, and there are workers ahead. If the trolley goes on as it is, it will kill four workers. If you draw the lever and the trolley goes to the right, you will kill one worker. At this time, should you draw a lever or not to draw? If you take the position of utilitarianism, "maximum number of greatest happiness" is the decision criterion. So you get a solution to save four people at the expense of one person. However, Kantian theory of duty can criticize the inappropriateness of counting the value of human life with numbers. This kind of situation such as "the problem cannot be solved from one viewpoint" can be expressed that "the problem has contingency." Tsujishita [9] discusses the meaning of contingency (futeisei) while comparing it with uncertainty (fukakuteisei). Uncertainty means that "you cannot determine which option will be chosen from a group of options." For example, the weather tomorrow is sunny, cloudy, or rainy is a certain set of options, and we do not know which the actual weather is until tomorrow. On the other hand, contingency is "it cannot be determined at any level" [10]. For example, snow falling in the middle of the summer is usually not included in the option group at all. Dilemma situation has contingency in the sense that nobody can capture the full picture of the problem from one viewpoint. In other words, if you answer from one viewpoint, new questions are raised from unexpected viewpoints, and it is impossible to obtain a fixed solution. Based on the above, we define "wadakamari" as follows: "in the face of contingency, reciprocating between various viewpoints in order to solve the problem or persuade others."

4 Wadakamari Gaming and Its Evaluation Framework

In wadakamari gaming, players discuss each other to build consensus on the theme "do you agree or disagree about making local cities compact cities?" This is because compact city problem can be seen as a sort of dilemma. In recent years, the Japanese government is promoting introduction of compact city. Although compact city is expected to improve the convenience of rural areas and raise the economic efficiency of them, on the other hand, there is also concern about the withdrawal of regional services in the original residential area, and as a result liberty of residence can be restricted. Also, with the withdrawal of villages in the middle mountain area, it might become difficult to manage mountains and forests. From the above, it can be said that the compact city has a dilemma structure such as "improvement of convenience vs restriction on liberty of residence" or "economic efficiency improvement vs environmental difficulty." It can be said that this is a dilemma structure because the disadvantages cannot be offset by advantages. The compact city is a real social problem with a dilemma structure, and it can be said that it is appropriate as a theme of wadakamari gaming.

By the way, as defined above, wadakamari is a state of reciprocal movement between viewpoints, and it is very difficult for researchers to directly observe it. Therefore, in this study, multiple indicators shown in Table 1 are used. Although these indicators are not variables that directly express wadakamari, if wadakamari occurs, it can be expected that a characteristic trend will be seen in these indicators. In this sense, wadakamari is positioned as a "construct" in psychology research. The construct itself cannot be directly observed by researchers, but by paying attention to variables that can be related to the construct, it is possible to indirectly approach it. If each indicator is viewed alone, it is difficult to judge whether wadakamari really occurs or not. For example, indicator 2 may not indicate wadakamari but may only indicate that he/she is shy. However, if indicator 2 correlates with other indicators, it will be difficult to explain by his/her shyness. In other words, as the indicators correlate with each other and are consistent, it can be said that the relevance of wadakamari indicators is high as a whole. By the way, for indicators 1, 4, and 5, only pros and cons or the reasons after (not before) discussion are used as indicators. This is because we are paying attention to the impact on players throughout the entire gaming.

We also evaluate what kinds of situations cause wadakamari. What should be noticed here are the contingency of the dilemma itself (the problem cannot be completely solved) and the contingency of the dialogue in consensus building process (cannot sufficiently persuade others with different viewpoints). In this study, it is thought that wadakamari is generated by these contingencies. Therefore, we pay

Table 1 Indicators related to wadakamari

Number	Indicator	Meaning of indicators
1.	Ambiguity of pros and cons tendencies after discussion	People with wadakamari cannot have a clear approval or disapproval position because their viewpoint is not determined
2.	Not speak actively in discussion	People with wadakamari cannot positively speak because the viewpoint is not determined
3.	Cannot consent to the group conclusions of pros and cons from the bottom of one's heart	Even if people with wadakamari can logically consent to the group conclusion of pros and cons from one viewpoint, he/she cannot consent to it from the bottom of one's heart because he/she can find problems from other viewpoints
4.	Reasons for pros and cons include reference to contingency	People with wadakamari are conscious of the inclusion of contingency in the problem
5.	Reasons for pros and cons include comparative judgment (this is an indicator related to resolution of wadakamari)	It is theoretically impossible to solve the dilemma problem by comparative judgment. Nevertheless, if he/she has solved the problem by comparative judgment, he/she has forcibly resolved wadakamari
6.	After the discussion, the number of viewpoints increases	Because someone with wadakamari tries to reciprocate between viewpoints, he/she will acquire new viewpoints

The authors' original indicators

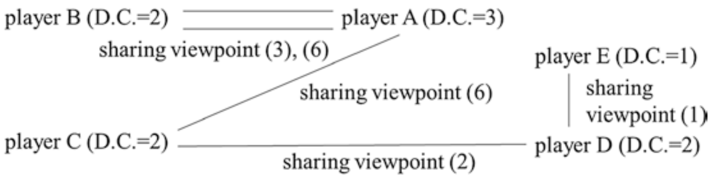

Fig. 1 An example of network analysis (DC means degree centrality)

attention to how the degree of emphasis on the dilemma and the differences of the viewpoints with other players in the discussion are related to the occurrence of wadakamari.

Some explanation is necessary for the contingency of dialogue. Here, the viewpoint of each player is identified by analyzing the text data for the reason of approval/disapproval. There are seven categories of viewpoints: (1) improvement of convenience, (2) improvement of economic efficiency, (3) infringement on liberty of residence, (4) insufficient environmental conservation, (5) viewpoints opposite to either of (1)–(4), (6) original viewpoint (logical), and (7) original viewpoint (nonlogical). Network analysis is used to evaluate the differences of viewpoints among players within the group. Connect players with the same viewpoint, and consider the number of edges connected to each player (called "degree centrality") as the degree of sharing of viewpoints with other players. Conversely speaking, a player with a lower degree centrality (e.g., player E in Fig. 1) can be regarded as having a large deviation from the other players and thus facing contingency of the dialogue. Since the content is not uniform for (5)–(7), we check the original text one by one to judge whether it is the same viewpoint or not.

5 Implementation and Evaluation of Wadakamari Gaming

5.1 Implementation of Wadakamari Gaming

Wadakamari gaming has been implemented on December 4, 11, 18, and 25, 2017. The participants are students who attend the subject "Science of Decision-Making" in Tohoku University (most of them are first year students). Participants are divided into four classes, and each class plays the gaming at rotation (players in each class play gaming once). Each class consists of ten groups, and one group consists of one facilitator and about six players. Facilitators are also students, but they are instructed not to express their own opinion and behave as a neutral moderator. Excluding facilitators, there are 223 players in all.

Players receive an explanation about the compact city first. In the explanation, in order to make the players aware of the compact city's dilemma structure, we explain mainly the merits and demerits of compact city mentioned above. Next, each player writes down the opinion of approval or disapproval of the compact city in questionnaire. Next, discussions were held freely within each group, and group conclusion is formed on approval or disapproval of compact city (about 40 min). After that, each group announces the conclusion of consensus formation within the class and finally again is asked in questionnaire about the pros and cons, the reason, the degree of satisfaction to the conclusion, etc.

Depending on the class, the degree of emphasis on the dilemma structure is changed. This is to check how emphasis on the dilemma structure exerts influence on wadakamari occurrence. The pattern of dilemma emphasis degree is shown in Table 2. "Discussion points" in pattern 2 are "why is it necessary to improve the local lifestyle convenience and economic efficiency?" and "the compact city infringes the liberty of residence and it might become difficult to manage forests and mountains. What kind of adverse effect will we have on our lives and society?" By setting these points, it is thought that discussion will be easy to concentrate on elements related to the dilemma structure. The large-size minute paper of pattern 3 is for facilitators to write down the content of the discussion about each discussion point and to share the

Table 2 Dilemma emphasis pattern

Pattern	Method of dilemma emphasis	Degree of emphasis
1	Present typical pros and cons opinion about compact city	Weak
2	Pattern 1 + present discussion points	Medium
3	Pattern 2 + use large-size minute paper	Strong

Table 3 Summary of representative question items (number of subjects)

Question	1	2	3	4	5
Was discussion time just right?	0	27	116	28	15
(The closer to 1 it is too short. The closer to 5 it is too long)					
The pros and cons of compact city (before discussion)	17	90	19	60	1
(The closer to 1 is agree. The closer to 5 is disagree)					
Are you not able to consent to the discussion group conclusion?	117	58	6	6	0
(The closer to 1 is able to. The closer to 5 is not able to. The actual question was reversely asked such as "are you able to consent to the discussion group conclusion?")					
Are you not able to logically consent to the discussion group conclusion?	107	61	14	5	0

contents within the group. This will also make it difficult for the players to forget the dilemma structure. In the four classes, two classes played with pattern 3, so the number of players is different (pattern 1 is 58, 2 is 57, and 3 is 108).

5.2 *Evaluation of Wadakamari Gaming*

The summary of data is shown in Table 3. There are many players who think the discussion time was reasonable. Table 4 shows the summary of wadakamari indicators 1–3. Regarding the pros and cons tendencies (indicator 1), there are relatively many people who agree with compact city before discussion, and this tendency becomes clearer after discussion. Many players could actively speak in the discussion (indictor 2). Although many players consent to the group conclusions, if asked "from the bottom of your heart? (indicator 3)," this tendency shifts to "can't consent to." Table 5 shows the tendency of text data about the reasons for approval or disapproval (the authors coded the text data). The number of both "have references to contingency" and "include comparative judgment" has increased after the discussion. However, there is a problem that the number of people before the argument is originally small in the first place, which will be discussed later. The average value of the number of viewpoints has decreased through discussion. This might be because there is a tendency to omit the reasons for approval as they are asked the same question twice (before and after the discussion).

Next, we analyze the relation between indicators of wadakamari and other variables. Here, conversion is added to index 1. Indicator 1 is, as it were, an indicator of neutrality regarding approval or disapproval. Therefore, we set 1 and 5 as 0, 2 and 4 as 1, and 3 as 2 and make it an ordinal variable of 0, 1, and 2 so that the value increases as it becomes neutral.

We confirm the relationship between the occurrence of wadakamari emphasizing the dilemma situation (contingency of the dilemma) and deviation of viewpoints with other players in the discussion (contingency of dialogue). We conduct multiple regression analysis with the wadakamari indicator as the objective variable. The results are shown in Table 6. Here, the results of only indicators 1 and 6 are shown

Table 4 Summary of wadakamari indicators 1, 2, and 3 (number of subjects)

Question	1	2	3	4	5
The pros and cons of compact city (after discussion) (indicator 1)	47	69	25	44	2
Were you unable to actively speak at the discussion? (indicator 2)	49	82	41	14	0
(The closer to 5 is "could not speak actively." The closer to 1 is "could speak actively." The actual question was reversely asked such as "were you able to actively speak at discussion?")					
Are you not able to consent to the discussion group conclusion from the bottom of your heart? (indicator 3)	85	69	22	11	0

Table 5 Summary of wadakamari indicators 4 and 5

	Have references to contingency (indicator 4)	Include comparative judgment (indicator 5)	Number of viewpoints (average)
Before discussion	$N = 2$	$N = 23$	1.4
After discussion	$N = 24$	$N = 38$	1.1

Table 6 Multiple regression analysis with indicators 1 and 6 as the objective variable

	Dilemma emphasis pattern (the larger the dilemma is emphasized)	Degree centrality (the smaller, the greater the difference in viewpoint with other players)	Adjusted R-squared
Indicator 1 (degree of neutral)	0.190∗∗∗	−0.263∗∗∗	0.090∗∗
Indicator 6 (viewpoints' increase)	0.153∗∗	−0.174∗∗	0.040∗∗∗

Note: ∗∗∗$p < 0.01$; ∗∗$p < 0.05$

because they are significant results. From this result, it can be seen that there is a tendency for wadakamari to occur as the contingency of the dilemma and the contingency of the dialogue are strong.

Finally, we check the consistency between wadakamari indicators. However, due to the limitation of the pages, only a table that shows both the tendency of consistency and inconsistency is presented here (see Table 7). Bold letters show consistent results, and underlining indicates inconsistent results. For indicators 2 and 4, 3 and 5 are consistent results. However, for 2 and 5, it is consistent that the value is negative, but it is not significant. Also for indicators 3 and 4, the positive values are consistent, but they are not significant.

Table 8 summarizes the consistency between indicators. "$\surd$" means values of correlation coefficients are consistent and significant. Blank cells are not significant, but the signs of the values are consistent, and "X" is not significant, and the signs are not consistent. "-" is the cell omitted because of duplication. There are many blank spaces for indicators 4 and 5, but this is considered to be caused by the fact that the number of corresponding samples is small for indicators 4 and 5. We extracted attitudes about

Table 7 Consistencies of indicators 2 and 3 and 4 and 5

	Indicator 4 (have references to contingency)	Indicator 5 (include comparative judgment)
Indicator 2 (could not actively speak in the discussion)	**0.148**∗∗	<u>−0.025</u>
Indicator 3 (cannot consent to the group discussion conclusion from the bottom of one's heart)	<u>0.012</u>	**−0.140**∗∗

Note: The numbers are Kendall rank correlation coefficient
$**p < 0.05$

Table 8 Consistencies of each indicators

	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
Indicator 1		√	√	√	
Indicator 2	–	√		√	X
Indicator 3	–	–	√		X
Indicator 4	–	–	–		
Indicator 5	–	–	–	–	

indicators 4 and 5 from the text answer about the reasons for approval/disapproval. However, rather than "the reason for approval/disapproval," it may have been good to ask a more mental attitude such as "reason for consent." Regarding indicator 6, there are almost no consistencies with other indicators. This is probably because the indicators other than indicator 6 are those showing the state of being wadakamari, whereas indicator 6 indicates a viewpoint change as a result of wadakamari. In other words, the former is "thinking process," and the latter is "adaptation to the present situation as a result of thinking." The difference of the meaning of the indicators may have resulted in the weak relationship between the indicators.

6 Conclusion

In this research, from concerns about the establishment of a dialogue in consensus building, we designed, implemented, and evaluated wadakamari gaming which promotes viewpoint switching. It became clear that wadakamari is easy to occur if the dilemma situation is emphasized or viewpoints for the problem are different from other people. In addition, it was shown that there is some relevance in wadakamari indicators. In the real consensus building situation, it is necessary not only to provide objective information on the problem but also to express the dilemma structure of the problem or make participants discuss others with different viewpoints in order to promote wadakamari. However, wadakamari is only a mode of thinking deeply about a problem. It is necessary to design another gaming in which players with wadakamari finish wadakamari at some point and head toward problem solving.

References

1. Adachi S (2001) Koukyoujigyou wo meguru taiwa no mekanizumu (Mechanism of dialogue over public works). In: Funabashi H (ed) Kagai/higai to kaiketsukatei (Harm, damage and solution process). Yuuhikaku, Tokyo, pp 1–43
2. Arai K (1998) Gaming simulation towa nanika (What is gaming simulation?). In: Arai K, Deguchi H, Kaneda T, Kato F, Nakamura M (eds) Gaming Simulation. Nikkagiren, Tokyo
3. Duke RD (1974) Gaming: the future's language. Halsted Press, New York
4. Ohnuma S (2011) Shakaiteki dilemma wo meguru goui keisei (Social dilemma for consensus building). In: Hirose Y (ed) Kasou sekai game kara syakai shinrigaku wo manabu (Learning social phycology through simulated world game). Nakanishiya Shuppan, Kyoto
5. Barreteau O (2003) The joint use of role-playing games and models regarding negotiation process: characterization of associations. J Artif Soc Soc Simul 6(2). http://jasss.soc.surrey.ac.uk/6/2/3.html
6. Kitani S, Hasebe T (2014) The influence of formal mindsets on decision maker attitudes when confronted with difficult problems: a view of gaming simulation "lost in space" using inner measurement. In: The shift from teaching to learning: individual, collective and organizational learning through gaming simulation. W. Bertelsmann Verlag, Bielefeld, pp 212–223
7. Doi T (2007) Amae no kozo (The anatomy of dependence). Kobundo, Tokyo
8. Morita S (1978) Nihon no mura (Japanese village). Asahi Shinbunsya, Tokyo
9. Tsujishita T (1998) Seimei to fukuzatsukei (Life and complex system). In: Yamaguchi M, Takahashi Y (eds) Suugaku, fukuzatsukei no kagaku to gendaishisou (Mathematics, science of complex systems and modern thought). Seidosya, Tokyo, pp 75–225
10. Nishikawa A (2011) Tamashii to karada, nou (Soul and body, brain). Kodansya Sensho Métier, Tokyo

Part VII
S&G for Empowerment of Human Mind

Experience Design for Understanding Social Withdrawal: Employing a Live-Action Role-Play (LARP) to Learn About and Empathize with *Hikikomori* in Japan

B.-O. Kamm

Abstract "Performance ethnography" seeks to give people a voice by staging events, plays, and exhibitions together with those under study. Still, the audience of such events remains just that and gains experience only second-hand. Contrastingly, live-action role-plays (larps) provide first-hand experience. Building on performance ethnography and taking the limits of "experimental anthropology" into account (i.e. to offer only glimpses of another reality), this paper showcases a larp that was designed together with former *hikikomori* (people in long-term, social withdrawal) from Japan to make their life worlds experienceable to others. The co-designed larp, "Village, Shelter, Comfort", seeks to go against the stereotype of laziness by raising awareness of the dilemmas some *hikikomori* are confronted with. The larp is part of an ongoing research project on learning effects of larping and an evaluation method for such effects.

Keywords Experimental anthropology · Hikikomori · Immersion · Live-action role-play · Social withdrawal

1 Introduction: *Hikikomori* and Performance Ethnography

Hikikomori in Japanese refers to people in long-term, social withdrawal and to the phenomenon itself [18]. What counts as *hikikomori* and what characterises this form of withdrawal continue to be debated in medical and public discourse since the late 1990s [15]. The Japanese Ministry of Health, Labour and Welfare lists criteria, such as a lifestyle centred on the home, an unwillingness or inability to attend school or work, a duration of at least 6 months, and no diagnosed mental illness [6].[1] At first

[1] The number of *hikikomori* is hard to assess because people in withdrawal rarely answer surveys. Based on surveys conducted at health institutions, however, "guesstimates" range from 200,000 to 640,000 [2, 5]. The ministry stopped counting people above 35 years of age as *hikikomori*, which distorts the picture.

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mostly addressed as a youth issue, today the number of *hikikomori* aged 40 or older increases constantly, who have stayed inside their homes and had no social contact beyond the immediate family for 10 or more years. Decreasing birth rates since the late twentieth century and an ongoing recession furthered a social climate in Japan, that is very much concerned with reproduction (in the biological and economic sense), so that media portrayals of *hikikomori* appear rather unsympathetic and depict them as lazy brats who should just get a job and a spouse.[2] Despite governmental and regional support campaigns, *hikikomori* remains a media stereotype and the only image many are familiar with. Further, *hikikomori* being handier than “social withdrawal”, the term has also crossed borders and is used in other languages as well. In Finnish, for example, the term is used for a self-help online group, *hikikomero* [3], and is also used in Italian to describe similar phenomena [14]. Since the 1960s, social phobias and social avoidance featured in the US American discourse [4].

A remarkable feature of the Japanese psychiatric discourse is the above definition put forth by the ministry: Social withdrawal is not defined as a symptom for other disorders (anxiety, depression, or schizophrenia) as is the current case in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) but as a syndrome of its own (“pure *hikikomori*”) [16].[3] Therapy focuses on guiding afflicted back into society and the job market.

“Pure *hikikomori*” lacks a clear-cut template for diagnosis because the “disorder” can take very different forms regarding triggering experiences, duration, and severity – which could be interpreted as one reason for a failed attempt to include it in the newest DSM 5. It appears more productive to treat *hikikomori* less as a mental illness but as an idiom of distress and a modality of taking a subject position [19]. Judging from media representations of youth issues, however, *hikikomori* has become a form of *common-sense knowledge* – a stable feature of Japan’s society – that is simply applied, disregarding its malleability and differences between cases. Former *hikikomori* emphasise multiplicity and how important a philosophical discussion on a broader societal level is. In their view, such a debate needs to go beyond a support that often turns into more pressure by squeezing people back into standardised life paths. Similarly, the project behind this paper sees *hikikomori* not as a problem but as a chance to rethink “normality”. This project investigated the practices and actors behind *hikikomori* through interviews with psychiatrists, former “patients”, and parents as well as participant observations in Internet forums. Following ideas of “performance ethnography”, the project seeks to make findings available to people without own experience to raise their awareness.

The qualitative research paradigm named “performance ethnography” [1] follows the tenet “show, don’t tell”. This pedagogically inclined approach seeks to give

[2] A related phenomenon has been named “parasite singles” [20]. While *hikikomori* are usually a matter of concern vis-à-vis a bread-winner masculinity ideal, parasite singles refer to women who stay at home and are dependent on the parents.

[3] This “pureness”, however, is very much contested in current studies on *hikikomori* and comorbidity, the presence of multiple disorders [5, 12].

people a voice by staging events, plays, and exhibitions together with those under study, allowing the audience a more qualitative engagement with research. Still, this putative audience gains experience only second-hand. Contrastingly, so-called live-action role-plays (larps) provide first-hand experience and a space for active learning.[4] Building on performance ethnography, this paper showcases the larp "Village, Shelter, Comfort" (VSC), which was designed together with input from former *hikikomori* from Japan to make their life worlds experienceable to others.

Larps can make visible things taken for granted and offer the experience of life worlds different from ones' own [8]. Larps usually encompass the physical and interactive performance of fictitious characters in an imaginary world. Thus, larps count as a form of role-playing because participants create characters with fictional but distinct personalities that are not just societal roles, such as father or employer. To realise their settings, larps make use of costumes, props, and changes to the environment. In this regard, a larp may not differ much from a stage play production. Most larps are based on a combination of shared storytelling and certain elements associated with gaming. Larps usually have plots, predefined series of events, but mostly proceed through the improvised play of the participants. There are no pre-written scripts for players besides their characters' motivations and goals. The shared storytelling often revolves around conflicts but not necessarily so. Most larps include also elements known from other forms of gaming, such as rules, obstacles, and achievements.

Many larps are played for fun; however, since the early 2000s, an increasing number of organisers and educators seek to use larp for purposes beyond the play itself. Building on techniques borrowed from similar practices (e.g. psychodrama, active learning, gaming, and simulation), they create larps with artistic visions, political, or educational agendas. Named "Nordic larp" because this form originated in Scandinavia, such larps can be found all over the world today, from Brazil to Syria [17]. VSC also stands in this tradition of experience design.

2 Village, Shelter Comfort

Co-designed with former *hikikomori*, the larp under consideration took cues from their experiences and dilemmas. The experience of many other *hikikomori* besides these informants is thus not part of the translation into a larp. This is the limit of any form of "experimental anthropology" [9]: We may offer a window into the realities of our informants but cannot deliver 100% accurate, "authentic" experiences. In collaboration with an educational psychologist who works on role-playing games in the support of children on the Asperger spectrum [10], this larp is furthermore not intended to "cure" *hikikomori* but to make it possible for others to experience the

[4] Originally an abbreviation, LARP, the term has become a word in its own in many languages and simultaneously became more inclusive concerning which practices are referred to. Thus, it is written in lower case, larp, throughout this chapter.

feelings of people who are in withdrawal and thus make them think and raise their awareness about the issue. To our knowledge, VSC is the first attempt of translating "social withdrawal" into a larp.

2.1 The Larp and Its Design

The design process began with two questions or challenges: (1) How to gain attention or interest from people not already involved in *hikikomori*? (2) How to translate the experiences of our informants in such a way that it does not necessitate lengthy explanations before play begins? In answer to the first question, we decided against using the word *hikikomori* in the title or the description of the larp and focused on the dilemma our informants had described instead. The Japanese title, "*Anshin kara no dasshutsu*", literally means the "Escape from Comfort" and hints at the paradoxical situation some *hikikomori* face. Many of our informants discussed the tension they experienced while being in a relatively comfortable space at home, which in the end made it impossible to actually enjoy this comfort. We considered other possible nouns besides *anshin* but came back to comfort to capture one half of the inner struggle between secluded security and the pressure to go out – may this pressure come from outside, for example, through parents or social workers who seek to bring the *hikikomori* back on a "normal" life path, or from inside, knowing that hopes of making a certain career will never be achieved if one stays at home. The English title refers to the larp's three scenarios, with which we seek to deal with the second challenge. All scenarios explore a similar dilemma extrapolated from the tension described above: Even though I might like to go out and cannot really enjoy the comforts of my seclusion, the apprehension of what might happen in the (unfamiliar) outside world holds me back and makes it impossible for me to decide what to do.

Put briefly, scenario 1 places the players into the roles of elders who govern a small, remote village that suddenly faces a mortal threat in form of a disease. Scenario 2 is set in a post-apocalyptic underground shelter where an elected council needs to deal with diminishing food supplies and overpopulation. Finally, scenario 3 takes place in a single, contemporary room, and the players become the mental and emotional faculties of the single occupant of this room who must deal with less and less comfort in their once perfect home (see Fig. 1 or the design document for details).

To avoid long explanations pre-play and allow also organisers to run the larp who have not studied *hikikomori* extensively, the first two scenarios were designed as a preparation for the third one. The isolated village society and the post-apocalyptic community feature in many popular media products so that possible participants may be familiar with the situation presented in the larp and may find it easier to comprehend the decision-making involved. Overpopulation pitched against a presumably radiation-poisoned surface world appears as a dilemma most people can accept.

Basic Facts

Design Document: www.b-ok.de/research/larp

Genre: Abstract to absurd realism. *Duration*: 5.5 hours *Actual play time*: 3.5 hours

Number of participants: 3 - 7 *Number of organisers*: 2 *Workload*: Medium

Possible locations: Black box, gallery, classroom, conference room

Playing style: Realistic, but with plenty of improvisation

Scenarios

1. The Village: The players become the elders of a small, remote medieval village in Europe or maybe rural Asia. Their ancestors have built the village at this far-away place to get away from the immoral and dangerous larger settlements. Travellers or merchants pass through, but rarely. Through hard work they have created a petite paradise on Earth and now enjoy the fruit of their labour happily. Suddenly, the elders must decide how to deal with the threat of a mortal disease. Should they stay or leave everything they have worked for? While they seek a solution, the danger becomes more and more serious.

2. The Shelter: The players become the elected members of the council that governs the supposedly last group of surviving humans in an underground shelter. This is a post-apocalyptic world, after a great war involving nuclear weapons or a planet-wide catastrophe. The shelter provides security, air, food and some comforts, but is a harsh realm. Its legal code knows only capital punishment, regardless of the crime. As the shelter's space is limited, the council continues to enforce a one-child-policy. There is no immediate danger, but an issue arises that will affect the long-term survival of the human race. Will the inhabitants stay and deal with the problem however they must, or do they seek a solution outside the shelter?

3. The Room: The players become the various mental and emotional faculties of a single person, living in a single room. These personae spend their - or better forget - time by playing games or surfing the internet. Supported by the parents, this lifestyle has continued for a while, with infrequent interruptions of an order being delivered or a social worker dropping by. One day, the person in this room, however, faces suddenly diminishing comfort. Will the occupant go out into the unknown world beyond in the hope of finding comfort there or stay in a space known that might continuously lose its appeal?

Fig. 1 Village, shelter, comfort: overview

Instead of throwing players into cold water, they gradually come to the point where they have experienced parallel dilemmas already, easing them into the tension of the single room. Using the parallels as guides instead of long explanations of research results *before* the larp followed the aim to allow players to explore the dilemmas on their own terms.

Each scenario is divided into scenes, which are introduced by the organiser in short descriptions read to the players and end after a specified time. Like other "Nordic larps", VSC deals with sensitive issues. Thus, Koljonen's bow-out mechanics are used as a calibration tool for emotional safety [11]. Targeting VSC at people with no larp experience also necessitates an easy practical setup, which is why we designed it as a chamber or black box larp relying on imagination and representational props. Almost all the props we use – drinking utensils for the elders, brooches for the council members, colourful sashes for the mental faculties, etc. – are 100-yen shop items that can be used for larps without any alterations [7].

2.2 Larp Evaluation

As of this writing, we have run VSC seven times, five times in Japanese and twice in English, with a total of 45 participants.[5] Based on their feedback, we could identify scenes and characters that needed adjustments and thus have reworked the larp several times. Each individual run had five to seven players, usually half of which were female. The first test-play and a second run involved graduate students in the field of educational psychology.

The other sessions encompassed participants between the ages of 21–50, who worked in various occupations, ranging from art, sales, to politics. Each run included a 1-hour prep-workshop and a debriefing. Based on our runs, we would like to demonstrate the debriefing and evaluation method we continue to develop for the purpose of making individual larp experiences communicable to others.

These experiences are just glimpses, simulations of the possible dilemmas *hikikomori* face, so players will not exactly learn how it is to socially withdraw and shut oneself in. The goal is that they are provoked to think about *hikikomori*. For this purpose, all scenarios are open-ended and do not offer clear resolutions. Because larps for entertainment usually offer a resolution-oriented play style, participants with larp experiences expressed frustration about not knowing the results of their decisions in VSC. During the direct debriefing after the larp and a longer, structured post-larp interview, one player emphasised that this lack of closure kept them thinking about the experience long after play, so exactly what we intended.

After each run, we let all participants voice their immediate reactions and discuss a few minutes about the larp. Time permitting, we followed with a visualisation and evaluation procedure based on the mixed-method approach *Personal Attitude Construct* (PAC) analysis. This evaluation strategy was developed by psychologist

[5] In 2018, the larp was also run at a high school in Tokyo, independent from us.

Naito Tetsuo for the purpose of evaluating the climate of classrooms and how it was experienced [13]. Used in various fields in Japan today, ranging from psychology, sociology, language education, to counselling, PAC analysis combines in-depth interviews with statistical clustering and visualisations to communicate individual experiences. Visualisation here refers to tree diagrams representing the connections between keywords the interviewees chose to describe their experiences. The visuality of the approach translates into its main advantage for learning purposes because it delivers a basis for the participant's reflection and makes their reflection also communicable to others.

During the interview or group discussion, we ask the participants to explain the meaning of each cluster and the relationship between or among clusters and also within clusters to explore their overall image of the experience (the dilemma) concerned and help them in their reflection. PAC analysis seeks to assist with and visualise individual processes of meaning-making. Furthermore, larps are highly fluid and impossible to standardise as the play evolves from player improvisation. Thus, only two notable examples were chosen for presenting possible effects of the larp experience. They had either no prior knowledge about *hikikomori* (example A) or were first-time larpers (B). In example A of Fig. 2, the participant (age 36, male, artist) designated two clusters, one relating to the painfully long thought process necessary to act (CL 1: Paralyzed by Action) in the last scenario, where this particular player took on the role of the "Psyche", the decision-making faculty of the mind.

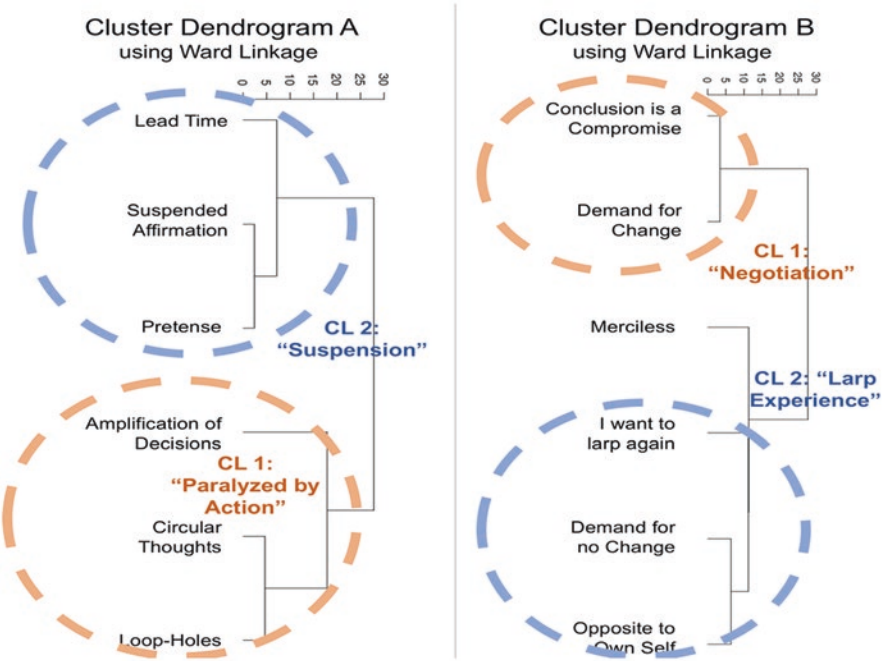

Fig. 2 Example dendrogram interpretations

The second cluster (CL 2: Suspension) describes how the player experienced the dilemma, namely, as a lead-up to the decision itself.

Example B (age 22, female, graduate student) also deals with the third scenario. Even though "Demand for Change" and "Demand for no Change" seem related as direct opposites, they are in two different groups. The first cluster reflects more on in-character negotiations to find a solution for the given dilemma (CL 1: Negotiation), while the second group relates to the larp setup and its game elements (CL 2: Larp Experience). The item "Merciless" sits apart and refers to the larp's hard choices.

The dynamics of the play itself unsurprisingly influenced what players gained from the larp. The player of Psyche discussed above, for example, took it more seriously that only he could interact with the outside world than did his counterparts in previous and later runs. Psyche listened to the other mental faculties, let them do the talking, which often took the form of "circular thoughts", some faculties voting for leaving, while others wanted to stay, only to be greeted with arguments for leaving again. When some faculties would become quiet and thus one opinion dominated, Psyche would perceive this as a "hole in the loop", on which they could finally act. Because the procedure to take even the simplest action, such as standing up, took so extremely long, the decision felt so much stronger (was "amplified"). If we look at the second example, where "conclusions are compromises", it becomes clear that the players of this run followed a decision-making process that emphasised harmonising opinions over playing out who would prevail by being the most persistent.

3 Concluding Remarks

Circularity and conservation vs. anxiety, compromise, and consensus were terms and keywords repeatedly voiced by most players (cf. Fig. 3). Being unable to decide what would be the best course of action is something with which all players could empathise; this would be part of their life worlds as well. Many stated that they had caught a glimpse of how it may be for some *hikikomori* to be caught between conflicting feelings of discomfort, curiosity, or a desire for change and the need to have everything stay the same (conservation, hesitation, risk).

Larping itself featured large among participants' responses: New players would like "to play again" and repeat such an experience despite the exhausting "mercilessness" of the dilemma and difficulties of acting or juggling their own perspective

Fig. 3 PAC analysis word cloud

with the outlook of their characters. Experienced larpers or larp designers especially voiced comments on the larp's setup. For example, some appreciated the haptic elements of scenario 3 very much, so that we added similar elements to the other two scenarios (a map to the Village, a book/kindle of law to the Shelter).

As a highly structured debriefing strategy, PAC analysis did not only help us adjust the larp's design so that it better served our purpose of offering a glimpse into some *hikikomori*'s dilemma. The method assisted participants in the process of making sense of their experience and visualise their learning. Correlating their larp experience with their everyday, what especially stood out was the realisation that *hikikomori* were not lazy but caught in a loop between difficult decisions. Due to the unresolved situation of the larp, many continued thinking about the experience and, so, about *hikikomori* – our first goal for this project: impart knowledge through active learning and direct experience to stimulate doubt about stereotypes.

This is but a tiny step concerning what our informants sought: a broader discussion. However, VSC is being picked up by high school teachers and run independently from this project, thus may be kick-starting the discussion about "normalcy" among students and parents our informants hope for.

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References

1. Denzin NK (2003) Performance ethnography. Sage, Thousand Oaks
2. Furlong A (2008) The Japanese hikikomori phenomenon: acute social withdrawal among young people. Sociol Rev 56:309–325
3. Haasio A (2015) Otherness, information needs and information sharing in the "small world" of the internet: a study of socially withdrawn people's information behavior. Doctoral dissertation, Tampere
4. Horwitz AV (2010) How an age of anxiety became an age of depression. Milbank Q 88:112–138
5. Ishikawa K (2017) "Hikikomori": social recluses in the shadows of an aging Japan. In: nippon.com. http://www.nippon.com/en/currents/d00332/. Last Accessed 25 Nov 2018
6. Ito J (2003) 10dai, 20dai o chūshin to shita "hikikomori" o meguru chiiki seishinhokenkatsudō no gaidorain: Seishinhokenfukushi-sentā, hokenjo, shichōson de dono yō ni taiō suru ka, enjo suru ka [Community mental health intervention guidelines aimed at "social withdrawal" of teenagers and twens]. Ministry of Health, Labour and Welfare, Tokyo (in Japanese)
7. Kamm B-O (2019) Adapting live-action role-play in Japan: how 'German' roots do not destine 'Japanese' routes. Replaying Japan 1:64–78
8. Kamm B-O, Becker J (2016) Live-action role-play or the performance of realities. In: Kaneda T, Kanegae H, Toyoda Y, Rizzi P (eds) Simulation and gaming in the network society. Springer, Singapore, pp 35–51
9. Kangas K (2015) Experimental anthropology. Presentation at Nordic Larp Talks 2015, Copenhagen, Denmark. https://nordiclarptalks.org/experimental-anthropology-kaisa-kangas/. Last Accessed 25 Nov 2018

10. Kato K, Fujino H, Yoneda S (2013) Tēburutoku rorupureingēmu katsudo ni okeru kokinoji-heisho supekutoramu-ko no goikeiseikatei [A process of "consensus making" in small groups of children with high functioning autism spectrum disorder, using a table-talk role-playing game]. Jpn J Commun Disord 30:147–154 (in Japanese)
11. Koljonen J (2016) Toolkit: let's name this baby! (Bow-out mechanics). In: Safety in larp. https://participationsafety.wordpress.com/2016/05/30/toolkit-lets-name-this-baby-bow-out-mechanics/. Last Accessed 25 Nov 2018
12. Koyama A, Miyake Y, Kawakami N, Tsuchiya M, Tachimori H, Takeshima T (2010) Lifetime prevalence, psychiatric comorbidity and demographic correlates of "hikikomori" in a community population in Japan. Psychiatry Res 176:69–74
13. Naito T (2003) PAC bunseki-jisshiho nyūmon [Introduction to practical PAC analysis]. Nakanishiya, Kyoto (in Japanese)
14. Ricci C (2010) Hikikomori. Narrations from behind a closed door. Aracne, Rome
15. Saito T (1998) Shakaiteki hikikomori: owaranai Shishunki [Social withdrawal: never ending adolescence]. PHP Shinsho, Tokyo (in Japanese)
16. Saito T (2014) "Hikikomori" kyūshutsu manyuaru [Deliverance manual for "social withdrawal"]. PHP Chikuma, Tokyo (in Japanese)
17. Stenros J (2014) What does "Nordic larp" mean? In: Back J (ed) The cutting edge of Nordic larp. Knutpunkt, Gråsten, pp 147–156
18. Tajan N (2015) Social withdrawal and psychiatry: a comprehensive review of Hikikomori. Neuropsychiatr Enfance Adolesc 63:324–331
19. Tajan N (2015) Japanese post-modern social renouncers: an exploratory study of the narratives of Hikikomori subjects. Subj Int J Crit Psychol 8:283–304
20. Yamada M (2001) Parasaito singuru no jidai [Era of the parasite singles]. Chikuma, Tokyo (in Japanese)

Hooshmand: Intelligence and Emotion Entangled in a Simulation Game

Saeed Shalbafan and Elyssebeth Leigh

Abstract In Persian "Hooshmand" means intelligence. The simulation Hoosmand-1 creates a clash between intellectual objectivity and emotional reactions to unexpected events. The simulated environment challenges skilled and experienced senior project managers to navigate their way through a set of complex decisions. Initial conditions are complicated but comprehensible, requiring application of knowledge and diligence. Then factors altering the context are introduced to create complex conditions in which standard responses no longer apply. We review outcomes of the project for which Hooshmand-1 was designed. In regard to project portfolio management, cost-benefit ratios and business strategies received more attention than resource availability. In regard to quality decision-making, the effectiveness of team cognition shows up as a key factor shaping performance under stress. "Black Swan" events, Groupthink traps, and Abilene Paradox thinking can all inhibit quality decisions, and Hooshmand-1 provides a context for their emergence and thoughtful analysis.

Keywords Simulation · Decision-making · Groupthink · Resilience · Uncertainty · Black Swan

1 Background to Design and Application of Hooshmand-1

Project portfolio management (PPM) committees deal with financial and operational decision within complex social structures created by competition for limited resources and conflicting goals and interests among representatives of different business units in the organization. Social constructs [1] influence decision-makers' perceptions, capacity for data integration, and their collective judgment as a group

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of senior managers in a project portfolio committee. Perceptions of managers influence their decision-making and are an important social factor in PPM committees as different decision-makers demonstrate different perceptions [2]. Data integration includes functional information systems, [3] proper facilitation processes [4], information overloads, and presentation and time pressures [5]. Existing research highlights the natural complexity of decision models in PPM because of the clashes among competing forces in a decision-making meeting.

This complexity of decision-making processes coupled with sources of uncertainty in PPM can generate very difficult conditions for decision-makers where they cannot achieve a stable solution based on group agreements. Sources of uncertainty external or internal [2] create unpredicted events for decision-makers which can result in unwanted consequences. Black Swan events [6] are identified as rare events having massive impacts across industries. For example, in oil technology gas shale extraction is a recent instance which has influenced the oil industries across the globe [7].

Management of uncertainty in decision-making in PPM is an area requiring close examination [8]. It is important to understand that nonconventional rules and tools are needed to manage such unusual conditions. Cynefin (a welsh word for place) [9] is one of these unconventional approaches; it refers to a framework which identifies five domains of knowledge and defines characteristics required to achieve effective decision-making in each domain of knowledge.

The simulation Hooshmand-1 represents characteristics of complicated and complex domains of knowledge into two separate scenarios based on conditions experienced in the complicated and complex domains [10]. The simulation requires participants to use probes to understand their context [11] and does so through creating disruptive events. The simulation creates a unique set of conditions for study of decision-makers' judgments and decision-making processes in PPM steering committee contexts where they are finding they have to cope with Black Swan events arising during their decision-making [12]. Figure 1 shows the process of simulation in a simple demonstration.

2 Judgment of Participants About Decision Criteria in Hooshmand-1

"Triads" are a triangular-shaped tool which allow for three alternatives on a question. The triads help people make judgment by asking them to compare three criteria at the same time, providing a less biased outcome than that arrived at through the use of traditional two-dimensional tools.

Participants play their assigned roles in each scenario and provide their reflection in a questionnaire. One of the interesting results has been the participants' judgments around the trio of key decision criteria of cost-benefits, business strategy, and

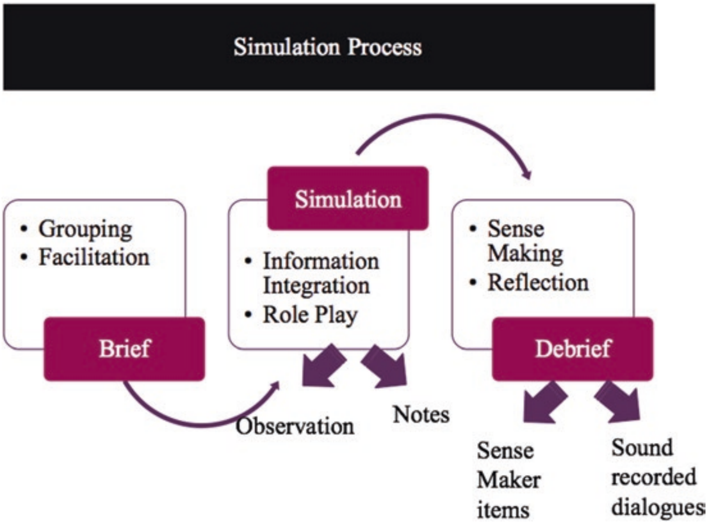

Fig. 1 The process of simulation Hooshmand-1

Fig. 2 Pattern of participants' perceptions for decision criteria before first real-time event in simulation Hooshmand-1

resources availability which shows that the pattern of opinions skews toward a preference for focusing on cost-benefit as participants preferred decision criteria as they experience unexpected events from Fig. 2 to Fig. 3.

Fig. 3 Pattern of participants' perceptions for decision criteria before first real-time event in simulation Hooshmand-1

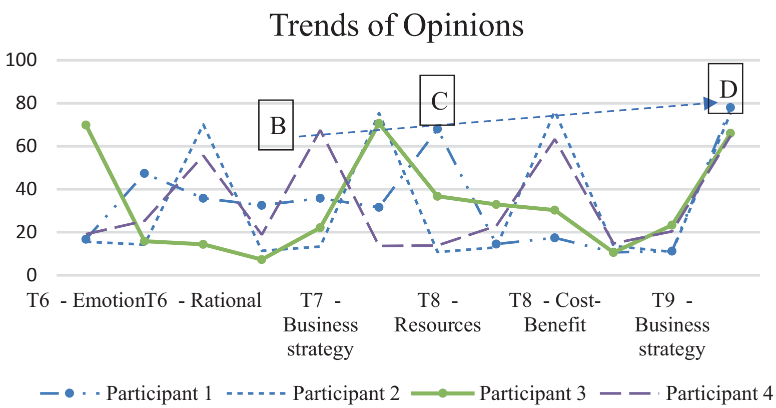

Fig. 4 Trend of opinion for decision criteria in PPM

Figure 4 shows three situations: at the beginning of complex domain as scenario 2 (b), at the end of Black Swan events, and (c and d) in the complex domain. The trend for the change of judgments demonstrated in Fig. 4 emphasizes how the increase in uncertainty focuses decision-makers' attention on cost-benefit as the only criterion to pay attention to in their decision-making meeting. This process of thinking diverts executive decision-makers from a robust decision-making, while clearer awareness of all the factors in the context would indicate that they should consider all decision criteria in balance.

3 Decision-Making Caveats During Simulation Hooshmand-1

The simulation is designed to study decision-making in PPM in groups of three participants who are in role representing the PPM steering company for an artificial company. This design encouraged each group to carry out decision-making in PPM and provided the first author with the opportunity to study potential caveats of decision-making processes as they operated within contexts that have been described by the terms “Abilene Paradox” and “Groupthink.” The concept of an Abilene Paradox (AP) describes situations in which “organisations frequently take actions in contradiction to what they really want to do and therefore defeat the very purposes they are trying to achieve” [13, p. 170]. Five interrelated components of AP that contribute to its occurrence are:

1. Public agreement that a current situation is acceptable but in private individuals are dissatisfied, which is called “pluralistic ignorance”
2. Ineffective communication when the majority of the group agree because of their perception that others do so
3. Communication of group sentiments based on their misinterpretation
4. Decision-makers’ reprise and their questions on the rationality of their decisions is not challenged
5. Failure of managers to understand the process that resulted in poor decisions in order to avoid such situations in the future [14]

Groupthink, as Janis [21] originally defined it, is a mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when the members’ strivings for unanimity override their motivation to realistically appraise [15, p. 1].

Three key symptoms indicate the existence of Groupthink in group decision-making (GDM). Symptom type I concerns overestimation of group power, while type II deals with closed mindedness and type III is related to pressure toward uniformity [16]. Data collected during play of the simulation Hooshmand-1 identified existence of symptoms type II and type III of Groupthink. The antecedent conditions of Groupthink during group decision-making in simulation Hooshmand-1 and the consequences of that are summarized in Fig. 5.

According to Shalbafan and Leigh [12], antecedent conditions are listed in parameters, A, B1, and B2 in Fig. 3. Decision-makers were from different organizations without any joint experience prior to the simulation. The key organizational issue faced was the insulation of groups from working together, as per rules used in the simulation, and lack of norms that left the decision to a group of three participants to decide how to work together and make a decision. Provocative conflicts arose from time pressures and complexity because of unexpected events which were engineered in the simulation and the difficulties of working in a simulation context as many participants were not familiar with the method or the PPM tools that were

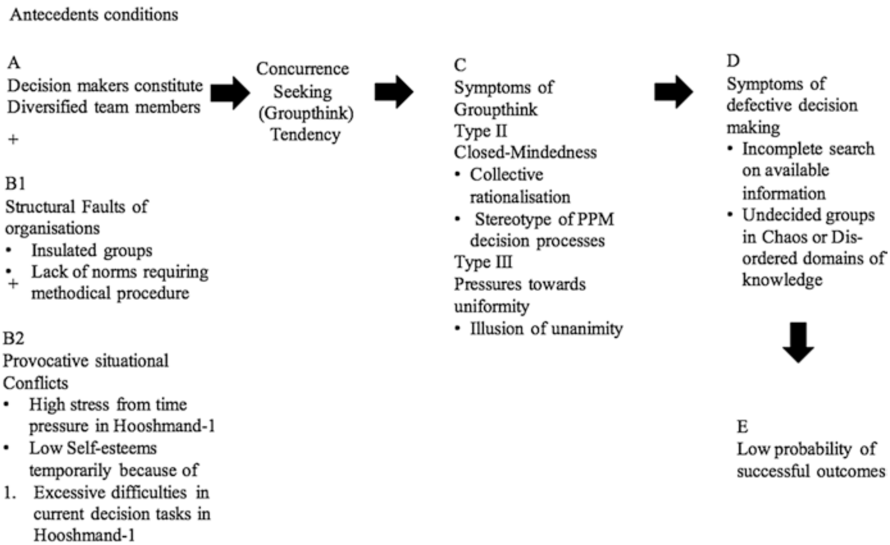

Fig. 5 Summary of antecedent conditions for Groupthink in Hooshmand-1 [12]

introduced in Context1 and Context2. All participants tried to progress at the same time. There is evidence that some groups did not absorb all available information on their folders and some other groups slid into chaos and disorder domains and could not reach a decision.

4 Resilience Factors for Group Decision-Making Under Uncertainty

Team cognition can play a role in decision-makers' resilience when they face uncertainty. Team cognition has an important role on team performance in data exchange in a group decision-making [17]. Simulation Hooshmand-1 could help teams to develop their knowledge and skills with regard to team awareness and transactive memory systems [18]. The simulation Hooshmand-1 has used movements among Cynefin domains of knowledge and pattern analysis [19] as indicators to measure achieved team cognition during the simulation Hooshmand-1. Table 1 shows some of the measures used for team cognition.

Another interesting point of evidence from the simulation Hooshmand-1 is the change of behavior across groups while they move through different phases of uncertainty. As the uncertainty increases over time in different scenarios, the focus on teamwork reduces, and group members tend to focus on individual actions which means reducing team cognition. This explains earlier findings explained in the last section that some groups missed out information available such as business strategy, resources plan, and financial criteria, because they could not make sense of all of

Table 1 Team cognition measures

Challenges	Solutions
Measures applicable to heterogeneous teams	Heterogeneous knowledge metrics (e.g., role-specific referents)
Measures that capture emergent cognition	Holistic measures taken at the team level (e.g., consensus ratings)
Holistic, embedded, real-time metrics	Communication pattern analysis (Hooshmand-1)
	Cynefin domain movements – (Hooshmand-1)
Measures of emergent team situation awareness	CAST: coordinated perception and action of team members in the face of change

Adapted from [20, p. 246]

them under uncertainty. The simulation Hooshmand-1 used a dyad which measures opinion about focus of activity on team and individuals. The SenseMaker software was used to analyze the results of dyads, and data analyses provided a comparison between opinion of participants in complicated (Context 1) and complex (Context 2) domains.

Figure 6 shows that the mean of distribution for “focus on team” has shifted toward “focus on individual.” This means the group of 43 participants demonstrated more individualism behavior during decision-making with unexpected events. This analysis highlights the importance of team cognition and people’s preparedness for difficult times. The simulation Hooshmand-1 has provided organizations opportunities to measure and assess team cognition through practice and role-based scenarios and improve their resilience to stay connected and utilize the team knowledge and skills for making quality decisions under stress and uncertainty.

5 Recommendation and Conclusion

The simulation Hooshmand-1 causes participants to generate patterns of behavior that can be recorded using SenseMaker software and the Cynefin concept of “domains of knowledge” which help to uncover their current decision-making modes. Once revealed, these patterns can be examined for the strengths and flaws in their reasoning enabling organizational committees to revise their practices to ensure that their decision-making sustains successful operation in times of uncertainty and complexity. The design of the simulation game allows participants to experience two stages of the Cynefin domains beginning with the use of complicated – expert – knowledge and shifting (without warning) to a context incorporating “Black Swan” events. Such conditions are not well understood, and the research conducted with Hooshmand-1 has demonstrated that even highly competent decision-makers can become susceptible to fatal errors. We conclude that when conditions require decision-making committees to shift to different, unfamiliar modes of decision-making, they are likely to fail if they do not consciously shift their pattern of thinking.

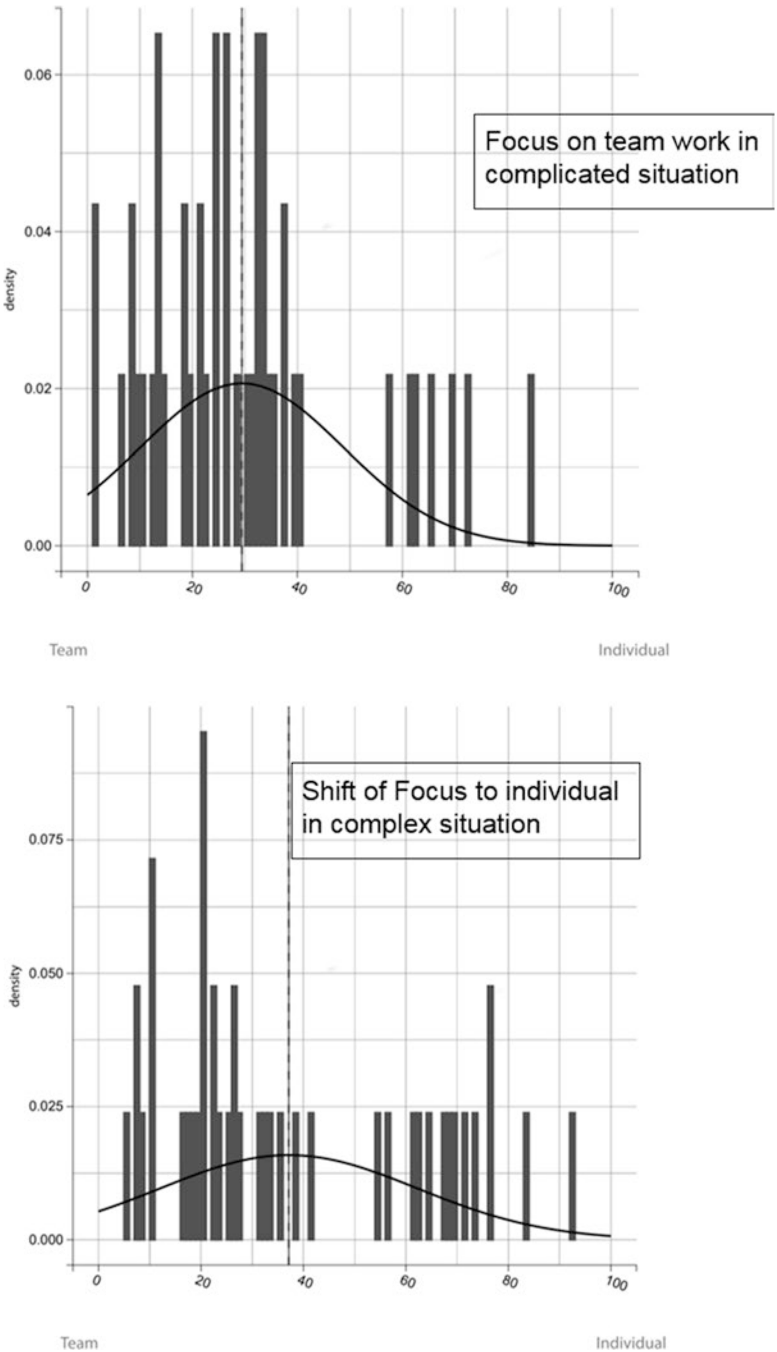

Fig. 6 Distribution of participants "pinion on focus on team vs. focus on individual

When conditions require committees to explore (called “probing” in the Cynefin model) for unknown options and unlearn their reliance on familiar, comfortable expertise, we recommend they begin with a direct and honest exploration of their own patterns of reasoning and thinking. Hooshmand-1 provides committees with insights into how their decision-making may be impaired, by such well-known flaws in human thinking as the “Abilene Paradox” and “Groupthink.” These insights once revealed can become the basis for a robust reassessment of the “health” of their decision-making processes. Taking this path to face the realities of decision-making in complex conditions requires a deal of honesty and sufficient time to absorb the potential for future adverse impacts if major changes in thinking processes are not made. The most likely alternative outcome is eventual disaster, as decisions – made without the benefit of reviewing requirements of the unfamiliar “complex” knowledge domain – fail to address the real nature of the conditions confronting the decision-makers.

References

1. Christiansen JK, Varnes C (2008) From models to practice: decision making at portfolio meetings. Int J Qual Reliab Manag 25(1):87
2. Korhonen T, Laine T, Martinsuo M (2013) Varying perfections of uncertainty among managerial actors in project portfolio management in EURAM European Academy of Management 2013, Tampere University of Technology Istanbul, Turkey
3. Ghasemzadeh F, Archer NP (2000) Project portfolio selection through decision support. Decis Support Syst 29(1):73–88
4. Unger BN, Gemünden HG, Aubry M (2012) The three roles of a project portfolio management office: their impact on portfolio management execution and success. Int J Proj Manag 30(5):608–620
5. Killen CP (2013) Evaluation of project interdependency visualizations through decision scenario experimentation. Int J Proj Manage 31(6):804–816
6. Taleb NN (2007) The Black swan: the impact of the highly improbable. New York Times
7. Lewis J (2011) The black swan in shale gas, cold water for upgrading: expect the unexpected in North America’s oil and gas renaissance. https://www.albertaoilmagazine.com/2011/11/a-black-swan-for-shale-gas-cold-water-for-upgrading/. Last accessed 26 June 2017
8. Petit Y (2012) Project portfolios in dynamic environments: organizing for uncertainty. Int J Proj Manag 30(5):539–553
9. Kurtz CF, Snowden DJ (2003) The new dynamics of strategy: sense-making in a complex and complicated world. IBM Syst J 42(3):462–483
10. Shalbafan S et al (2017) Application of Cynefin framework to facilitate decision-making in complex conditions in project portfolio management in IRNOP 2017. Boston University, Boston
11. Snowden D (2002) Complex acts of knowing: paradox and descriptive self-awareness. J Knowl Manag 6(2):85–88
12. Shalbafan S, Leigh E (2018) Design thinking: project portfolio management and simulation – a creative mix for research. In: Lukosch H, Bekebrede G, Kortmann R (eds) Simulation gaming. Applications for sustainable cities and smart infrastructures. ISAGA 2017, Lecture notes in computer science, vol 10825. Springer, Cham
13. Kim Y (2001) A comparative study of the “ABILENE PARADOX” and “GROUPTHINK”. Public Adm Q 25(2):168–189

14. Harvey M et al (2004) The Abilene paradox after thirty years. Organ Dyn 33(2):215–226
15. Hart P, Irving L (1991) Janis' victims of groupthink. https://www.jstor.org/stable/42859338. Last accessed 26 June 2017
16. Yetive SA (2003) Groupthink and the gulf crisis. Br J Polit Sci 33:419–442
17. Huey-Wen C, Yu-Hsun L, Shyan-Bin C (2012) Team cognition, collective efficacy and performance in strategic decision-making team. Soc Behav Pers 40(3):381–394
18. Fernandez R et al (2017) Developing team cognition: a role for simulation. Simul Health 12(2):96–103
19. Cooke NJ et al (2000) Measuring team knowledge. Hum Factors 42(1):151–173
20. Durso FT et al (2007) Handbook of applied cognition, 2nd edn. Wiley, Hoboken
21. Janis IL (1972) Victims of groupthink. Houghton Mifflin, Boston

Self-Esteem Building Activity: Personality Development of Thonburi University Students

Kamares Rithdaychar

Abstract Self-esteem refers to how much you value yourself. It's when you know that you are important and talented. People who have a healthy self-esteem typically do well in school and workplace and get along well with others. People with a healthy self-esteem know what their talents are. This workshop will run self-esteem building activity by using This Is Me exercise. People can learn from This Is Me exercise by drawing self-portraits and completing the questions about sense of identity, strength, friendship, and encouragement to build people self-esteem, encourage people to learn to love themselves for who they are, and develop a growth mindset and are more likely to persevere in the face of challenges.

Keywords Personality development · Self-esteem · Growth mindset

1 Introduction

In the era of change, a society has a problem of self-confidence. The study found that relation had an effect on humans' feeling – stress [4]. Besides, humans with low confidence hardly focus on an action affecting their own life, and they remain inactive for the development of abilities including the progress of potentials. On the other hand, humans with high confidence see the development as important to improve on potentials. Thus, to support everyone having their proper self-confidence can improve their potentials and create new thing for the society.

According to Rosenberg and Owens [3], the results demonstrated that a group of people with low confidence have experienced on disappointment and several problems. A negative thinking causes a plenty of problems. For example, humans with low confidence always over interpret any matters; they also feel anxious about social interaction without confidence. Guindon [1] surveyed the behavior of humans having low self-confidence, and the finding found five characteristics: shy and quiet,

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insecure, underachieving, negative, and unhappy. Therefore, the study of personality development is crucial for increasing self-confidence in all humans and affecting on a good change of society. In addition, the researcher created a short-term activity to test and stimulate participants. All participants had a chance to self-consider by understanding and to self-reinforce what they like or what they are expert at. At last, all participants can know their own potential and confidence which can be developed to be better.

The researcher created Self-Esteem Building Activity: This Is Me based on two theories: Thorndike's connectionism theory and Hull's systematic behavior theory summarized as follows. Edward Lee Thorndike [5] proposed the idea of interaction between stimulus and reaction (Thorndike's connectionism theory) to research the learning laws of each person. Law of readiness is illustrated that human learning can get better if they have the willingness of body and mind. For Law of exercise, it can be shown that if humans always practice their skills more and more with understanding, they will have durable knowledge. Furthermore, law of use and disuse is demonstrated that the durability of knowledge will arise if humans do that thing frequently. Last, law of effect is described that humans who are satisfied with any results of action will desire to learn continuously, so the receiving of satisfying results is the main factor of learning. Hull [2] presented the systematic behavior theory.

The learning process arises from the law of reactive inhibition. That is to say, if learners' body becomes tried, learning is on a decline. Next, Law of Habit Hierarchy is the theory that explains when individual learners are stimulated, they differently respond to the simulators. When learning more, learners can have a reaction in the higher level or respond with accuracy and following social standards. Finally, with Goal Gradient Hypothesis, the more learners achieve their objectives, the more they respond.

According to the learning theory and collection of the data from the samples, the researcher designed Self-Esteem Building Activity: This Is Me so that the participants can learn and catch sight of themselves dispassionately. The participants are anticipated to understand their own actual pattern and character of personality because most of the people in the society do not usually ask questions themselves. Individual people have been shaped by their surroundings, which include their expectations to meet the social standards and their virtual needs to be in the society. Questioning from analyzing the learning theory brings about Self-Esteem Building Activity: This Is Me. The researcher takes it to experiment with these samples to find the questions and activity pattern which encourage the participants to do the activity the most easily and effectively.

2 Problem Formulation

This study was conducted to review and recognize the participants' inner potentiality in order to establish their internal and external self-confidence after playing games.

2.1 Objectives of the Study

1. The first objective was to study an achievement in self-confidence of the participants after finishing the activity.
2. The second objective was to use Self-Esteem Building Activity: This Is Me as instructional material for impressing on self-development.

2.2 Participants

The samples used in the study consisted of 30 participants aged 18–30 years old who are interested in attending the "Self-Esteem Building Activity: This Is Me." The Convenience Sampling technique was used to select the samples.

2.3 Experimental Manipulation

1. "Self-Esteem Building Activity: This Is Me" Educational Game
2. Four features of self-confidence before (pretest) and after (posttest) attending to "Self-Esteem Building Activity: This Is Me" were investigated through the questionnaire.

2.4 Procedure

Self-Esteem Building Activity: This Is Me is a learning game which the participants are expected to find their cloaked potential through a test designed for this game. This test is divided into two parts:

1. Self-Imagination: Every participant gets drawing devices to draw self-portrait imaginarily. The participants draw only their prominent points. The significance of this activity is to build their confidence in physical characteristics more. This affects their confidence in developing their personality and the potential for taking care of themselves more.
2. Sense of Identity: The participants have to answer the questions analyzed from the two learning theories: Thorndike's connectionism theory and Hull's systematic behavior theory. The questions live up to the potential for capability, determination, relation, and the way to develop themselves.

When the participants finish doing both of activities, they will have an aim and a way to develop themselves prominently. Furthermore, Self-Esteem Building Activity: This Is Me causes them to find their true personality and characteristic, as well as get some suggestions and ideas which support them to reach their potential. The five steps for attending "Self-Esteem Building Activity: This Is Me" were stated as follows:

1. The researcher informed the steps to do the questionnaires and asked the subjects to complete them.
2. Self-Imagination: All participants were given the materials to draw their imagination self-portraits. In order to do this activity, the participants need to elicit their positive distinctive point.
3. Sense of Identity: The participants were asked to answer the questions built up by the researcher. The questions were conducted according to Thorndike's connectionism theory and Hull's systematic behavior theory. The key term of the questions was to elicit people's potentiality in ability, intention and correlation.
4. A video clip of successful people's life experience and their point of view was shown in order to strengthen the participants' inspiration.
5. The participants were given the questionnaire to examine posttest achievement.

3 Problem Solution

First, the researcher asked for the collaboration and permission from the participants of the study in order to collect data. Second, the participants were asked to participate in a pretest. Third, before allowing the participants to do the activity, called Self-Esteem Building Activity: This Is Me, the researcher explained the steps, rules, and purpose of the activity to the participants. Fourth, the participants performed the activity for 30 min. Fifth, when the activity was completed, the researcher explained and told the participants the results of the activity. Sixth, the participants participated in a posttest. Seventh, the researcher analyzed the data summarized the significance of the activity.

3.1 Data Analysis

The researcher analyzed the data using the following metrics:

1. The content analysis was used to analyze the results of the activity, Self-Esteem Building Activity: This Is Me.
2. $\bar{x}$ was employed to analyze the results of pretest and posttest.
3. The researcher employed T-dependent test to compare the results between pretest and posttest.

3.2 Results

This subsection illustrates the confidence level of the participants prior to the activity, Self-Esteem Building Activity: This Is Me. The results indicate that the participants had generally low level of self-confidence ($\bar{x}$ = 2.22, S.D. = 0.27). Based on the four categories of rationale for self-confidence level, it was shown that the participants had moderate level of own review ($\bar{x}$ = 2.56, S.D. = 0.97), moderate level of realization of own potential ($\bar{x}$ = 2.28, S.D. = 0.97), low level of self-confidence ($\bar{x}$ = 1.96, S.D. = 0.86), and low level of self-improvement of own potential ($\bar{x}$ = 2.06, S.D. = 0.62) as shown in Table 1.

The section below (Table 2) mentioned the participants' confidence level after attending the activity, Self-Esteem Building Activity: This Is Me.

The results in Table 2 indicate that the participants have a very high level of self-confidence after participation in the activity (Self-Esteem Building Activity: This Is Me). Moreover, it was shown that the participants had very high level of own review ($\bar{x}$ = 4.38, S.D. = 0.60), realization of own potential ($\bar{x}$ = 4.54, S.D. = 0.54), self-confidence ($\bar{x}$ = 4.34, S.D. = 0.76), and self-improvement of own potential ($\bar{x}$ = 4.62, S.D. = 0.70) which is the highest level.

4 Conclusions

The study results show the importance of the self-esteem building of individuals. According to the mean, standard deviation, and scales to interpret the results from the questionnaires studying the four aspects of self-esteem before and after the Self-Esteem Building Activity: This Is Me, both pretest and posttest results are clearly different and in concordance with Edward Lee Thorndike [5]'s idea, which emphasizes the relationship between the stimulus and reflection. This reflection includes law of readiness (knowing the activity pattern and what they should do), law of exercise (realizing their potential or what they do without noticing that they can do), and law of use and disuse (knowing their potential and having more confidence when watching videos of inspirations), which is in concordance with the law of effect and Hull's [2] idea. This idea presents Hull's systematic behavior theory

Table 1 The confidence level before attending the activity, Self-Esteem Building Activity: This Is Me

Self-confidence	$\bar{x}$	S.D.	Meaning
Own review	2.56	0.97	Moderate
Realization of own potential	2.28	0.97	Moderate
Self-confidence	1.96	0.86	Low
Self-improvement of own potential	2.06	0.62	Low
Total	2.22	0.27	Low

Table 2 The confidence level after attending the activity, Self-Esteem Building Activity: This Is Me

Self-confidence	$\overline{x}$	S.D.	Meaning
Own review	4.38	0.60	Very high
Realization of own potential	4.54	0.54	Very high
Self-confidence	4.34	0.72	Very high
Self-improvement of own potential	4.62	0.70	Very high
Total	4.47	0.13	Very high

showing that the process of learning results from the law of reactive inhibition. Each of the participants received a different mean of the test. The next one is law of habit hierarchy. This depends on applying the activity in the individuals' daily life. The last one is goal gradient hypothesis – the more participants know their potential, the more they are ambitious to increase their potential.

4.1 Suggestions

Due to the clear increase of the analysis results of the activity Self-Esteem Building Activity: This Is Me, this can be claimed that including this inspiring activity in any study disciplines tend to improve individuals' confidence.

4.2 Further Research

1. The time of each sample should be extended to study how the confidence and the potential increases. The main aim is to encourage the participants to realize and improve their potential to benefit the society in the future.
2. The groups of the participants should be changed so that the research results can be compared.

References

1. Guindon MH (2002) Toward accountability in the use of the self-esteem construct. J Couns Dev 80(2):204–214
2. Hull CL (1951) Essentials of behavior. Greenwood Press, Westport
3. Rosenberg M, Owens TJ (2001) Low self-esteem people: a collective portrait. Cambridge University Press, New York
4. Silverstone PH, Salsali M (2003) Low self-esteem and psychiatric patients: part I–the relationship between low self-esteem and psychiatric diagnosis. Ann Gen Hosp Psychiatry 2(1):2
5. Thorndike EL (1899) The associative processes in animals. Ginn and Company, Boston

City of Emotions: Case Studies for a Broader Scope of Intervention

Catalina Oțoiu and Paola Rizzi

Abstract This chapter discusses two case studies, which are part of our initiative to promote gaming simulation in Romanian business and educational settings. Our goal was to adapt "City of Emotions," an urban planning gaming simulation, to other intervention and learning contexts. The first case study analyzes an organizational change intervention, where "City of Emotions" was used with the whole management team of a public Romanian company, in order to develop shared leadership and to help them find common ground for business innovation. Our second case study highlights the benefits of using "City of Emotions" to teach students about participatory processes and about the benefits of learning through interaction, as well as reflection *in* and *on* action. Feedback from participants in both situations was positive, both with regard to their somewhat new experience with gaming simulation and with regard to their learning outcomes.

Keywords Participatory processes · Organizational innovation · Collaborative learning · Reflection in action · Reflection on action

1 Introduction

Romania is still shy about gaming simulation. There is eagerness and willingness to keep up with global changes and developments in all fields, and, especially among younger people, there is openness to everything that is "cool." We live in a time

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when gaming simulation "expands its borders" [1] wide enough that there is urgent need for integration of both application and research within a cohesive game science paradigm [2]. As such, *games*, *gaming*, and *simulation* are all "cool" words. So, just mentioning "gaming simulation" seems to make everything more appealing, both in business and education. But, people generally have little experience with it. They usually *think* they know what it entails, but are never quite prepared when having to participate. This is especially true in public organizations, which are still mostly bureaucratic and tend to equate complicated processes, seriousness, and rules to effectiveness and performance. In educational settings, students generally expect to have interactive learning sessions, but don't usually give a lot of thought to learning outcomes. Nor do they recognize the value of reflexivity in learning, or understand the learning process as social interaction [3, 4]. Hence, in our experience, people here leave a gaming simulation situation a little dazed and a lot excited. *Dazed*, because they can hardly believe that such a fun, carefree environment and activity could actually produce insights, and drive change, and could facilitate reflexivity and learning. *Excited*, because *Wow, it's actually possible*! So, Romania is still shy about simulation and gaming, but the people are also eager to experience it.

This paper strives to show how "City of Emotions" [5] was adapted to serve as a powerful intervention and learning tool in other settings than the original urban planning model was built for. While the research questions that drive our investigation are relevant for both case studies, the purposes of the two situations are different, and so, from a theoretical standpoint, the relevant concepts also vary.

Considering this, we chose to structure this chapter as follows: we first briefly discuss the method behind our research and describe the frame of the game; then, we discuss the two case studies, explaining our game design and debriefing adaptation choices. Within each study we discuss the relevant concepts used and their theoretical grounding and present participants' perspective on their experience of the gaming simulation. Finally, we integrate our findings from a facilitation standpoint, we discuss some of the lessons learned and some of the challenges we were faced with, and we conclude with some suggestions to overcome those challenges in future endeavors.

2 Method

The research questions which guided both our intervention and its current analysis are the following: *Is it versatile enough to serve its purpose in both organizational and educational contexts? Does the mechanism of the game still work in these different settings? Does the model suit the different learning outcomes, each setting requires? What are the challenges that stem from the adaptation process, and how can we overcome them?* One overarching, meta-research question refers to the applicability of gaming simulation in the, still bureaucratic, organizational Romanian environment and the, still teacher-centered, educational system.

We employed a case study method [6] for our research since it was the most suited to verify these research questions. The data for our analysis was gathered from debriefing sessions and written feedback from our participants, as well as video recordings of their interactions where recordings were allowed.

We used a theory-driven approach [7] to the evaluation of the gaming situations for each application of City of Emotions. This facilitates the theoretical integrity of our work. It guided our intervention, and its analysis of it, by offering the theoretical concepts and behavioral manifestations to look for when seeing the "game in use" [8, 9]. Before we move to our findings, the next section briefly discusses the model of City of Emotions, which we then adapted.

2.1 City of Emotions

The idea behind "City of Emotions" [5] is that *places* and *spaces* can generate emotions or are associated with emotions. These might vary from individual to individual. For some of us, thinking back to our grandparents' house may bring along *joy*, *happiness*, and a feeling of being *carefree* and *daring*. For some, it may evoke *longing*, or even *sadness*. If we refocus this at the community level, the variation in emotions occurs between the different groups of people who are a part of said community, as well. Young mothers may feel *safe*, because their neighborhood park is well kept and well lit. Teenagers may feel *excited* they have a place to hang around and conduct mischief and their mothers' *relief* that said mischief at least happens somewhere close by, guarded and safe. *Variation* in the emotions a space may elicit does not necessarily mean *contradiction* between them. It does, however, suggest that there are different perceptions of one singular space and that we have different perspectives, interests, and needs in relation to the spaces and places we inhabit. A community, a city, implies putting together a large variation of points of view, needs, interests, and requirements [10]. "City of Emotions" highlights these variations and offers opportunities to understand them. As such, it was previously used in different urban planning contexts to facilitate participatory processes.

The gaming simulation was built to accommodate a various number of participants, working in groups. The task of each group is to design their own neighborhood and to use as a starting point a certain emotion they feel their real living space gives them or, as an alternative play, an emotion they would like to associate with their ideal living space. As a group they have to decide whether they want to reflect a current or an ideal space and which emotion they want to reveal and then actually go through the urban design process. Once each group has a finished product (a picture, drawing, or even model of their neighborhood), the groups have to come together and build one city composed of all these neighborhoods/emotions which then they will all have to live in. This means negotiating ways to integrate sometimes different spaces and sometimes conflicting emotions and values. It is this process of integration and its debriefing that has an impact on participants and that underlines the importance of participatory processes for creating shared living spaces and communities. It is in this format that "City of Emotions" has proven to be a powerful tool for initiating and emphasizing participation in real-life urban planning processes [11].

3 Findings from Two Case Studies

3.1 Organization of Emotions (Case Study 1)

The first case study focuses on the adaptation of the urban gaming simulation for organizational contexts. More specifically, we used it as a means to help develop a common understanding of an organizational context, uncover hidden assumptions with regard to leadership, and build common ground for organizational innovation.

In September 2017 we were asked to facilitate a 5-day workshop on leadership development for the management team (15 participants) of a public company in Cluj-Napoca, Romania. We planned the workshop session around the functional leadership model [12] and expected to work specifically on developing leadership behaviors within small teams. At the very beginning of the workshop, we discussed their expectations with regard to learning outcomes. In this process two main issues emerged: they wanted to be better leaders for their respective teams, and they were interested in learning about culture and its impact on their role as leaders. As we went further into this process, we were presented with an unexpected opportunity. It was the very first time the whole management team was there within the same learning and development context. One of the participants stated, "We have never really been in this situation before, with all of us in one room, and actually sharing our individual problems in such an open way." And because of this, we decided to shift the focus of the workshop from developing individual leaders to developing a leadership team. We employed what Schein [13] describes as process consultancy. In Schein's perspective, the role of the consultant is to offer organizational members the context for in-depth exploration of their core assumptions. This exploration starts by encouraging them to identify important cultural artifacts (i.e., physical space, organizational structure, processes, and procedures) and then asking them why they do things the way they do them. This leads to exposing shared values and, furthermore, to uncovering the most implicit level of organizational culture, core assumptions. And this is where we found an appropriate place for "City of Emotions."

Even at this stage, it was apparent that communication among them was stilted and they were uncomfortable in the workshop situation, due to the group situation. A new wave of employees had come a few years before, and the entire company was divided between the "new ones" and the "old ones," even at the management level. There were trust issues and gossip, and people didn't take responsibility for their work, saying that it is fully controlled by the upper management structure (the CEO) and they had no input.

Considering our new focus on developing a team of leaders, the objective we formulated for the game was to offer a space for them to start and actually interact as a team and in a productive manner.

We drew on their input in this initial discussion to build our conceptual map for the design adaptation process [14]. From a team science perspective, building a team involves creating a history of interaction [15], developing team cohesion and an inclusive social network, and creating a psychologically safe environment which facilitates communication [16]. This in turn creates the opportunities for team cognition development (i.e., shared mental models, cross-understanding [17, 18]), and, finally, the development of an innovation-oriented culture through norms which encourage creativity and exploration, experimentation, and autonomy and don't punish failed initiatives [19].

With this in mind, we formed two teams of seven and eight participants, respectively, and asked them to imagine their ideal organizational department based on a certain emotion they want it to reflect and, hence, a set of values they want to build that department on. We then asked the two groups to integrate the departments within the same organization. There were no other alterations to the structure of the game, except for the replacement of the city with the organization, which we found to be the more salient context in this particular case. We did however exclude the option of describing their organization and report the current emotions associated with it.

Firstly, we did this because it provided a clean slate for them to build upon. They were obviously uncomfortable with sharing problems with the group, so this alternatively increased their willingness to offer their input. Secondly, from a design thinking standpoint, this approach facilitates organizational innovation [19, 20], and this was one of their stated goals.

Innovation, they say, has its own governing laws which imply uncertainty and explorations, as opposed to the general order and stability organizations tend to strive for. This is also very much in line with the complex adaptive systems view on organizations, which states that effective systems function "on the edge of chaos" in that they continuously balance structure and flexibility [21]. While rules and norms that grant stability and certainty are important for the executive functions of an organization, they are also rooted in the past, built upon past experiences. For innovation to occur, solutions should diverge from the past, not reinforce it. Hjorth and his colleagues [22] argue that "you can deal with gaps by imposing a template, picked from practice or habit, and in this way cement over the crack, or you can relate to it affirmatively by bending open the crack, to move into the open and embrace playing." We believe the design model of City of Emotions does just that: it creates the opportunity to break from known scenarios, routines, and norms and to step toward a new realm of possibilities. This is essential for innovation to occur [20].

Debriefing was focused at the beginning on their descriptions of their respective ideal department. Without specific input from us, they did not draw an ideal physical space to describe it but used instead metaphors. For one group, it was a colorful depiction of a hot air balloon, and they explained it represented *freedom*. For them, freedom means creativity and autonomy in their work. The weights on the side of the basket keep them grounded in reality and focused on their objectives. The basket itself keeps them together as a team. The other group drew a diamond. The feeling they invoked was *excellence*, represented by the purity and brilliance of the diamond. The sharp edges represented performance and the many facets, the many different individuals. When trying to put them together in the second stage of the simulation, they predictably had a hard time doing it and in the end settled on a compromise solution of allocating the different representations to different facets of the business (i.e., accounting is the diamond, and the new innovation department is the hot air balloon). Hence, in the second stage of the debriefing process, we asked if there could have been an alternative solution to merge the two visions, and this offered them their first shared insight: “we have no common ground or understanding of where we want this company to go.” Building on that, we encouraged them to share their own perceptions on the current situation and found that even that was lacking. All of the information about strategy, vision is with the CEO, and while they got glimpses of it, they did not have the whole picture. Moreover, this inquiry process led to other insights into their current functioning. When discussing the open values of their company, innovation was top of mind for our participants. It is also one of the declared company values on their website. However, when we went into details with regard to how that value is incorporated and reflected by their daily work, they were stumped to offer any concrete examples. “We have procedures we need to follow… they don’t afford much innovation.” Once some of the core assumptions and values were uncovered, we entered the final debriefing stage. This focused on using their interaction within the workshop setting as a proxy for understanding patterns in their still group of people and not yet team. We relied on the conceptual model of the simulation to discuss team emergent states and processes, their current interaction patterns, and steps to build a team.

From the perspective of team development and collaboration, during the 3 days following the gaming simulation, we could see an increase in the amount of information they were willing to share and in advice-seeking behaviors. These could be the very first steps into building psychological safety and trust. The social network of communication within the group was also more inclusive by the end of our session. Their written feedback was positive with regard to the entire session, and some of the more common insights they reported were with regard to their unbelievable lack of common ground, as well as the need to further explore opportunities for them to work in a more integrated manner and increase cooperation at the management level.

3.2 City of Youth (Case Study 2)

For our second case study, we are going to focus the discussion on the debriefing section of the game. In terms of structure and game processes, we followed the indications of the original design. The participatory framework behind it, which forms the conceptual model of the game, was also entirely implemented. Our audience was however different than its usual architects and urban planning specialists or students. We played the game in two different classes on educational psychology. The purpose of the class was to teach students how to teach, and hence, we added a secondary purpose for City of Emotions – that of introducing gaming simulation as a tool and methodology for their future work as educators.

For most of our participants (35 students), this was the first experience with gaming simulation. We discovered this in a brief session before the game where we discussed what efficient learning meant to them. Their responses were mainly along the lines of "understanding" the information they are supposed to learn. Moreover, we explored issues like who is responsible for generating the information and knowledge, and in their view, this was mainly the teacher. They extrapolated on their role in the learning process, and they understand it as being an "active role" in the sense that they ask questions and further their knowledge through independent studies. When asked what they believe is the role of their peers in class, they stated that responsible behavior, as in paying attention and not disturbing the class should be shared by all. Sadder still, when reflecting back on their experience with interactive teaching, they report a proper usage of presentation skills by the teacher, a friendly class environment and teacher enthusiasm.

We believe that, when it comes to educational settings, the main challenge stems from how students understand and perceive learning. Due to prior experience and the way in which our educational system is built, they expect learning to entail a process where the teacher has all the information, knowledge, and expertise and, during teaching, he or she imparts their knowledge to students. As is, students are bystanders whom, depending on their own motivation, effort and intellect can absorb more or less of it. They rarely understand that learning is an interactive process and that they are as much responsible for the outcome as the teacher is. This is what Klabbers [3] refers to as learning through acquisition, where one accumulates information, as opposed to learning through interaction, where one learns to produce structures which are self-organizing and which serve as contexts for action. Both are needed and should be integrated within the learning space.

Schon [23] introduces a differentiation between *reflection on action* and *reflection in action.* The former refers to the analysis post event, while the latter emphasizes the importance of paying attention while the event takes place and you are still able to influence actions and results. While case studies in class offer opportunities for students to think how they would react as professionals in a certain situation, it does not offer the ground of being intentional about your actions and decisions when it counts. Gaming simulation on the other hand highlights just that.

Hence, we ran the gaming simulation and proceeded to debrief it for underlying the participatory processes they went through. The focus here was on their own feelings and emotions related to the space they designed and how they were in accordance/or in contradiction with the space designed by their colleagues. We then asked them to think about how easily, or not so easily, they were able to integrate all the different components of their collective design. We asked them to analyze the negotiation processes they went through and to try and reflect on the different perspectives they had to caliber. Finally, we asked them to identify different settings where such conflicting points of view could emerge. They were easily able to extrapolate outside of the classroom and provide examples from organizational settings or community settings. At this point we led the debriefing toward their learning process and asked them to pinpoint key moments in the simulation game that had an *Aha!* effect for them personally.

Furthermore, we emphasized that reflecting on the learning experience is in fact learning in itself [4]. To conclude the debriefing session, we asked them to imagine they were the teacher and to address the simulation from a critical perspective. What would they have done differently in the facilitation? What would they have focused on and discussed during debriefing. Their feedback at the end of the session was positive in terms of the experience, and they stated that they would support a curriculum that integrates such teaching methods.

4 Discussion and Conclusion: The Good, the Bad, and the Ugly

As with any other experience, some of our work flowed seamlessly, some was bad, and some was quite ugly. In this final section of our paper, we tackle our findings from a facilitators' point of view, and we wish to underline the main challenges we were faced with. We dub them challenges, and not insurmountable problems, as we believe they can be overcome. Being the optimists that we are, we will start with the good. We can safely state that the general answer to our research questions is Yes! Yes, City of Emotions is versatile enough to respond to the different needs of contexts such as organizational and educational settings. Yes, the design model behind it and the gaming simulation mechanism are sturdy enough to fully respond to the different learning challenges and needs. And yes, gaming simulation is a powerful enough tool to overcome cultural and systemic tars that mar the current Romanian culture and environment. We found enthusiasm in our students for new (to them) methodology, and we found eagerness in our workshop participants for a new way of thinking and doing.

And now the bad! Thankfully, the bad was not all that bad at all. Mainly the issue we found with our student group was their unease with the drawing part of the game. City of Emotions was built for architects and urban planners, and perhaps for them drawing comes natural. The immensely successful Parcobaleno Project [11] involved children, and children have no boundaries when it comes to play and playing. Our students were more sat in their ways, and they generally defined themselves as "non-artistic." It was a limitation they imposed on themselves. We overcame it by encouraging them through the drawing process and by insisting that *anything goes*. And it mostly worked. Another issue that was problematic was with the time frame of the game. A regular class session takes 2 h, and that was the time frame we had to work with. In the original version, with art prone people involved, this is enough to run the game. However, given the time they needed to overcome their artistic complex, and considering the dual focus of our debriefing on both participatory approaches and gaming simulation as a worthy teaching and learning methodology, that given time frame was a challenge. We don't recommend altering the design as to exclude the drawing, since it is integral to the gaming simulation mechanism and, as such, invaluable for the debriefing stage. We do however suggest adjusting the time frame in such a way that it allows for a proper run of the game and taking into account the background of the participants when doing this.

And finally, and inevitably, the ugly! Unsurprisingly, our ugly was found in the organizational setting. Thankfully, it was not a participant-related problem, nor was it related to the run and facilitation of the simulation game. Unlike "the bad," which discusses issues related to the implementation of the game, "the ugly" pertains to the larger organizational context. Schein [13] talks about the importance of obtaining organizational and leadership commitment, and Klabbers [8] states that identifying the Problem Owner is one of the first steps in the gaming simulation design process. This ensures an understanding of the objectives of the simulation by all parties involved as well as facilitates long-term implementation of learning outcomes. While we believe we have obtained commitment from our participants and have run the game in accordance with their needs, the CEO was never integrated into the development process. In our understanding part of the problem, to begin with, was his unwillingness to release control and encourage initiative. As such, we are confident that we have raised awareness among our participants and have challenged their mental models with regard to their functioning as a team. However, since we currently lack follow-up data, we are cautious in declaring a completely successful intervention in terms of organizational cultural changes and innovation. To mitigate the potential negative effects is a question of obtaining organizational commitment just as with any other organizational intervention process.

Extrapolating on "the ugly," we included in our debriefing sessions a short section on the shyness toward gaming simulation that we were faced with in different contexts. Their hypotheses and our experience in other organizational settings lead us to believe that the reason for it could be poor practice. When it comes to business, companies, more often than not, acquire training programs based on opportunity, cost-effectiveness, and fads, rather than strategic planning of their HRM programs. Training exercises are often evaluated in terms of participant satisfaction and the fun they had. Not all practitioners take the time for proper debriefing. Moreover, from a gaming simulation standpoint, "the primary function of gaming is not information transfer, but influencing thought and action" [24]. This does not happen when debriefing is overlooked or treated as a by-product. Without a carefully thought out debriefing process, we can't really say it was a gaming simulation at all. And in the absence of a proper design process and of thorough debriefing, gaming and training exercises are exactly what Klabbers [24] coined "a box of tricks."

For our concluding remarks, we want to restate our positive experience with the adaptation of "City of Emotions." It is a highly versatile frame game, which easily engages participants with different backgrounds and experience. Because of its design that allows for great interaction among the participants, in the debriefing sessions we facilitated, we were able to uncover and highlight a variety of processes and emergent states at team level. At the same time, it is a powerful tool for creating awareness at the individual level as well.

References

1. Harviainen JT (2017) Editorial: expanding the borders of simulation/gaming. Simul Gaming 48(3):295–298
2. Klabbers JHG (2018) On the architecture of game science. Simul Gaming 49(3):207–245
3. Klabbers JHG (2000) Learning as acquisition and learning as interaction. Simul Gaming 31(3):380–406
4. Chirica S, Andrei DM, Ciuce C (2009) Aplicații practice ale psihologiei organizationale. ASCR, Cluj-Napoca
5. Rizzi P, Sidoti B (2004) La citta delle emozioni (The city of emotions). In: Rizzi P (ed) Giochi di Citta. La Meridiana, Molfetta
6. Yin R (2003) Case study research: design and methods, 3rd edn. Sage, Thousand Oaks, CA
7. Hense J, Kriz WC (2008) Making simulation games an even more powerful tool. Introducing the theory-based evaluation approach. In: Calwe LD, Hofstede GJ, Peters V (eds) Why do games work. In search of the active substance. Kluwer, Deventer, pp 211–218
8. Klabbers JHG (2009) The magic circle: principles of gaming and simulations, 3rd edn. Sense Publishers, Rotterdam
9. Peters V, Ewerwijn H, van de Westelaken M (2014) The evaluation of a discipline: a framework for evaluating simulation games. In: Duke RD, Kriz WC (eds) Back to the future of gaming. W. Bertelsmann Verlag, Bielefeld
10. Rizzi P (2014) On the Nature of Gaming-Simulation, 2nd rev edn. Scriptum, Krakow
11. Rizzi P, Guarino M (2018) Parcobaleno: Qui serve un po' di magia! Le idee dei più piccoli per la ricostruzione. In: Belingardi C (ed) Manuale di Progettazione Partecipata con le Bambine e i Bambini. Zeroseiup, Bergamo
12. Morgeson FP, DeRue DS, Karam EP (2009) Leadership in teams: a functional approach to understanding leadership structures and processes. J Manag 36(1):5–39
13. Schein EH (2004) Organizational culture and leadership. Wiley, Hoboken
14. Duke R (2014) Gaming: the future's language, 2nd edn. W. Bertelsmann Verlag, Bielefeld
15. Salas E, Rosen MA, Burke SC, Goodwin GF (2009) The wisdom of collectives in organizations: an update of the teamwork competencies. In: Salas E, Goodwin G, Burke SC (eds) Team effectiveness in complex organizations: cross-disciplinary perspectives and approaches. Psychology Press, Taylor & Francis Group, New York, p 2009
16. Edmonson AC (1999) Psychological safety and learning behavior in work teams. Adm Sci Q 44(2):350–383
17. Huber G, Lewis K (2010) Cross understanding: implications for group cognition and performance. Acad Manag Rev 35(1):6–26
18. Klimoski RJ, Mohammed S (1994) Team mental model: construct or metaphor. J Manag 20(2):403–437
19. Liedtka J, Ogilvie T (2011) Designing for growth: a design thinking toolkit for managers. Columbia University Press, New York
20. Hess E, Liedtka J (2012) The physics of business growth: mindsets, system, and processes. Stanford University Press, Stanford
21. Brown SL, Eisenhardt KM (1998) Competing on the edge: strategy as structured chaos. Harvard Business School Press, Boston
22. Hjorth D, Strati A, Drakopoulou S, Weik E (2018) Organizational creativity, play and entrepreneurship: introduction and framing. Organ Stud 39(2–3):155–168
23. Schon D (1983) The reflective practitioner: how professionals think in action. Temple Smith, London
24. Klabbers JHG (2014) Gaming as language for dealing with complex systems in general. In: Duke RD, Kriz WC (eds) Back to the future of gaming. W. Bertelsmann Verlag, Bielefeld, pp 12–29

Emerging Hope After Disaster: The Parcobaleno Project

Paola Rizzi and Monia Guarino

Abstract We are currently observing a renaissance of the use of gaming simulation in urban planning. However, it is very rare that a game is followed up by so-called 'debriefing' after an urban gaming simulation (UGS), i.e., the practical applications drawing directly from the design process.

This paper describes a project on the design and construction of a school park and playground that was destroyed by the earthquake of 2012 in Emilia-Romagna, Italy and the crucial role of the UGS framework called the 'City of Emotions' (Rizzi P, Sidoti B, La città delle emozioni. In Rizzi P (ed) Giochi di Città. La Meridiana, Molfetta, pp 101–104, 2004 (in Italian)), which was renamed 'Park of Emotions' in this case study. In 2016, Parcobaleno park was awarded for its innovative approach in design and management at the 6th edition of 'Città per il verde', amongst other reasons.

Keywords Reconstruction plan · Participatory design · Public space · City of Emotions

1 Introduction

The use of gaming simulation in urban planning is increasing, especially in the arena of participation in urban design and planning. The popularity and increasing interest in so-called 'gamification' reflects this. However, despite its use, in only a limited number of cases have the game sessions been followed up by what is the meaningful 'debriefing' of an urban gaming simulation (UGS): implementation of the results and evaluation of the design process. The results are often included in the

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'introductory' and 'final consensus' phases but not during the design process. The reasons for why this is the case are varied: the most probable and common one is that participation is seen as a "catalogue of wishes and needs" more than elements or implementing criteria for the designer. Therefore, UGS is more a sort of communication tool to increase the level of interaction between decision-makers and final users. We believe that, if it is included in an effective and efficient process of participation, the potential of UGS can increase the quality of urban design. The UGS named 'City of Emotions' [1] was used in a project for the design and realization[1] of a school park and playground after the earthquake that destroyed the city of Emilia-Romagna in 2012. The UGS, which was renamed 'Park of Emotions', guided the entire process through suggestions and feedback and being a checking tool for the landscape designers. As result, Parcobaleno park is now a shared public space, which, in 2016, was awarded for its innovative approach in design and management at the 6th edition of 'Città per il verde', amongst other reasons.

1.1 UGS and Participatory Design

Participation can make a decisive contribution to the process of appropriation or reappropriation of space by individuals who dwell within it. It can also provide different ways of dealing with individual and collective capacities of perception, amongst others by using gaming simulations. They contribute to the construction of various and sometimes original forms of participation, new forms that do not exclude the roles of the participating communities, like decision-makers and experts, who must create new methods and options because the participation deploys itself entirely and then helps the collectivity to unravel its internal contradictions [2]. Fixing a strong sign is neither necessary nor sufficient to outline the guidelines for the development and transformation of an area or territory, especially if the project for that sign is not a result, at least partially, of a perceived and shared context [3, 4]. To talk about context is to invoke a more solid link between citizens and institutions and to educate on how to understand the complex urban systems in order to make it all possible.

The planning practice is always searching for approaches that give visibility to participatory processes and create the point of connection, exchange, and mutual adaptation between participation and spatial organization.

These are the reasons why UGS has become part of the equipment in the tool box of an urban planner. Gaming simulation has been used in planning for many decades as an instrument for analysis and research. Since the 1990s, the use and development of this instrument has improved the area of participation or, in general, of

[1] The facilitator of the entire process was Monia Guarino, the structure of the UGS and evaluation was under the scientific responsibility of Paola Rizzi, the design and technical supervision of the realization of the park was by landscape designer Robert Malagoli, Landscape Design Office Roberto Malagoli, Mirandola, Italy.

involvement processes at all levels: information, communication, and interaction addressed to citizens as well as groups of interest [5, 6].

Nevertheless, it is possible to see a large gap between theory and practice: rarely are the results of participatory processes, including UGS, clearly implemented in design. The results, rather than being included and implemented in the urban design or plan, are seen as 'nice possibilities/ideas' or ideal goals.

It is important to make a distinction between informative top-down processes in contrast to the 'openness' of effective participation and bottom-up processes. It is a fact that, in the bottom-up approach, it is the public administration, rather than community, that is, the promoter of such initiatives, that determines the limited involvement of citizens [4]. In the last decade, administration made a strong and declared willingness to activate participative planning processes. This was the case for Novi: the municipality made it clear since the day after the earthquake that the reconstruction plan was to be accompanied by a participatory process.

The organic plan was the outcome of this and one the actions was the decision to use participatory design for the elementary school's park.

1.2 Background: The Emilia-Romagna Earthquake

Italy is a seismic country but, after the earthquake of L'Aquila, the country was affected by a series of quakes that struck Emilia in 2012 on May 20th (M 5.9), May 29th (M5.8), and June 3rd (M 5.1). The disaster hit one of the most strategic areas of the Italian economy, as the 2% of the GDP is produced there. The area was not classified under a national law as being vulnerable to earthquakes according to the suggested national classification applied by the regional administration to new buildings and constructions (OPCM 3274 2003) [8]. It is important to be reminded that the area was under review to upgrading its level of seismic risk.

The damage caused was serious: 58 municipalities were affected, 27 people died and 500 were injured, 45,000 people lost their homes, and 900,000 people were affected or displaced[2].

Since the first steps/moments of recovery, the reconstruction phase was supported by a participatory process.[3]

Novi di Modena is one of the 58 destroyed small towns. It is located on the flatlands of Pianura Padana with a population of 10,245 in an area of 51.8 km^2, with a density of 200/km^2. More than 50% of the built environment was destroyed or severely damaged and more than 5000 people were evacuated. After the first emergency, the

[2] The data and statistics about the earthquake are detailed in the documents and information produced by Region Emilia Romagna. Cfr. "Geological, seismic and soil survey" by E-R Ambiente, 2013. https://ambiente.regione.emilia-romagna.it/geologia-en/temi/sismica/earthquake-20-may-2012

[3] LR 122/2012 and art. 9 of norms for approval of LR 122/2012 stated that the participation of the population is compulsory in the reconstruction plan of the municipality. In Italy, this is the first time that participation is recognized as a fundamental part of the urban planning process.

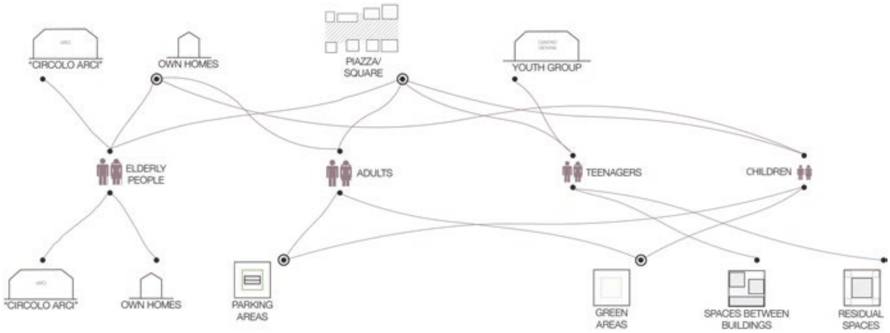

Fig. 1 Use of the public space in Novi before and after the disaster in the red zone. (Adapted from Margherita Chiappe: Rebuilding after the earthquake: public space as a promoter for urban regeneration. The case of Novi di Modena. Master's thesis in Architecture, 2015 supervisors: Paola Rizzi, Monia Guarino, Lorenzo Cotti [7])

administration started to work on the reconstruction plan following the guidelines of the regional law that prescribes the involvement of the local population in the plan. After 2 years, the result was the organic plan[4], a strategic plan of different actions and proposals that was strongly linked to the physical plan of reconstruction. One of the most important goals of the reconstruction plan was to support and help the population to overcome the social trauma post-disaster by revitalizing urban areas and identifying and/or creating new spaces and places as a gathering point for the community. Among the proposals, one was considered with a lot of care: the reconstruction of the elementary school and its playground and park. It involved children and families: their houses were destroyed or had to be repaired and the only element that was still standing was a tree in front of the collapsed school. It is for this reason since the beginning of the reconstruction of the school that the playground and park were seen as being of significant importance. It is important to understand that, before the earthquake, the children used the playground as a public space, especially the main square, as well as their gardens at home. After the earthquake, they used what was left of the greenery and parking area (Fig. 1). Therefore, it is understandable why they were desperately seeking a place where they can enjoy activities and play games.

2 Going Back to the Roots: From 'City' to 'Park of Emotions'

"A bit of magic is needed!" was the slogan of the first meeting in January 2014 of the children and parents with facilitators and designers.

[4] Cfr. Comune di Novi di Modena, Relazione sintetica Piano Organico, December 2014. This is the final document released by the municipality which includes urban policies, strategies, and actions. https://www.comune.novi.mo.it/index.php/fatti-il-centro-tuo

The decision of the facilitators was to use and adapt a UGS called the ‘City of Emotions’, an open-frame game that had already been used in many different cases, from community development to participatory design of public spaces. The participants were divided into design teams representing different groups of citizens.

Each group designed its own neighborhood, keeping in mind a certain emotion that the participants felt as given by their real living space or an emotion they would have wanted to associate with their ideal living space. Once each group completed this process, all of the groups came together and positioned all the neighborhoods generated by the game within the same city in which they had to live.

The idea behind the game is that places and spaces can generate emotions or are associated with emotions. These might vary from individual to individual or between different groups of people.

The ‘city’ was replaced by ‘park’, which transformed the game into ‘Park of Emotions’. Its use was structured into three phases: identification of the feeling/emotion, composition of the different corners designed, discussion and evaluation of the final scenario.

The main goal was to obtain a proposal that, once implemented, could give new life to the demolished area of the old school and embrace the active involvement of the children.

2.1 *Playing ‘Park of Emotions’*

The activity was divided into three phases. It took 40 h of UGS and design workshops with students aged 8–9 years divided into six classes (3rd grade and 4th grade A, B, C sections) of the elementary school (January–April 2014), three meetings with parents and teachers, and two public hearings with the presentation of the guidelines to the community.

The students were divided into different teams and asked to design an ideal corner of the school park and playground instead of a city. The result was the detailed drawing of specific ‘corners’:

- First phase: Design. The focus of the first step was to work on the emotions given to a future life after reconstruction. With the support and suggestions of the teachers, the children were divided into groups according to their sensitivity. They created a map of the corner, presented this to the other teams, and, finally, there was discussion and selection of the features of each corner. A surprising result was that the corners of ‘boredom’ and ‘freedom’ were designed with almost the same criteria: large empty spaces, very few games, no physical elements. The phase took 4 h per class from March to April 2014.
- Second phase: Composition. This phase involved the evaluation of three hypotheses on how to put together all of the different corners: a shape of a star, distributed along a path or merged. There followed discussion and selection of the most suitable solution (Fig. 2). As a result, the children widened their perspective and

Fig. 2 One of the gaming sessions of 'Park of Emotions'

they included the park, the playground, and the school garden. They proposed a sort of green belt where all the designed corners could be distributed. The time required was 4 h per class during April 2014. Before entering the third phase, the facilitator combined all of the proposed solutions into a single scenario.

- Third phase: Discussion and final model. After the discussion of the proposed scenario, each class designed a physical model that was combined with the others into one big model. Each corner was designed following the suggestions that originated from an emotion or value identified by the children as fundamental for community life. In Parcobaleno, there are the corners of 'calm', 'cheerfulness', and 'friendship' linked to leisure time; the corner 'love' devoted to the urban garden; the corner 'joy' for free meetings accessible to everybody; and, finally, the 'amusement' corner, which is dedicated to outdoor activities and sports, and is close to the gymnasium, as their functions complement each other. The third step required 4 h per class during May 2014.

Conclusions The final model was presented to the parents and citizens of Novi and a referendum was held to give a name to the new park. An 'urban picnic' was organized in the main square and all of the pupils and their families and all the citizens were invited. The name chosen was Parcobaleno, a combination of the words 'parco' (park) and 'arcobaleno' (rainbow). At the same time, after the name decision, the facilitators and designers implemented the results of the UGS in the design guidelines of the park. On 13th December 2014, the public process of selection of the landscape designer was launched and the final proposal was presented, discussed, and approved by the administration. The crowd-funding for the realization began. At the end of the 2015, everything was set for the works. The construction activities began on 10th March 2016 and Parcobaleno was inaugurated on 24th September 2016. The area of the park is 4500 m^2 and it contains a house on the tree, a basketball court, a wall for climbing, Wi-Fi, and other facilities. The realization of Parcobaleno was monitored by school classes via a diary, interviews with the

Fig. 3 The work in progress was monitored by the children and their teachers

workers, and discussions in class (Fig. 3). At the opening, the children noted that all of their emotions were recognizable in the settings and features of the new park. For the children, the logo of Parcobaleno, a tree, as in the house in the tree, meant a new safe start.

3 UGS/Participatory Design in Reconstruction After a Disaster: Some Reflections

The results of the use of a gaming simulation and its effects on the process are very positive. Looking at the process itself, it is possible to recognize some challenges and difficulties.

Starting from the difficulties, the main goals of the project were twofold. The first was to overcome the social 'trauma' generated by earthquakes, rejuvenating places, and giving buildings new reference points for community life. The second difficulty was also fundamental to enhancing the creative competencies of children, accommodating their original contents without manipulation in the park design.

Regarding the challenges, the facilitators and designers had to endure long periods of design and work in progress procedures without waning in enthusiasm and needed to sustain full interest during their participation in the whole project.

Finally, the process also had some strengths: the guidelines shared and decided by the entire community, originality and feasibility of the project proposals, the attention and care of future users with different needs and abilities, and, finally, the innovation and sustainability of the materials used. In fact, the paths were made using the debris obtained from the demolition of the school and the park furniture was produced using recycled material. Parcobaleno park received a special award in the section of 'Urban Green' for the "innovative lighting of public space" due to the innovative management, energy saving, creativity in the use of illumination of different zones of the garden, and for its original aesthetic sense.

4 Conclusions and Further Research

The UGS 'City of Emotions' has proven to be a powerful tool for initiating and emphasizing participation in real-life urban planning processes, especially in healing social trauma after disasters.

The results obtained are relevant not only to the process of the design of the new school park but it confirms the power of UGS to enhancing a dialog among different targets that follow different 'codes' and possess different knowledge and skills. In the process of participation and design, the technicians and experts adopt a technical language, while the adults and public use plain words, sometimes slang, and so on. 'Park of Emotions' put the designers and the children in different positions: to the first group, participants were asked to play along and, instead, the kids were left to be in charge of the design. The designer has to accept the uncertainty and vagueness of the children and be open to where their curiosity will lead.

The process achieved two important goals. The first was to increase the collaboration and cooperation of all citizens, including the youngest, and, second, the guidelines are applicable to other similar situations. The collaboration and cooperation improved because the population shared the task of innovative design of a public space of high spatial and environmental quality and, by the public hearing, all of the citizens were involved, as the choice of the name for the park was decided by a public referendum. The guidelines formed during the process were very positive and, therefore, the administration decided to apply them as general technical guidelines for public space design in the future.

Today in Novi, Parcobaleno park is an often used, popular, and livable public park. It brings together not only kids and pupils but also teenagers, the elderly, and families. School classes often use the park as an open-air classroom.

The most important finding was the confirmation that UGS offers the opportunity of efficient participatory design but, more importantly, the proper and well-tutored use of UGS could offer to the kids who had been severely affected by seeing the ruins of their former school a new hope for a different and better life after the disaster.

The future research will try to develop and use this activity in the concept of 'dual space' [6] as a learning and preparedness space during peace time and as a comfortable living zone for evacuees after the occurrence of a disaster.

References

1. Rizzi P, Sidoti B (2004) La città delle emozioni. In Rizzi P (ed) Giochi di Città. La Meridiana, Molfetta, pp 101–104 (in Italian)
2. De Carlo G (1976) Gli spiriti dell'architettura. Editori Riuniti, Roma (in Italian)
3. Rose G (1996) Place and identity a sense of place. In: Massey D, Jess P (eds) A place in the world place, cultures and globalization. Oxford University Press, Oxford, pp 87–132
4. Rizzi P, Vania A (1999) Community visioning e le Nuove Tecnologie dell'Informazione e della Comunicazione: visti, uditi o compresi? 45–48 Archivio di Studi Urbani e Regionali, 65, Franco Angeli, Milano, Italy (in Italian)
5. Rizzi P, Promsaka Na Sakkannakron S (2014) Conceptualizing the essential role of gaming simulation as a risk communication technique for enhancing urban resilience against natural disaster 345–356. In: Kriz W (ed) The shift from teaching to learning: individual, collective and organizational learning through gaming simulation. Bertelsmann Verlag, Bielefeld
6. Rizzi P, Marcia A, Denti B, D'Ascanio F (2017) Strumenti di supporto a territori fragili e vulnerabili: dalla giocosimulazione al Piano di Protezione Civile, Resilienza, Circolarità e sostenibilità 307–310 Special Issue, Urbanistica e Informazioni, INU (in Italian)
7. Chiappe M (2015) Rebuilding after the earthquake: public space as a promoter for urban regeneration. The case of Novi di Modena. Master's thesis in Architecture, supervisors: Prof. Paola Rizzi, Arch. Monia Guarino, Arch. Lorenzo Cotti, University of Sassari, Alghero, Italy (in Italian)
8. Regione ER (2012–2017) L'Emilia dopo il sisma. Report su cinque anni di ricostruzione, http://www.regione.emilia-romagna.it/terremoto. Last visited 2018/06/25

Part VIII
NEO-Simulation Gaming Toward Active Learning Era

Developing a Cohesive Active Learning Approach by Integrating Theoretical Case Studies and Practical Problem-Based Learning Principles

Francis X. Otieno

Abstract This chapter explores a hybrid approach to teach students from diverse nationalities and disciplines within a limited time by lowering the communication and distinct academic barriers by using a social constructivist model that ushers students into the social aspect of instruction. Case study and problem-based learning (PBL) is employed as teaching approach and assessed using the Rich Environments for Active Learning (REAL) framework which is a comprehensive instructional system that promote study and investigation within prescribed contexts. The REAL evaluation shows high student comprehension and increased collaboration among students and teachers and cultivation of rich and involved knowledge structures using realistic case studies and articulated PBL performances.

Keywords Case study · Integrated active learning approach · Policy science · Problem-based learning

1 Introduction

The program of international problem-based learning (PBL) offered at Ritsumeikan University draws students from a wide series of disciplines and nationalities. The primary course objective is to set a stage for designing a business entity that can address social issues, by drawing on the diverse backgrounds of the students. In spite of the rich student diversity, since most students are not from a business background, there is a need to bridge the business competence gap to enable the students to achieve the course objectives. To bridge the gap in the shortest time possible while allowing for full comprehension of the basic concepts, an integrated theoretical and practical approach is needed.

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One of the instructional strategies that illustrates this approach is PBL. This approach embodies the theoretical foundations and instructional procedures espoused in the Rich Environment for Active Learning (REAL). In this respect, this paper presents the experience gleaned in the international PBL course offered by College of Policy Science elucidating the concepts of the REAL approach that integrates the academic concepts of a case-based approach and practical strategies based on PBL methodology. This should enable students to draw up cross-disciplinary solutions as they develop their business skills.

2 Diversity in the College of Policy Science

The goals of any institute of higher learning are to link intellectual, theoretical concepts with the social and professional demands of the world. Thus, the university seeks to design curricula aimed at enabling students to develop certain set of skills that go beyond academic goals and a singular discipline. The policy science program at Ritsumeikan University envelopes this philosophy.

2.1 Policy Science

Policy science is a relatively new discipline that was initiated to offer a cohesive and comprehensive array of methods to address real-life issues in ways that clarify and secure societies' common interests. In addition, the School of Policy Science endeavors to build degree-generic competencies and transferable skills that can be used for various functions and tasks [1]. In this regard, policy science as an academic approach is positioned to address a vast number of issues and at several levels, such as regional, national, and international, or at levels of governance covering areas such as management and leadership; or it is, in general, an approach that looks at solutions that impact human life in areas that encompass decisions carried out to improve health, education, and political practices. In this regard, an increasing number of people across diverse academic disciplines are embracing policy science as a way to address the plethora of issues and problems faced by society. This diversity of the College of Policy Science at Ritsumeikan University is reflected by the range of composition of its lecturers who are experts in a number of disciplines and also by its exchange students who come from a cross section of undergraduate and graduate fields. The international PBL course is taught by an instructor whose background is rooted in technology management, and it is in this regard that the objective of the international PBL course is biased toward the instructor's field of expertise in developing innovative business start-up companies that have the potential to address societal issues.

The design of the international PBL course syllabus encourages an interdisciplinary approach that attempts to acknowledge the existence of complementarities drawn from the diverse students' backgrounds. Therefore, the instructor presents a problem selected to allow the students to leverage their diverse strengths [2]. Following the recommendations of studies done at the Monterrey Institute of Technology and Higher Education, it is recommended that students have a working knowledge or competencies in the area of the project theme. In this case, the students were required to have a working knowledge of fundamental business concepts so that they could attain the requisite abilities to come up with formidable solutions. Case studies were used to enrich the students' business competencies by employing Harvard-produced business case studies that are biased to venture firm creation and development and small- and medium-sized company strategies.

2.2 Case Study

Case studies that use a case-based approach (CBA) employ real-life situations that present important distinctive characteristics, especially in the application of the decision-making process. One of their key benefits is their ability to capture what Hodkinson and Hodkinson [3] call "lived reality." They portray real-life situations involving decision-making processes by main actors while at the same time simplifying complex concepts.

In the international PBL class, case studies biased to the business field were used to achieve two primary objectives. One was to develop business competence since the students did not come from a business background. The second was to avoid emphasizing specific answers to specific problems and instead to enforce skills concerning analytical aptitude and decision-making abilities and capabilities.

The students were divided into groups of three or four, and they were expected to make presentations and reports on a case assigned to them. To create an acceptable presentation, the group members had to work within a given time frame, drawing on their respective talents. This forced them to deal with the real problems efficiently, using limited resources in terms of time and, to an extent, limited knowledge that they only derived from the classroom. Thus, while developing their theoretical competence, the students also developed skills in communication and cooperation, which were further enhanced by the shift in the focus of learning from the teacher to the student.

2.3 PBL

Tabira and Otieno's research on enhancing education through a customized, augmented ICT approach showed that shifting the focus of pedagogy from the teacher to the students leads to a learner-centered approach that consequently enhances a learner's motivation to study while encouraging active student participation and engagement [4].

PBL has gained prominence in recent education literature and study where proponents like Dewey qualify the importance of PBL learning as adept to instruct students so that they are better prepared to face practical life. Dewey has been a harsh critic of the traditional method of education dissemination, in which the student remains a passive recipient of knowledge, whereas the teacher acts as the source and transmitter of predefined facts. He argued instead for an active approach and practical experiences that groom students through an ongoing learning process that can be applied to a dynamic world [5].

PBL students try to solve questions without any prior knowledge, and they attempt to find answers by exploring several options provided by an open-ended question that does not call for a singular solution. For that reason, rather than construct a setting where the lecturer is obligated to teach and where the students are mere recipients of the knowledge, PBL prompts students to apply themselves to the specified situation. Researchers are quick to conclude that this added activity approach is better than more passive methods at developing deeper understanding, and learners are more inclined to comprehend when they engage in playing rather than traditional learning experiences [6, 7].

In addition, PBL has been called an ideal method that educators employ to assist students in clarifying non-standardized issues [12]. The approach of using non-standardized issues calls for learners to come up with various solutions. Moreover, responsibility is placed on the students, while the educator's role is relegated to that of a facilitator rather than a provider of information [8, 9].

The profound flexibility of the School of Policy Science to adopt to this learner-based pedagogy is presented within the integrated framework of the case study approach and PBL methodology.

3 Implementation of the Integrated Framework

The course was designed to create a learning environment that stresses the main characteristics of the PBL approach; that is, the contents must be applicable and interesting, with clear objectives defined in stages and that lead to diverse but appropriate solutions that develop skills and competencies relevant to the real world. The learning environment emphasizes integration, comprehension [10], and execution. Integration is the process of linking past knowledge to current knowledge by enriching students' prevailing knowledge [11]. Comprehension refers to the importance of contextualizing learned strategies drawn from diverse disciplines.

This acquisition and linkage of knowledge and its consequent comprehension is carried out by students, who are expected to present credible justifications for their recommendations and solutions for the problems in their assigned cases, drawing from past examples and applying them in appropriate contexts. This execution by students is referred to as generative learning in the REAL framework, where students are demanded to produce something of value. In this case, the students work on projects while building competencies that will enable them produce something of value.

3.1 Developing and Building Competence

For the students to produce something of value, they were required to acquire the principal understanding of business concepts and practical applications through original and realistic case studies that were legitimately procured from Harvard Business School. The case studies included aspects such as business development, business management, and cross-border expansion strategies. The students were divided into groups of four or five that had a balance of nationalities paired with a Japanese counterpart (each group had to have at least two Japanese students). This was done to foster homogeneity by having students with a Japanese background as the common denominator and, at the same time, to create a balanced integration owing to the heterogenous backgrounds of the students in the course. In addition, the Business Model Canvas (BMC) was introduced. The BMC has been used and adapted to suit specific business scenarios and applications, by developing a singular reference drawn from the similarities of a wide range of business model concepts.

The instructor encouraged cooperative teamwork and collaboration throughout the process, from brainstorming sessions on ideas for a business to the development and mapping out of the ideas into concrete solutions. Figure 1 shows one of the mapping out sessions where the groups are actualizing the theoretical concepts gleaned from case studies. The instructor encouraged the students in each group to establish practicable roles and responsibilities that would facilitate the smooth running of the group activities. Interchanging the roles after a specified period was also encouraged so the students could have uniform experiences of the diverse responsibilities.

This kind of active engagement was made possible by the resources provided for active learning activities. For example, the laptop shown in Fig. 1 was provided to each group so that the students could summarize their findings in a concrete document and use the computer as a learning (e.g., search) tool for their project.

Fig. 1 Students engaged in a concept development discussion

3.2 Resources for REAL

Apart from the laptop computers, to enrich the integrated framework, other structural resources were used to facilitate the REAL approach. Figure 2 shows the use of movable furniture that can be rearranged to suit the needs of the group assignment on the particular day. Additionally, smart boards were provided so that the students could present intermittent work to the instructor, who played the role of a client or audience when evaluating the project's progress.

3.3 Follow-Up and Regular Assessment

After building fundamental competencies, the students were expected to leverage their diverse strengths as international students to come up with a business idea that reflected their diverse backgrounds. Based on the common denominator of Japan, the business should be able to operate in Japan and later expand to ASEAN countries. The instructor furnished students with the socioeconomic metrics and political data of various ASEAN countries to enable the groups to make an informed decision about expansion strategies for a chosen ASEAN country. The students were expected to select a country that was the most suitable for the business expansion, and the strategy had to be consistent with their initial business model.

Fig. 2 Flexible resources and materials to promote active learning and unrestricted class movements (Smart boards and wheeled furniture)

4 Discussion

The pedagogical shift from lecture-focused to student-focused learning presents an environment for the development of a new set of skills that are applicable to the real-world setting. This paper presented the details of the international PBL course that uses the integrated framework with the REAL approach. The course also showed that the generic competencies that confirmed the skill set highlighted in the Tuning Project can be categorized into three aspects, namely, instrumental, personal, and systemic (Tuning Project, online).

Instrumental skills concern planning, organizing, oral and written communication in a given language, computer language, and problem-solving capacity. Personal skills include teamwork aptitudes, working in an interdisciplinary team, contextualization, and critical thinking. Systemic skills consist of self-learning, creativity, and awareness of different cultures. They also include entrepreneurship and sensitivity to environmental issues. As these skills are complementary to the REAL framework, we examine the aspects presented in the international PBL class in terms of the REAL framework. Table 1 presents a cross-tabulation of the components of the REAL framework as experiences in the PBL course in relation to the skill needs for an authentic PBL approach.

5 Conclusion

Table 1 shows that the integrated framework presented through the REAL approach produces the required skill set for an authentic PBL implementation. Therefore, the integrated framework helps to provide an environment where students play active roles in their own learning after a basic competence-building procedure is implemented. In the context of the international PBL class, the students developed real-life skills as shown in the Tuning Project. Specifically, they acquired skills biased to critical thinking, group dynamics, and international expansion strategies. Finally, a cross-tabulation was presented to summarize the objectives achieved in terms of deployment as presented in the REAL attributes and in terms of the student outcomes and skills gained, shown in relation to the corresponding Tuning Project factors.

Table 1 REAL framework components in relation to PBL skill

	Instrumental	Personal	Systemic
Student responsibility and initiative	x	x	x
Generative learning strategies	x	x	x
Authentic learning context		x	
Assessment and evaluation strategies	x		
Cooperation and collaboration	x	x	

References

1. Connolly T, Stansfield M (2006) Using games-based eLearning technologies in overcoming difficulties in teaching information systems. J Inf Technol Educ 5(1):459–476
2. Lacuesta R, Guillermo P, Luis F (2009) Active learning through problem based learning methodology in engineering education. IEEE, 39th ASEE/IEEE frontiers in education conference. Session M4C
3. Hodkinson P, Hodkinson H (2001) The strengths and limitations of case study research. Paper presented to the learning and skills development agency conference, making an impact on policy and practice, Cambridge, pp 5–7
4. Tabira Y, Otieno F (2016) Integration and implementation of sustainable ICT-based education in developing countries: low-cost, en masse methodology in Kenya. Sustain Sci 12(2):221–234. Online edition
5. Savery JR (2006) Overview of problem-based learning: definitions and distinctions. Interdiscip J Prob Based Learn 1(1):5–22
6. Dorn DS (1989) Simulation games: one more tool on the pedagogical shelf. Teach Sociol 17(1):1–18
7. Shellman SM (2004) Active learning in comparative politics: a mock German election and coalition-formation simulation. Pol Sci Polit 34(4):827–834
8. Lambross A (2002) Problem based learning in K-8 classrooms. Corwin Press, Thousand Oaks
9. Hmelo-Silver CE, Barrows HS (2006) Goals and strategies of a problem-based learning facilitator. Interdiscip J Prob Based Learn 1(1):21–39
10. Scott GR, Dunlap JC (2002) Problem-based learning as an example of active learning and student engagement. In: Yakhno T (ed) Advances in information systems. ADVIS 2002, Lecture notes in computer science, vol 2457. Springer, Berlin/Heidelberg
11. Hannafin Michael J (1992) Emerging technologies, ISD, and learning environments: Critical perspectives. Educ Technol Res Dev 40(1):49–63
12. Strobel J, van Barneveld A (2009) When is PBL more effective? a meta-synthesis of meta-analyses comparing PBL to conventional classrooms. Interdisciplinary J Problem-Based Learning 3(1)

Physical and Mental Environments for Simulation and Gaming: The Facilitator's Role as a Designer of Environments

Mieko Nakamura

Abstract There are many distracting factors in an environment of simulation and gaming. This study focuses on the role of a facilitator as a designer of physical and mental environments in simulation and gaming. With the help of a facilitator, more people will be able to concentrate on the activities in simulation and gaming and review their experiences in a metacognitive manner to extract a general strategy through debriefing. This study discusses how to design a good environment for participants from the perspective of a facilitator.

Keywords Good environment · Debriefing · Design · Facilitator's role · Simulation and gaming

1 Introduction

There are many distracting factors in a learning environment. People are both physically and mentally affected by their environments. In this study, I discuss the importance of designing appropriate environments for simulation and gaming (S&G) and the role of a facilitator in maintaining a good environment for participants, particularly focusing on designing a good environment for participants of S&G.

Currently, I am teaching the course "Project Management and Decision-Making" using S&G at a university in Japan. Occasionally, teachers are asked to vacate their room for another teacher and allotted a new room. I was requested to move for the second consecutive year, and each room I was assigned was smaller than the last. Consequently, I worked in three different types of rooms, which made me think about the effect of physical environments on my students. Table 1 depicts the conditions of the rooms and the numbers of participants for each course from 2015 to 2017. Each year, two classes were organized, and approximately 50 students participated regularly.

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Table 1 Rooms and participants during 2015, 2016, and 2017

Year	Size (m^2)	Seats	Movability (desks, chairs)	Number of participants in two classes
2015	500	140	Middle (immovable, movable)	39–43, 47–52
2016	170	160	Low (immovable, immovable)	48–53, 49–55
2017	120	128	High (movable, movable)	47–52, 48–56

In 2015, I was assigned a large room. It is usually used as a study hall for students of the design course and seats 140 people. The desks are heavy and immovable, whereas the chairs are on casters and are movable. Six or eight pairs of desks and chairs are arranged in groups. The room is sufficiently spacious to accommodate approximately 50 participants, who usually arrange themselves into small groups by placing their chairs in circles. Each group can easily concentrate on their work without interrupting others.

The 2016 room was small, approximately one-third the size of the room I had been assigned the year before. This room is used for lectures and seats 160 people. Both desks and chairs are screwed to the floor and are immovable. When participants work in groups, it is difficult for them to concentrate, since most groups are seated very close to one another and the students interrupt each other's work. In addition, half of the members in a group have to sit facing backward to work within their group since the desks and chairs are immovable.

The 2017 room was even smaller, approximately two-third the size of the 2016 room. It is usually used for lectures and active learning and seats 128 people. The desks are on casters and are movable, and the chairs are very light and movable, as well. When participants work in groups, they gather their desks and sit close together in small circles. While working in groups, even when the room is crowded, students can usually overcome distractions and concentrate on their work in the following manner: First, group members sit facing each other by arranging their desks and chairs as required; second, each group sits at a certain distance from the other groups by keeping unused desks and chairs between themselves and the other groups. Although this room was the smallest, it provided students the most room to move among all the rooms that I have been assigned.

2 Physical Environment and the Facilitator's Role

I collected data from the students who had registered for the course from 2015 to 2017 (see Table 1). Each course comprised 15 classes, during which several S&G sessions were conducted. Three classes were scheduled as a unit. The first and second classes were used to conduct games, and the third class was a debriefing session. The topics of games were communication, leadership, team building, social dilemma, and production management. In each of the two gaming classes, the groups worked in parallel, and the participants filled out a debriefing form and shared opinions within their groups after completing their work. The students took these forms home to prepare reports for the debriefing session to be conducted in the third class. In the third class, students silently read five to ten reports of their classmates. This class included a mini-lecture by the teacher and a group discussion, as well. In each class, students were assigned to different groups with different classmates.

In this study, participants were requested to rate their perceptions regarding S&G on a seven-point scale. The semantic differential method was used with 15 pairs of words related to S&G (see Table 2). From 2015 to 2017, the questionnaire was distributed at the beginning and end of each course. The study used the data collected from the students who had filled out both the pre- and post-surveys; it is noted that data from 87 students were analyzed for 2015, data from 102 students for 2016, and data from 103 students for 2017. As shown in Table 2, the three lowest mean scores in the pre-survey were recorded for Q1 (bright–dark), Q4 (necessary–unnecessary), and Q15 (interesting–uninteresting)—for all the 3 years, S&G was perceived as being bright, necessary, and interesting. This perception remained the same in all post-surveys, except for the one in 2016, when respondents perceived S&G as being less necessary. On the other hand, the three highest mean scores in the pre-survey were observed for Q9 (tough–enjoyable), Q10 (difficult–easy), and Q12 (complicated–simple), all of which were beyond the midpoint of the scale (4)—for all the 3 years, S&G was perceived as being enjoyable, easy, and simple. This perception changed in the post-survey, in which S&G was still perceived as being enjoyable, but not easy or simple as before.

At the end of the course, S&G was considered significantly more "rational and intellectual" in 2015 and 2017 and less "necessary and important" in 2016. The

Table 2 Means from 2015 to 2017

	2015 (n = 87)		2016 (n = 102)		2017 (n = 103)	
	Pre	Post	Pre	Post	Pre	Post
Q1 bright–dark	2.25	2.39	2.35	2.51	2.03	2.10
Q2 light–heavy	3.14	3.14	3.05	3.28	2.74	3.08*
Q3 hot–cold	3.24	3.16	3.41	3.46	3.01	2.97
Q4 necessary–unnecessary	2.43	2.66	2.45	2.92**	2.38	2.54
Q5 loud–quiet	3.39	3.03**	3.44	3.31	2.93	2.88
Q6 serious–unserious	3.51	3.68	3.46	3.53	3.54	3.58
Q7 rational–emotional	3.84	3.43*	3.57	3.82	3.79	3.39*
Q8 important–unimportant	2.63	2.69	2.65	3.11**	2.56	2.82
Q9 tough–enjoyable	5.20	5.05	4.92	4.72	5.25	4.86*
Q10 difficult–easy	4.20	3.79*	4.29	3.92*	4.48	3.74**
Q11 intellectual–nonintellectual	3.44	2.87**	3.61	3.48	3.90	3.17**
Q12 complicated–simple	4.36	3.32**	4.25	3.53**	4.59	3.46**
Q13 intensive–mild	3.87	3.78	4.07	3.85	3.64	3.49
Q14 deep–shallow	2.95	2.72	3.21	3.20	3.42	2.71**
Q15 interesting–uninteresting	2.44	2.31	2.58	2.91	2.54	2.42

*$p < 0.05$; **$p < 0.01$

unique aspect of the course conducted in 2016 was the small room with low movability (see Table 1). In 2016, many participants had to sit in cramped postures to form a group, and the groups were all seated close together. Further, the participants were constantly distracted in terms of both sound and sight.

The next question to be addressed is what factors should be focused on by facilitators. Case 1: If I am assigned a room with movable desks and chairs, I will ask people to move the desks and chairs as much as possible and make the space appropriate for their work. If the room is too big, I can merely use a part of it; however, if the room is small, I can put unused desks and chairs between groups so that participants can focus on their work without interruptions. Case 2: If I am assigned a room with immovable desks and movable chairs, I will ask people to move the chairs, sit closely in groups, and keep some distance from other groups. If the room is big, groups can work without being distracted by other groups; however, if the room is small, participants will have difficulty concentrating in their work. Case 3: If I am assigned a room with immovable desks and chairs, I will put signs on desks to denote different groups so that each group can sit in an assigned space, at some distance from the other groups. This would be adequate in a big room but not in a small room. Therefore, when the room is big, the facilitator can decide where each group should sit, reduce the number of obstacles, and finalize distractions. When the room is small, the facilitator should attempt to make the conditions as optimal as possible for the participants; however, sometimes, such efforts will be ineffective. In conclusion, having an appropriate room to use is the best solution; if this is not possible, the second-best solution is to arrange the room as appropriately as possible.

3 Mental Environments and the Facilitator's Role

3.1 Mental Environments After a Game

The early stages of a S&G are quiet and slow, whereas the later ones are faster and noisier, since people become more involved in the S&G as it progresses. In other words, competent game designers are supposed to carefully structure the mechanism of games. Similarly, skilled facilitators are expected to structure the mechanism of the debriefing process. After the game, people exchange their perspectives to understand what happened during the game. They are expected to review their experiences using metacognitive skills. For this purpose, facilitators should prepare appropriate mental environments. With the help of a facilitator, participants can extract general strategies applicable to real-world issues in the future. I will discuss what a facilitator takes into consideration while structuring a debriefing.

After a game, participants feel various emotions: accomplishment, disappointment, excitement, frustration, and so on. They need to release these emotions and calm down immediately after the game. Once they are calm, they are able to focus on what happened during the game, listen to others' perspectives, and exchange opinions on their own experiences and/or how other members interpreted their experiences. Pivec [1] proposed a debriefing model with four stages, based on Kolb's model [2]. Examples of questions to be asked in the four stages were taken from Pivec's study [1, pp. 30–31], which are as follows:

- Experiencing: "How do you think the simulation went?"
- Reflecting: "What happened?" and "How did the group work as a team?"
- Thinking: "What should have been done?" "What could have been done better?" and "What would you have done differently?"
- Applying: "What knowledge, skills, or attitudes displayed in this simulation would be useful for the clinical setting?" and "How could or would you use this in the clinical setting?"

Although Pivec's [1] questions were in the context of nursing education, they are applicable to the debriefing of S&G, in general. Here, I focus on the "thinking" stage, which requires participants to consider what-if scenarios. It is crucial that thinking is located between "reflecting" and "applying" because this ensures that participants expand their minds and think about situations more carefully. What-if scenarios help them distance themselves from their experiences in the S&G and view the situations from a new perspective. Therefore, the order of questions is important. The facilitator's role is to ask appropriate questions at the appropriate time.

3.2 Intelligent Novices and Informed Instruction

Now, I focus on how a facilitator can design a mental environment for debriefing. Bruer [3] pointed out that children cannot generalize from one learning situation to another. This seems true for participants in the debriefing sessions of S&G, as well. As a facilitator, I have sometimes observed that participants have difficulty in reviewing their experiences in a metacognitive manner to extract general strategies. In this context, I propose that Bruer's [3] theory can be applied to debriefing.

According to Bruer [3], an "intelligent novice" is one who knows how to learn, has "high-order skills," and thus can solve novel and ambiguous problems. High-order skills require extensive domain knowledge, a good understanding of when to use this knowledge, and metacognitive monitoring and control. If we expect participants to extract strategies from their experiences in S&G and apply these strategies to real-world issues, we should instruct them to be an intelligent novice so that they can transfer their S&G strategies to the real world.

Based on Bruer's [3] suggestion, we can design three-stage instructions for debriefing. First, participants should confirm their knowledge of facts and methods. This corresponds to answering questions such as "What happened?" "How did you respond?" and "Why did you make that decision?" These questions confirm participants' knowledge about the main topics in the S&G. Second, the participants should be presented with hypothetical situations to make them think about other or future cases, for example, "What should have been done?" "What would you have done differently?" "What strategy do you propose?" "How would you apply this strategy?" and "When would you apply this strategy?" The participants should assess and discuss appropriate timing/conditions. Knowing when to use knowledge is a crucial aspect of using it appropriately. Third, people should consider themselves from the third-person perspective and evaluate the positive and negative aspects of their strategies with the help of questions such as "What are the merits and demerits of your strategy?" "Why would you use it?" and "Can you think of any other alternatives?" In this progressive manner, participants would be able to expand their perspectives and deepen their understanding. Such development may occur at different paces for different participants. We need to factor in these individual differences during debriefing.

3.3 Importance of Considering Participants' Characteristics

Nakamura compared two groups of people with different senses of readiness toward S&G and obtained the following result: "Learning seems to have occurred through S&G at different levels of readiness in participants. The level of readiness affects participants' willingness to jump into the world of S&G. Those who feel hesitation toward S&G may be able to overcome it through S&G, while those who are ready to enter S&G may be able to develop a wider perspective" [4, p. 63]. The level of readiness is considered to affect the participants' willingness to participate in S&G. It may be related to the number of S&G experiences of a participant.

I introduce a study that reveals the difference between experienced and inexperienced participants. I conducted a questionnaire survey to compare two groups of participants (inexperienced and experienced) with two different types of questionnaires (a past-oriented one and a future-oriented one), and the details of this survey are as follows:

Participants were divided into groups of four and asked to play a communication game [5]. To play the game, each group receives a set of 36 cards and a big 36-square board. The cards are evenly distributed, and each player receives nine cards. Each player chooses one corner and, in turn, places a card on a vacant square on the board to make connections between two corners. Some cards have a straight line or an intersection, whereas others have curved lines. In summary, the four players should talk extensively among themselves and cooperate to make connections successfully. The winner is the team that obtains the highest score. The score is the number of cards between connected corners.

After playing this game, the participants answered a questionnaire on the degree of speaking, listening, participation, and satisfaction on a 6-point scale, ranging from 1 (never) to 6 (fully). Further, toward the middle of the questionnaire, half of the participants were asked a past-oriented question (When you look back at this gaming session, what do you think you should have done?), whereas the other half were asked a future-oriented question (If you can participate in the same gaming

Table 3 Means of satisfaction in the four groups

	When asked a past-oriented question	When asked a future-oriented question
	Mean (SD) (*n*)	Mean (SD) (*n*)
Inexperienced	4.67 (1.26) (42)	4.25 (1.35) (44)
Experienced	3.68* (1.83) (31)	4.81 (1.19) (31)

*$p < 0.01$

session once more, what will you do?). In addition, there were two different groups of people: One group played this game during the early phase of the course, whereas the other played it at the end of the course. I named the former group, who had experienced two S&G sessions before this game, "inexperienced" and the latter group, who had experienced seven S&G sessions before this game, "experienced." Between 2013 and 2015, 148 participants played this game, as well as answering the questionnaire.

As shown in Table 3, experienced participants reported significantly low satisfaction when the past-oriented question was asked ($F(3, 144) = 2.67$, $p < 0.01$). Why were experienced participants less satisfied after answering the past-oriented question? One reason may be regret. The goal of the game was to obtain a high score as a team, and there was a clear winner. Therefore, inevitably, most participants felt frustrated at losing and blamed themselves; further, the past-oriented question reminded them of their mistakes and made them feel less satisfied. On the other hand, the future-oriented question made them focus on a hypothetical second chance at the game. Therefore, they could feel satisfied with the results. Why were inexperienced participants very satisfied with the results after they had answered the past-oriented question? They were probably less inclined to blame themselves, since they were not yet accustomed to S&G. They felt less frustrated at losing and, hence, were satisfied even after the past-oriented question was asked. Overall, the past-oriented question had the power to cause experienced participants to think more cautiously about their sense of satisfaction. This result indicates that a facilitator who is preparing for debriefing should consider the characteristics of participants, such as their S&G experience.

3.4 Role of the Facilitator in a Debriefing

The instructional design (ID) model indicates how facilitators can structure a debriefing session for S&G. Shimamune [6] outlined several basic rules, as follows: Clarify what to teach and the reason for teaching, know the learners, make a list of steps that lead to a target behavior, break down a task into small steps, explain and demonstrate the target behavior, allow students to practice the target behavior, check the acquisition of the target behavior, and provide positive feedback immediately after performance. According to Shimamune's [6] suggestions, a facilitator should primarily clarify the purpose of the S&G during debriefing and explain why the topic is important and why the S&G is played.

We have already seen that participants' readiness to play and previous experiences with a S&G influence their attitudes toward S&G during and after the session. The facilitator could help the participants review what had happened in the S&G and extract a strategy applicable to real-world issues based on their respective degrees of readiness and experiences. Participants are assumed to have metacognitive skills and know how to use them; however, it is possible that not all participants do have these skills. Instead of automatically assuming that participants can use their metacognitive skills, we should break down questions into smaller parts for those who have difficulty in considering a panoramic view.

Such small steps may be created using a basic "debriefing form," which could start by asking students to explain their feelings and then propose past- and future-oriented questions. In general, the first part of the form refers to the issues at hand, such as "How are you feeling?" The second part refers to events and reflections, such as "What happened?" "How did you respond?" and "What do you think about your response?" The next part refers to the past by asking questions such as "What did you learn from this S&G?" and the future by incorporating questions such as "In what kinds of future situation do you think you can apply what you learned in this experience?" The past-oriented question should be asked first, so that it forms a bridge to the future-oriented question. Such small steps can help participants who experience difficulty in reviewing the events in S&G, although quick learners can ignore some steps.

As noted earlier, a facilitator should emphasize the purpose of debriefing and how it benefits participants. In other words, filling out the debriefing form enables them to reflect on what happened during the S&G and provides time for them to calm down. By sharing their opinions within the team, participants can broaden their perspectives. By collecting fodder for and writing a report, participants can connect their learning to real-world issues. As homework assignments, participants may be asked to review what happened, write what they would have done differently, explain how the strategy they extracted from this experience could be used to deal with real-world issues, and predict the results of their strategy.

Information on participants' readiness toward playing S&G and their number of S&G experiences would help a facilitator structure the debriefing. When participants have very little readiness and very few experiences with S&G, they may seem inactive. However, this does not mean their minds are inactive. Facilitators should understand that the participants may be struggling inside. One of the important roles of a facilitator is to wait and encourage the participants patiently.

4 Limitations and Future Research

As shown in Table 1, the 2015 room was larger than the 2016 room, and the 2016 room was larger than the 2017 room. Certainly, the type of physical environment affected participants' attitudes. A comparison of the annual student evaluations for the years 2015–2017 revealed that the 2015 scores were the highest, whereas the 2016 scores were the lowest. The scores for 2017 fell midway between those of 2015 and 2016 probably because the effects of the small room could be mitigated using a little ingenuity, such as placing unused desks and chairs between groups. Table 2 reveals that the limitation of the physical environment in 2017 could be overcome to a certain degree, which proves that a facilitator can contribute to making physical environments better. This is a meaningful finding since the necessity of "active learning" is increasing in Japan, and most classrooms in Japanese universities are lecture rooms. If active learning is sought to be popularized and S&G is conducted in a crowded room without understanding how the physical environment influences participants, the end result may be disappointing. It is the facilitator who plays an important role in making the physical environment as appropriate for S&G as possible. Simultaneously, the facilitator should clarify the importance of physical environments and the need to focus on room settings.

In addition to improving the physical environment, facilitators can help improve the participants' mental environment, although the latter is a more complicated process. Preparing a list of questions appropriate to the content and participants' characteristics is the first step. Structuring the questions to make them effective is the second step. Paying special attention during debriefing to those who face difficulties is yet another step. Further, allotting adequate time for debriefing is important. An ideal session with sufficient time for debriefing involves the following: oral debriefing as a starter, a debriefing form, sharing of answers and opinions, and report writing as the homework assignment. When such measures work, participants are able to have panoramic views and extract general strategies applicable to real-world issues. Moreover, they continue to grow mentally by utilizing their S&G experiences to develop strategies to overcome real-world problems. Certainly, the facilitator's role is not to take participants to where the facilitator wants them to go, but to encourage them to reach where each of the individual participants want to reach.

Finally, I specify that the data introduced in this study were collected using questionnaires and I examined the tendencies reflected by the mean scores. As facilitators, we look after the participants of S&G both as a group and as individuals. We should pay special attention to those who behave uniquely. Any behavior beyond our expectations adds something new to our understanding, and it should be respected. In addition, we may need a new method to measure the long-term effects of S&G, since such effects appear to be occurring more in the long term than in the short term.

References

1. Pivec CRJ (2011) Debriefing after simulation: guidelines for faculty and students. Master of Arts/Science in Nursing Scholarly Projects, 14. https://sophia.stkate.edu/ma_nursing/14
2. Kolb DA (2007) The Kolb learning style inventory (Version 3.1). Hay Group, Boston

3. Bruer JT (1993) Schools for thought: a science of learning in the classroom. MIT Press, Cambridge, MA
4. Nakamura M (2016) Participants' perceptions of gaming simulation. In: Kaneda T, Kanegae H, Toyoda Y, Rizzi P (eds) Simulation and gaming in the network society. Springer, Singapore, pp 53–63
5. JOYPOD (2004) TUNAGE. Retrieved November 30, 2018, from http://www.joypod.net/tunage-/ (in Japanese)
6. Shimamune S (2004) Instructional design: rulebook for teachers. Yoneda Shuppan, Chiba (in Japanese)

The Context Dependency of Four Persuasive Game Design Principles

Annebeth Erdbrink, Rens Kortmann, and Alexander Verbraeck

Abstract This paper explores the context dependency of four popular persuasive game design principles in order to improve their effective implementation. To prevent the use of badly chosen design principles that can be counterproductive, other authors showed the importance of tailoring persuasive game design principles to various gamer personalities. In this paper we aim to further theoretically explore the context dependency of four popular principles. With the elaboration likelihood model as a framework, we present examples of different scenarios that describe how these four persuasive game design principles can either enhance or reduce the motivation and/or ability of the player to elaborate on the persuasive message of the game. Although we emphasize the theoretical nature of this paper, it may form a starting point for experimental research on persuasive game design principles. Results from this future research will ultimately contribute to the overall effectiveness of persuasive games, whose application is valuable within an active learning context.

Keywords Persuasive game design principles · Context dependency · ELM model

1 Introduction

The main goal of persuasive games is to shape, reinforce or change players' attitudes or behaviour beyond the gaming session [1]. Their design principles can be considered the key drivers of their success [2]. Unfortunately few guidelines exist concerning the effective implementation of these persuasive game design principles [3]. The choice and the suitability of a design principle that contributes to the persuasive message of the game are therefore often based on a designer's own intuition [4].

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To prevent the use of badly chosen persuasive design principles that can be counterproductive, research shows the importance of tailoring [5]. Elaborating on these findings, Orji et al. [4] suggest a design approach for tailoring persuasive game design principles to various gamer personalities.

Apart from players' personalities, we believe there are more context factors that might improve the effective implementation of persuasive game design principles. In this paper we therefore aim to further explore the context dependency of persuasive game design principles and suggest how game designers can take this into account when selecting and implementing these principles.

We assume that in many cases, persuasive game designers want to reach a large and diverse group of gamers with their design. For this exploration we therefore chose to focus on four popular (interrelated) persuasive game design principles with an overall good average effect across gamer types as identified by Orji et al. [4]: *self-monitoring and suggestion* and *competition and comparison*. Next our research question is the following: how does the effectiveness of these four popular persuasive game design principles depend on the context in which they are applied?

To clarify our research method, we first give a brief overview of the origin of the four selected persuasive game design principles of our exploration.

1.1 Origin of Selected Persuasive Game Design Principles

Based on a literature review on persuasive games and the design principles they used, Orji et al. [4] identified ten popular persuasive game design principles that originate from the field of persuasive technology (PT), more specifically from prior research of Fogg [6] and Oinas-Kukkonen and Harjumaa [7].

Fogg holds the most dominant perspective on persuasion through technology (including digital games) [6]. According to his behaviour model for persuasive design [8], behaviour is a product of three factors: motivation, ability and triggers. For a desired behaviour to occur, these three elements must converge at the same moment. When the behaviour does not occur, the model argues that at least one of the elements is missing. Considering the model to be too limited to be applied directly to persuasive system development, Oinas-Kukkonen and Harjumaa [7] elaborated on Fogg's work and developed the Persuasive Systems Design (PSD), suggesting 28 persuasive system design principles.

Limitations As also noted by Kors et al. [3], we believe Fogg's perspective on persuasion seems somewhat limiting. It's main focus seems to lie on simply making the user do what the system requests. How attitudes are actually shaped through the interaction with the system to influence consistent behaviour seems rather overlooked. Kors et al. [3] emphasize that this is surprising since "the substantial attitude-behaviour relationship that is inherent to persuasion seems ignored".

Since the persuasive design principles of Oinas-Kukkonen and Harjumaa [7] are partly based on Fogg's perspective and the selected game design principles of Orji et al. [4] are subsequently build upon their work, we argue that the selected persuasive game design principles *self-monitoring and suggestion* and *competition and comparison* might be limited concerning their persuasive effects.

1.2 Method: The Elaboration Likelihood Model as a Framework for Our Theoretical Exploration

Due to the underexposed role of attitude formation concerning persuasion through technology (including persuasive game design principles), we chose the elaboration likelihood model (ELM) [9] as a framework for our exploration, following Kors et al. [3]. This model of persuasion from the field of social psychology, namely, specifically focuses on the actual formation of attitudes and describes how likely a person would change his/her attitudes based on a persuasive message [9]. The process of generating favourable and unfavourable evaluative reactions to the content of the message is called elaboration.

According to the ELM, the likeliness a person elaborates on a persuasive message is dependent on the level of motivation and ability. To explore how the effectiveness of the persuasive game design principles *self-monitoring and suggestion* and *competition and comparison* depends on the context in which they are applied, we therefore aim to map examples of different scenarios in which the design principles either enhance or reduce the motivation and/or ability of the player to elaborate.

Interestingly motivation and ability each have several sub-variables that subsequently affect the persuasion indirectly [10]. Motivating aspects are *relevance* of the message, *need for cognition* and *responsibility* for the message. The aspects for the ability to elaborate are *knowledge and understanding* of the message, *available time* to elaborate, *distraction* from elaboration and *repetition* of the message [11, 12]. When applied in a persuasive game design context, most of the sub-variables seem to be able to be influenced by the game designer [3]. Our exploration therefore exists of the description of examples of possible theoretical scenarios in which *self-monitoring and suggestion* and *competition and comparison* could influence the motivation and/or ability of the player to elaborate through these sub-variables. We exclude *need for cognition* for this exploration because we believe that is a personal trait that can't be influenced by the game [13].

The ELM proposes two processing modes of persuasion: the central route (in which persuasion is mediated by systematic processing of message arguments and other relevant information) and the peripheral route (which features the influence of peripheral cues and includes a variety of less effortful mechanisms) [10]. Attitude change is considered to be the most resistant and enduring when people process information via the central route [10].

1.3 Purpose of Paper and Outline

Although theoretical and explorative, the presented findings in this paper may form a starting point for future experimental research on the context dependency of persuasive game design principles. We hope to inspire game designers to improve the effectiveness of their designs and game scholars to deepen their knowledge of persuasive game design. Section 2 describes the exploration of the context dependency of *self-monitoring and suggestion* and *competition and comparison* by means of examples of possible theoretical scenarios. In Sect. 3 conclusions and limitations of this paper are discussed, and suggestions are made for future research.

2 Context Dependency of *Self-Monitoring and Suggestion* and *Competition and Comparison*

2.1 Self-Monitoring and Suggestion

The game design principle *self-monitoring* (also *feedback*) allows people to track their own behaviours, providing information on both past and current states [4]. The assumption of this design principle is that it provides players with (self) insights by examining their data and subsequently changing their behaviour based on these insights. Kersten-Van Dijk et al. [14] also call this the self-improvement hypothesis.

Suggestion is a design principle that suggests certain tasks (for achieving favourable outcomes) to players during the game [4]. It is based on the assumption that these suggested tasks motivate players to perform the desired behaviour.

Effects on Motivation Both *self-monitoring* and *suggestion* seem to be able to enhance motivation to elaborate on the persuasive message of a game through influencing the *responsibility* of the player. Through *self-monitoring* the outcome of personal efforts is made visible, and when this is accompanied by cues that emphasize the players' identity (e.g., players' name and picture), this might intensify the experience of *responsibility*. When *suggestion* points out what the possible undesired effects can be when the player does not perform the suggested task, we argue it might positively influence *responsibility* too.

Self-monitoring might also influence the feeling of *relevanc*e of the persuasive message, but we argue that this only arises when the player is able to compare his/her monitored behaviour to some standard or goal. According to Bandura's self-regulation theory [15], individuals proactively motivate and guide their actions by setting challenging goals and making effort to fulfil them. So when a standard or goal is salient, it is more likely that the player is motivated to rectify the deviations from this standard or goal [14]. Interestingly a standard can be made salient when the player can compare his/her performance in the game with that of others through a ranking list, for example.

Effects on Ability *Self-monitoring* and *suggestion* seem to be able to enhance as well as reduce the ability of the player to elaborate on the persuasive message of the game. At first they seem promising principles to provide specific *knowledge and understanding* concerning the desired behaviour. *Suggestion* can inform the player with extra knowledge why a specific task is important to perform or suggest a specific skill that is needed to perform the desired behaviour. Also within *self-monitoring* we believe this might be possible, for example, when providing feedback on current and past states of the player, extra information can be given that explains these states.

But *self-monitoring* and *suggestion* might also reduce the ability of the player to elaborate. A negative side effect of *self-monitoring* can occur when the player experiences that he/she is being observed and evaluated. According to the social facilitation effect [16], the presence of others (regardless of actual presence or via electronic means) increases an individual's level of arousal, which can inhibit the performance of behaviours that are complex or new. This suggests that during the performance of a relatively complex and new task, the player should not experience *distraction* by *self-monitoring*. The game designer can try to avoid this undesired effect by not providing feedback during these new tasks but only afterwards.

Lastly, a possible undesired effect of *suggestion* can be that the player experiences too much pressure to change a certain behaviour. When *repetition* of suggested tasks is applied too much, we argue that this can easily occur. This may have such an impact on the mood of the player that he/she will not be able to process the persuasive message of the game through the desired central route but through the peripheral route [17].

2.2 Competition and Comparison

The design principle *competition* allows the user to compete with other players [4]. *Comparison* provides a means for the player to view and compare his/her performance with the performance of other user(s) [4]. Both are based on the assumption that humans are competitive beings and have a natural drive to compete [7].

Effects on Motivation As earlier suggested *self-monitoring* might influence the player's feeling of *relevance* of the persuasive message in the game when a certain standard or goal is made salient. We argue that through *comparison*, such a standard can be visualized. In that sense *comparison* can enhance the player's motivation to elaborate. This might also happen through the feeling of *responsibility* that can arise when a player compares his/her performance on the desired behaviour with other players. We assume that when it is emphasized that a group of others perform a certain behaviour, this could increase the feeling of *responsibility* to also participate.

How *competition* can enhance the motivation of the player to elaborate seems less evident. At first sight it mostly seems to make the player enjoy the game more [18], but not necessarily increase the chance of elaboration. We believe however that *competition* can positively influence the *relevance* of the persuasive message of the game when the competitive element is an integral part of the game's narrative (which includes the persuasive message). When implemented in that way, it might be most effective when the player not competes with other players but with characters or objects that are part of the persuasive story. Obviously players can form groups and compete together against a common enemy.

Effects on Ability To enhance the ability of the player to elaborate on the persuasive message of the game, *comparison* might increase the *knowledge and understanding* when it is specifically explained to the player how the other players reached certain goals (concerning the desired behaviour). *Comparison* however might also reduce the ability to elaborate when it will function as a *distraction.* We believe this could happen when the player experiences that through *comparison*, it is emphasized that other players perform much better than he/she. This might result in low self-efficacy [19], which negatively influences the desired performance. To solve this undesired scenario, we suggest that the earlier described design principles of *self-monitoring* and *suggestion* can help the player to increase the self-efficacy of the player; *self-monitoring* can show prior successful performances of the player, and *suggestion* might suggest a certain skill that the player can use to perform better again.

Competition seems to reduce the ability of the player to elaborate in two different situations. We argue that when *competition* is experienced by the player as one of the most important elements of the game, this might function as *distraction* from elaboration. When a game is highly competitive, players get emotionally aroused [20]. This arousal affects processes of perception and produces simplistic thinking [20].

So just as the effect of the earlier described scenario when too many suggestions are made, the mood of the player will likely influence the route to persuasion. Instead of the preferred central route, it is assumed that the peripheral route will be taken by the player in this situation. A second situation when *competition* might reduce the ability of the player to elaborate on the persuasive message is when the player is asked to be competitive the entire game long, without any *available time* which allows the player to take time to reflect on the message. It is therefore recommended to provide the player with sufficient moments of rest after intense moments in the game [3].

3 Conclusions, Limitations and Future Work

3.1 Conclusions and Recommendations

The effectiveness of the popular persuasive game design principles *self-monitoring* and *suggestion* and *competition and comparison* seems to depend on the context in which they are applied. Specifically to what extent these principles enhance or reduce the motivation and/or ability of the player to elaborate on the persuasive message of the game (generating favourable and unfavourable evaluative reactions to the content of the message). With the elaboration likelihood model (ELM) as a framework for our exploration, we specifically focused on how a persuasive game designer might influence the sub-variables of this motivation (*relevance*, *responsibility*) and ability (*knowledge and understanding*, *available time*, *distraction* and *repetition*) through the implementation of the four selected persuasive game design principles.

Enhancing Motivation and Ability The outcomes of our theoretical exploration show that both principles are able to enhance the motivation and ability of the player to elaborate. With implementing *self-monitoring* and *suggestion*, a game designer might increase the *responsibility* of the player concerning the topic of the game by emphasizing the personal identity of the player and by pointing out what undesired effects might occur when the player does not perform the suggested task. *Knowledge and understanding* can be improved when extra information is provided on current and past states of the player that explains these states and when the player is informed why a certain task is important to perform. *Relevance* can be strengthened when a certain standard or goal is made salient to the player.

For *competition and comparison*, we also found scenarios that might enhance the motivation and ability of the player to elaborate. When a certain standard is made visible through *comparison*, it can contribute to the *relevance* and the *responsibility* of the player. Through *comparison*, *knowledge and understanding* of the matter can be influenced when it is specifically explained to the player how the other players reached certain goals. *Competition* can increase the *relevance* of the persuasive message of the game when the competitive element is an integral part of the game's narrative (which includes the persuasive message).

Reducing Motivation and Ability Both *self-monitoring* and *suggestion* and *competition and comparison* might reduce the motivation and ability of the player to elaborate on the persuasive message of the game as well. First of all we argue that game designers should prevent that a player experiences the feeling of being observed through *self-monitoring* when he/she is performing a difficult or new task in the game, because this might lead to *distraction* to properly elaborate. It should also be avoided that the message of the game is presented too often through *suggestion.* This negative effect of *repetition* can cause that the player feels a certain unpleasant pressure to change a behaviour, which will reduce the ability to elaborate.

When implementing *competition*, a designer should be aware that the competitive element is not the most important one in the game because then it might cause *distraction* from elaboration. Also the designer should prevent that there is no *available time* to elaborate for the player on the message of the game because he/she is asked to be constantly competitive during the game. Finally designers should be aware that *comparison* can cause *distraction* of elaboration when the type of comparison emphasizes too much that other players perform much better than the player.

Differences and Internal Relation Between the Four Persuasive Game Design Principles As a combined design principle, *competition and comparison* seem less strongly connected internally than *self-monitoring and suggestion*. Although they might indeed complement each other, we believe they could also be implemented separately in a persuasive game. We argue that the implementation of *competition and comparison* might be more risky concerning undesired scenarios. But with awareness of the context dependency, it can be a powerful persuasive game design principle. Interestingly, we found that *self-monitoring and suggestion* and *competition and comparison* might complement each other in certain scenarios.

3.2 Limitations and Future Work

Due to its theoretical and explorative nature, this paper has some limitations. The elaboration likelihood model as a framework for our exploration limited the scope of the context dependency. We specifically focused on the effects of the design principles concerning the persuasive message of the game and left out the engaging aspects of the design principles that might also contribute to the overall persuasive power of the game. Another limitation is that our examples of scenarios focused on digital games, while we realise that persuasive games can be effective in an analogue setting as well.

For this paper we only explored the context dependency of four selected popular persuasive game design principles, but obviously there are many more to further analyse in order to improve their effective implementation. We therefore suggest that future work should first explore the context dependency of a broader set of popular persuasive game design principles. For each design principle, then certain game mechanics can be listed. Next the outcomes of these explorations should be empirically tested in simple experiments and field tests.

With this paper we aim to create awareness of the context dependency of persuasive game design principles amongst game designers and scholars. Finally we believe it may form a starting point for future experimental research in order to improve the effective implementation of persuasive game design principles. Results from this research will ultimately contribute to the overall effectiveness of persuasive games, whose application is valuable within an active learning context.

References

1. De la Hera Conde-Pumpido T (2013) A conceptual model for the study of persuasive games. In: Proceedings of DiGRA 2013 – DeFragging game studies, pp 1–15
2. Schrier K (2017) Designing games for moral learning and knowledge building. Games Cult:1–38. https://doi.org/10.1177/1555412017711514
3. Kors MJL, van der Spek ED, Schouten BAM (2017) A foundation for the persuasive gameplay experience. In: Proceedings of the 10th annual Foundations of Digital Games conference, Foundations of Digital Games
4. Orji R, Vassileva J, Mandryk RL (2014) Modeling the efficacy of persuasive strategies for different gamer types in serious games for health. User Model User-Adap Inter 24:453–498

5. Kaptein M, De Ruyter B, Markopoulos P, Aarts E (2012) Adaptive persuasive systems. ACM Trans Interact Intell Syst 2(2):1–25
6. Fogg B (2003) Persuasive technology: using computers to change what we think and do. Morgan Kaufmann, San Francisco
7. Oinas-Kukkonen H, Harjumaa M (2009) Persuasive systems design: key issues, process model, and system features. Commun Assoc Inf Syst 24(28):485–500
8. Fogg B (2009) A behavior model for persuasive design. In: Proceedings of the 4th international conference on persuasive technology, Claremont, CA, USA
9. Petty RJ, Cacioppo JT (1986) The elaboration likelihood model of persuasion. Adv Exp Soc Psychol 19:123–205
10. Bohner G, Wänke M (2002) Attitudes and attitude change. Psychology Press, Cornwall
11. O'Keefe DJ (2002) Persuasion: theory and research, 2nd edn. Sage, Thousand Oaks
12. Perloff R (2008) The dynamics of persuasion: communication and attitudes in the 21st century, 3rd edn. Lawrence Erlbaum, New York
13. Cacioppo JT, Petty RE (1982) The need for cognition. J Pers Soc Psychol 42(1):116–131
14. Kersten-van Dijk ET, Westerink JHDM, Beute F, IJsselsteijn WA (2017) Personal informatics, self-insight, and behavior change: a critical review of current literature. Hum Comput Interact 32(5–6):268–296
15. Bandura A (1991) Social cognitive theory of self-regulation. Organ Behav Hum Decis Process 50:248–287
16. Zajonc RB (1965) Social facilitation. Science 149:269–274
17. Bohner G, Weinerth T (2001) Negative affect can increase or decrease message scrutiny: the affect interpretation hypothesis. Personal Soc Psychol Bull 27:1417–1428
18. Prensky M (2001) Fun, play and games: what makes games engaging. In: Digital game based learn. McGraw-Hill, New York, pp 1–31
19. Bandura A (1977) Self-efficacy: toward a unifying theory of behavioural change. Psychol Rev 84:191–215
20. Van Egeren LF (1979) Cardiovascular changes during social competition in a mixed-motive game. J Pers Soc Psychol 37:858–864

Digital Versus Analogue Multiplayer Gaming: Comparing Learning Outcomes

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Abstract In this study, we explore the similarities and differences in learning effects produced by playing a digital and an analogue version of the disruption management game for container terminal operations. We organized the analogue game sessions with students in the United States and digital game sessions with students from Greece. We analysed a postgame survey that captured the learning experiences of the participants to compare the differences and similarities of the learning effects of either game. Based on the results, we conclude that the type of game has limited effect on the learning experience, while incorporation or exclusion of learning principles does have.

Keywords Analogue games · Communication · Container terminal operations · Digital games · Disruption management · Information sharing · Learning

1 Introduction

A lot has been written about the use and effectiveness of digital [1] and analogue games [2] as game-based learning method. Digital games and board games have stark differences in terms of production time, costs as well as ease of use. However, comparisons between the learning effect of digital and nondigital simulation games are rather underdeveloped. The immense popularity of digital entertainment games suggests that players enjoy playing games, and these positive emotional experiences can themselves be viewed as positive outcomes of playing games [3]. Board games provide, especially for group play, the spatial structure, social setting and physical interactions [4].

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In this study, we explore the differences in learning effects produced by a digital and an analogue game on students with respect to information management and communication in complex and dynamic situations that require collective problem solving. We will provide the background and description of the games used in our study in the following section.

2 The Disruption Games: Digital and Analogue Versions

Both games under study are named disruption management game and are set in the ambience of container terminal operations. We will provide a side-by-side description of both versions since the underlying principles and game mechanics are similar in both games. Before delving into the games, we provide the background and objective of these games.

2.1 Background: Disruptions in Container Terminals

Container terminals are crucial hubs in the global transportation network of goods that act as coupling and decoupling points for the transfer of containers from sea to land and vice versa. The storage area of the terminal is called the yard, where containers are stored in stacks, thus facilitating the decoupling of seaside and landside operations [5]. Planning and aligning all functions in a container terminal is a difficult task [6]. All planning activities of the terminal are interrelated, and changes in one plan have a big influence on other plans [7].

Container terminals are often affected by a wide range of disruptions like common equipment failures, sudden demand shocks, weather conditions, conflicts and political unrest or even terrorism [8]. Each of these aspects, described for instance [9, 10], can have debilitating ripple effects on the container terminal, causing financial, operational or collateral losses and in rare cases affecting human operator safety [11]. Container terminals have to battle these disruptions and prevent the negative effects by focusing on disruption mitigation by enabling integrated planning through effective information management. These challenges form the basis for the learning objectives of a game to teach participants on the importance of information management for integrated and collective problem solving towards effective disruption mitigation in container terminal operations. In our games, players explore the role of expert in dealing with disruptions especially from an information sharing perspective.

We chose to develop a board game first because it was the most cost effective, flexible and social platform to represent multiple perspectives and information sharing challenges in integrated planning operations. Both the digital and analogue versions of the disruption management games were designed based on the triadic game design approach of balancing the aspects reality, meaning and play [12].

2.2 Board Game

The board game is a multiplayer game that consists of five different roles (berth planner, vessel planner, control tower operator, resource planner and sales) [13]. Each role (excluding the game master) is responsible for specific planning and operational tasks in the container terminal. A facilitator gives feedback about player decisions after every round. The game board and cards are illustrated in Fig. 1. See [14] for a detailed description of the roles and rules of the game.

2.3 Digital Game

The digital game is a quasi-multiplayer version that is played by a single player. It consists of three roles (control tower operator, berth & vessel planner and sales). The player can choose one of the three roles, while the other two are automated. The other two roles are simulated in the game. These roles respond to the decisions of the player. The decisions of the automated players are modelled in decision trees, where the choice of the automated player depends on the type of information he or she receives. The player receives feedback whether their action or shared information was useful or not. We also introduced an element of randomness in the automated player choices in order to avoid 100% rational decision-making which is not realistic among human beings. The reasons to choose a quasi-multiplayer and role

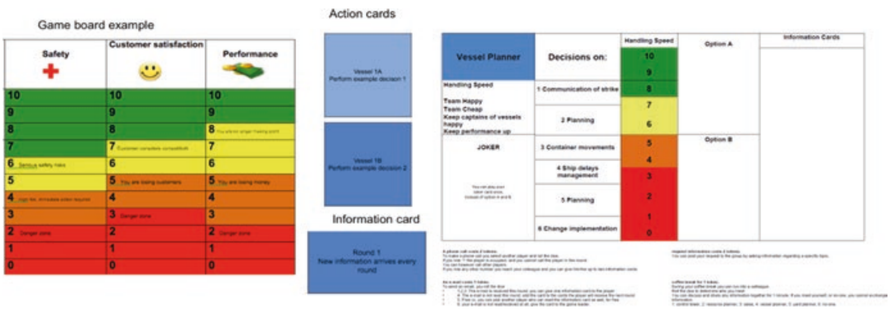


Fig. 1 Left side, overall game board of the disruption management board game; right side, individual game board of the disruption management board game

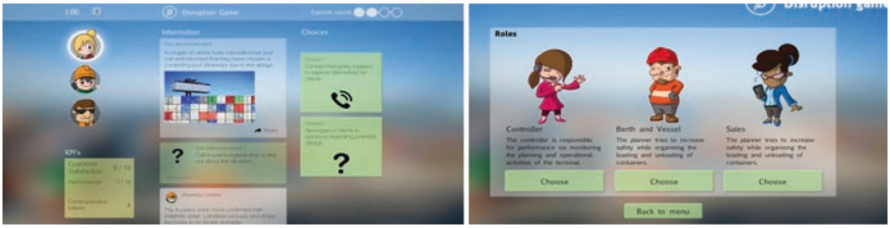


Fig. 2 The digital version of the disruption management board game

reduction are explained in detail in [15]. There is no facilitator needed. Figure 2 shows some screenshots of the digital version of the disruption management game.

2.4 Game Play

As the games unfold, disruptions start occurring that drastically affect individual operations as well as the operation of the entire organization. Three disruption scenarios, each with varying levels of severity, have been modelled in both games.

The objective of the players in both games is to maintain healthy levels of three main key performance indicators of the terminal, namely, safety, customer satisfaction and performance during different rounds. With each round of the game, the event complexity increases, and the disruption situation escalates, unless some action by the players is taken. In order to make the ‘right’ decision and ‘win’ the game, participants need to manage information, communicate and coordinate if necessary, monitor the effects of disruptions and take the necessary actions at the right time to mitigate the negative effects.

3 Research Methodology and Design

3.1 Experimental Set-Up

The overall design of the game sessions for both the digital and analogue version had similarities in terms of location, briefing and debriefing. Both game sessions were carried out in classroom settings. Every game session of the disruption management game began with a nondigital face-to-face briefing usually lasting 20–25 min. The various intermodal operations, terminal processes, roles in the container terminal and the equipment used were described in this stage.

For the board game, the game session adopted, participants were gathered around a table in a spacious room. The room was prepared in advance for the play, by prearranging the required game objects. Depending on the size of the group, one or more

Fig. 3 The classroom setting of board game play and digital game play

game facilitators orchestrated the game play. The game facilitator was given a game manual that describes the role and the method of orchestration.

The digital game required that players use computers and a mouse to play the game in their classroom. The game interface was self-explanatory, and the role of the facilitator was only limited to briefing and debriefing and technical assistance in case of computer failure. An overview on the different game play sessions is depicted in Figure 3. The players played the game individually, and they could play the game several times from different role perspectives.

After five rounds of game play, the game session was concluded with a debriefing session, where the game facilitator explained the principles of disruption management, the challenges faced by practitioners, the relationship of the game elements to the said challenges, the progress of the game play, a review of the scores and the reasons for obtaining these scores, potential alternative strategies, a comparison between scores of different play groups and the reasons for the differences, etc.

After the debriefing session, the game facilitator encouraged the participants to provide feedback about the game and their own learning experience, after which the players had to answer a postgame survey about their learning experiences. The questions consist of interval questions about preparation of future work and understanding information sharing and an open question about their perceived learning. The students received partial course credit for their participation. We will discuss the results of the survey in the following section for both games.

3.2 Sample

A first experimental set-up of the board game was conducted with 80 bachelor students majoring in supply chain, logistics and transportation at a large university in the United States (see Table 1). The sample during the game play with the digital

Table 1 Detailed information about the sample

	Board game	Digital game
Number of participants	80	30
Background	Students USA	Students Greece
Number of completed surveys (response rate)	44 (55%)	29 (97%)

version consisted of 30 master students majoring in transportation at a Greek university. Although the groups came from different countries, the students studied the same subject, and neither group had much professional experience with risk management.

4 Results: Learning Outcomes of the Two Games

The postgame survey questions focused on the learning experiences of the student participants after the gaming session, regarding the preparation for future work information sharing.

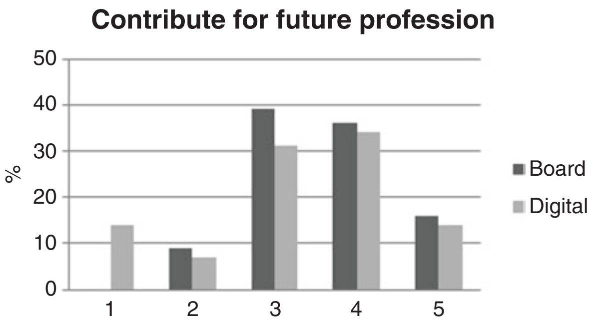
4.1 Preparing for Future Work

To assess the impact of the games, we asked the players if the learning principles (information sharing, communication, teamwork, etc.) of the disruption management game would prepare and help them to handle real-world disruptions as future supply chain professionals (see Fig. 4).

From the survey data of the **board game**, about 16% of the students responded that it would be *very helpful*, 36% of the participants felt that the learning experience from the game would be *helpful*, and 39% felt that it would be *somewhat helpful*, and 9% answered *slightly helpful* to better prepare them to handle real-world disruptions. Not even one participant responded that it would be not helpful.

With respect to the respondents of the **digital game**, 14% reported that it would be *very helpful*, 34% felt that it would be *helpful*, 31% felt *moderately helpful*, 7% felt that it would be *slightly helpful*, and 14% felt that it was *not helpful*.

Fig. 4 Comparison between analogue and digital version on the question if the game contributes for their future profession (1 = not helpful, 5 = very helpful)



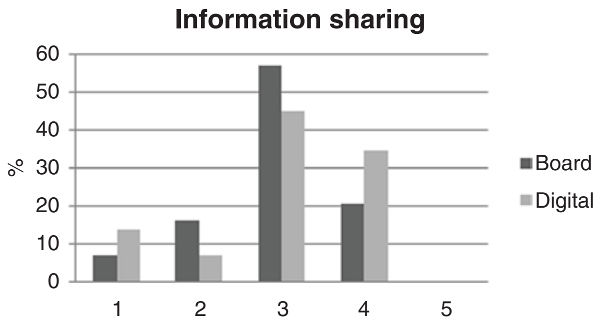


Fig. 5 Comparison between analogue and digital version on the question about relevance of information sharing (1 = not relevant at all, 5 = extremely relevant)

4.2 Information Management and Communication

To understand how well the participants assessed the importance of information sharing and communication for resilient operations, we asked the respondents about their thoughts on the relevance of information sharing for their decision-making during the game play (see Fig. 5).

In the **board game version**, 20% of the participants felt that information sharing was *very relevant*, while 57% felt that it was *relevant*, 16% felt that it was only *slightly relevant*, whereas 7% of the participants did not think that it was relevant at all.

In the **digital game**, 34% of the participants felt that information sharing was *very relevant*, while 45% felt that it was *relevant*, 7% felt that it was only *slightly relevant*, whereas 14% of the participants did not think that it was relevant at all.

4.3 Key Learnings

In addition, we asked the participants to name three key learning points. In both sessions, good communication was mentioned most (15 out of 44 respondents of the analogue game and 12 out of 29 in the digital game). Although mentioned less, in both sessions, the respondents mentioned 'balancing key performance indicators', 'Sometimes takes decisions with negative influence' and 'align strategies and priorities'. The answers also showed some differences. The respondents of the board game session answered that information sharing and selected information sharing are key learning points, while the respondents of the digital game answered that team work and collaboration was one of the key learning points.

4.4 General Remarks

Finally, the respondents had the possibility to add some additional comments about the game and the session. The remarks about the **board game** were that they enjoyed the experiences of the game. Moreover, participants felt that the board game was an interesting, interactive and practical simulation. They said that it was a good exercise to understand the importance of disruption management in transportation and supply chains. They mentioned that the game showed that it was difficult to predetermine a perfect or optimal solution to manage disruptions. However, two participants felt that the game could have been more beneficial to the participants if they had more experience in the port industry. A critical feedback against the game was about its complexity since some participants took longer than others to understand the game mechanics.

The participants of the **digital game** stated that it was an engaging activity. In addition, they mentioned that the game educates them about risk management. One participant remarked that the game was a nice team experience. Other students suggested to play a board game to increase the interaction with team members. One student was entirely unsatisfied with the game.

5 Discussions and Conclusion

The goal of this paper was to compare learning outcomes after playing a digital and a board game with the same topic and learning objective. Having conducted two studies with the disruption management board game and the digital version of it, the results show that they are both good exercises to understand the importance of disruption management in transportation and supply chains.

The learning outcomes of both the digital and analogue version were very similar in terms of students learning about the information sharing and the preparation for their future profession. However, there was one stark difference in the responses of the students related to the open-ended question on the learning effect of the games. In addition to information management and communication, the participants of the digital game stated that teamwork was very important for effective disruption management. This is a thought-provoking outcome given the quasi-multiplayer nature of the digital game where the social interaction and the perception of teamwork were not tangible since the other players were automated. On the other hand, it shows that the interaction with the non-player characters in the game is a powerful means to represent the value of teamwork and its role for the topic addressed by the games. It is known that if non-player characters are not only visualized in a realistic way, but also behave realistically, they foster the flow and immersion, and thus the learning effect of a game [16].

Another notable difference was observed in the way students enjoyed either game. Participants of the board games seemed to enjoy the game play experience more than the participants of the digital game. This could very well be attributed to a lively social environment of the board game and the lack of social contact in the digital game. In addition, the use of real-world pictures in the digital game increases physical fidelity (the level of realism on which the audio-visual context is represented) therefore more structured and less fun, in comparison to functional and psychological fidelity (the level on which tasks are represented and the level on which emotions like stress and joy are represented) offered by the board game which provided more room for creativity and imagination [17–19]. The result on the fun element of the games was auxiliary and based on observations of the facilitators.

One limitation of the present work is that we did not analyse any cultural influences. This could be a subject of further research. For our learning objective, both digital and nondigital games seemed suitable. Our main conclusion from the study is that the learning effect of a game need not necessarily depend on the type of game (digital or analogue) but rather on the learning principles incorporated or left out in either game.

References

1. Papastergiou M (2009) Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. Comput Educ 52(1):1–12
2. Ramani GB, Siegler RS, Hitti A (2012) Taking it to the classroom: number board games as a small group learning activity. J Educ Psychol 104(3):661
3. Connolly TM, Boyle EA, MacArthur E, Hainey T, Boyle JM (2012) A systematic literature review of empirical evidence on computer games and serious games. Comput Educ 59(2):661–686
4. Xu Y, Barba E, Radu I, Gandy M, MacIntyre B (2011) Chores are fun: understanding social play in board games for digital tabletop game design. In: Proceedings of DiGRA 2011 conference: think design play
5. Steenken D, Voss S, Stahlbock R (2004) Container terminal operation and operations research – a classification and literature review. OR Spectr 26:3–49

6. Brinkmann B (2011) Operations systems of container terminals: a compendious overview. In: Bose J (ed) Handbook of terminal planning. Springer, New York, pp 25–39
7. Bose J (2011) General considerations on container terminal planning. In: Bose J (ed) Handbook of terminal planning. Springer, New York, pp 3–22
8. Verbraeck A, Kurapati S, Lukosch H (2016) Serious games for improving situational awareness in container terminals. In: Logistics and supply chain innovation. Springer, Heidelberg/New York, pp 413–431
9. Behdani B (2013) Handling disruptions in supply chains: an integrated framework and an agent-based model. Doctoral thesis, Delft University of Technology
10. Harrington LH, Boyson S, Corsi T (2010) X-SCM: the new science of X-treme supply chain management. Routledge, New York
11. Gurning S, Cahoon S (2011) Analysis of multi-mitigation scenarios on maritime disruptions. Marit Policy Manag 38:251–268
12. Harteveld C (2011) Triadic game design: balancing reality, meaning and play. Springer, Heidelberg
13. Kurapati S (2017) Situation awareness for socio technical systems: a simulation gaming study in intermodal transport operations. TRAIL Research School, Delft. https://doi.org/10.4233/uuid:0f9fe428-baa0-4e8c-948fe30a1c289727
14. Kurapati S, Lukosch H, Verbraeck A, Brazier FMT (2015) Improving resilience in intermodal transport operations in seaports: a gaming approach. EURO J Decis Processes 3:375–396
15. Klemke R, Kurapati S, Lukosch H, Specht M (2015) Lessons learned from creating a mobile version of an educational board game to increase situational awareness. In: Gráinne C, Tomaz K, Christoph R, Johannes K, Lavoué E (eds) Design for teaching and learning in a networked world: 10th European conference on technology enhanced learning, EC-TEL. Springer, Cham, pp 183–196
16. Panzoli D, Peters C, Dunwell I, Sanchez S, Petridis P, Protopsaltis A, Scesa V, de Freitas S (2010) A level of interaction framework for exploratory learning with characters in virtual environments. In: Intelligent computer graphics. Springer, Berlin, Heidelberg, pp 123–143
17. Feinstein AH, Cannon HM (2014) Fidelity, verifiability, and validity of simulation: Constructs for evaluation. Dev Bus Simul Exp Learn 28
18. Lukosch H, van Nuland B, van Ruijven T, van Veen L, Verbraeck A (2014) Building a virtual world for team work improvement. In: Meijer SA, Smeds R (eds) Frontiers in gaming simulation. ISAGA 2013, Lecture notes in computer science. Springer, Cham, p 8264
19. Lukosch H (2013) Balancing fidelity of simulation game environments to increase situational awareness skills. In: International conference on games and learning alliance. Springer, Cham, pp 370–375

Simulation Game Complexity Perception: An Approach to the Research Model

Marcin Wardaszko

Abstract This paper presents and discusses the research framework of complexity in simulation gaming. The complexity of a simulation game has three dimensions: game systematic complexity, game social complexity, and complex dynamics of gameplay. The author presents two perspectives on the complexity of a simulation game. The first perspective is a designer perspective and game-scoring model proposed by the author to solve the internal model dilemma of interdependence. The second perspective is the player's perspective and, in this paper, the research model and procedure are described for discussion.

Keywords Complexity · Game design · Research methodology · Research model · Simulation gaming

1 Introduction

Understanding complexity, systems dynamics, decision-making, and building models and multi-agent systems capable of representing reality are just some of the problems of designing simulation games in the social-psychological context. The growing number of contributions is understandable from the point of view of the ever-changing reality. Social, business, and political structures become more complex and the environment in which they operate becomes more unstable and, thus, it becomes more complex for predicting its potential states and outcomes [1–4]. Answering the call to the growing complexity and the need to transfer this into learning and modeling artifacts, the way we design simulation games has changed too. This change has been fueled by the expanding pool of knowledge on simulation and gaming design, and, on the other hand, by technological progress, resulting in the growing number of platforms that we can use to design and deliver simulation games. In a recent article, Wardaszko [5] introduced the model of simulation game

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complexity divided into two perspectives: the designer's perspective and the player's perspective. Both of those perspectives come with their own features and dilemmas analyzed from the standpoint of simulation game delivery and its effectiveness.

The aim of the paper is to deepen the understanding of the dependency between the designer's and the player's perspectives on the complexity and validation of the proposed model. In this paper, the author introduces the research method validating the proposed model within widely accepted validation frameworks [6, 7].

The complexity in simulation gaming design is an important factor contributing to the quality of games and learning through them, but it also represents a non-trivial phenomenon in the simulation and gaming itself [8]. In order to analyze the changing role and scope of complexity understanding and usage in simulation and gaming, it has to be addressed in an interdisciplinary way and with a multi-level approach to scientific inquiry in mind [8, 9].

The term 'complexity' is well known to games designers and practitioners across various fields and implementation arenas. More careful examination brings us to the conclusion that the approach to the role of complexity is very utilitarian and point-of-view related. Complexity varies for the games designer and it changes its role within the design process. Users facing the complexity of the simulation game and real-world reference system also observe the complex problem and can influence it through their interactions.

Simulation games complexity plays a major role in learning through games systems. Games are one of the best methods to teach about complex systems and problems [1]. On the other hand, games and/or task complexity reduces the effectiveness of learning, i.e., if the learner feels that the task is too difficult or complex, they will be less likely to engage in the activity and not feel motivated to learn or reflect. The so-called complexity paradox [10] works counterintuitively to games as a learning tool. We can observe this many times during simulation gaming sessions. People play games or undertake activities and make decisions even when they feel uncomfortable with the level of complexity they face, but they still learn, or simply play the selected game anyway.

The complexity of a simulation game is transferred to players through the lens of the game interface [11], which is a tool in managing interaction complexity and limits players in the way in which the game communicates and transfers information to them [12]. Players perceive the level of task complexity based on the game and gameplay. This level also depends on the profile of a given player, i.e., their experience with games, age, culture, level, type of education, etc. (see Fig. 1).

Players experiencing complexity in the simulation game they play are influenced by three dimensions of complexity that interact with each other:

- Game systematic complexity – can be derived from the number of rules, variables, and interactions between them. This represents both how many decisions have to be handled, as well as the 'depth' of the decisions that need to be made, which is how much information and how many variables players have to take into consideration for a given set of decisions.

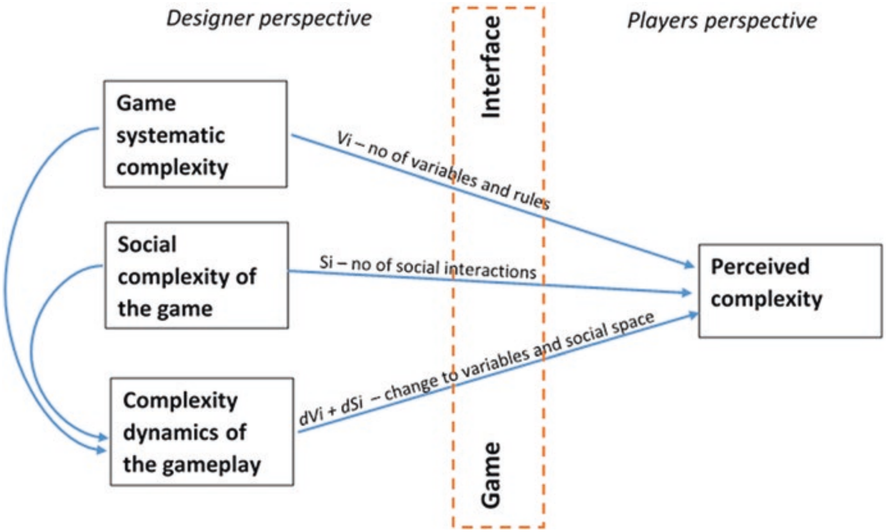

Fig. 1 Simulation game complexity perception model in a simulation game

- Game social complexity – simulation games are social systems [13] that have dynamics and structures. Complexity is represented as interactions with different agents, parties, and roles within the game.
- Complexity dynamics of gameplay – changes to the systematic and social complexity that require the player to adapt to a new situation or game configuration.

The first two dimensions are derived from the classical theories represented in the existing literature on dealing with complexity in simulation games, the validity of games, and state-of-the-art game design [12, 14–18]. The third dimension has been adapted from the dimension of dynamic decision-making and represents the body of knowledge analyzing human behavior when a decision has to be made today, altering the state of the system and influencing the new level of decision-making tomorrow [19]. These dimensions indicate that dynamic decision tasks vary in regards to dynamic complexity, which is a counterintuitive behavior of complex systems that arises from interactions between agents over time [20]. This is caused by the misperception of feedback, time delays, stock-and-flow problems, and a tendency to look at the world from a narrow reductionist perspective. The simulation games mimicking complex real-world systems are not free from the dynamic complexity, as the objective is to teach people to deal with complex problems with greater efficiency. If one of the constantly arising issues is the increasing complexity in real-world systems, it leads to a change in the way simulation games are designed, adding more dynamics to both games and the gameplay itself, organizing it in a more flow-oriented fashion [21].

2 Solving the Internal Structure Dilemma

The biggest challenge of research is to build an applicable research framework within the two dynamic and multi-facet environments that are codefendants within the same game space. The research framework aims to validate the theoretical model. The validation process will require the need to analyze and compare the research results on perceived complexity from different games and target audiences. Thus, we face the problem of normalization for comparability. On the side of game design, we have different games, with different scenarios, roles, contexts of use, time management, types of interfaces, and so on [22]. This creates the problem of the ability to compare data between games and their gameplay. From the player's perspective, we have external and internal variables describing the target audience, such as age, gender, education, previous experiences, their work industry, attitude towards gaming, social group, and so on.

Both of the described perspectives influence each other and are codependent in view of the simulation game complexity (see Fig. 2). Thus, in order to build an internal dependency structure, we need to propose the model limitation method that will allow for data comparability within the same research framework.

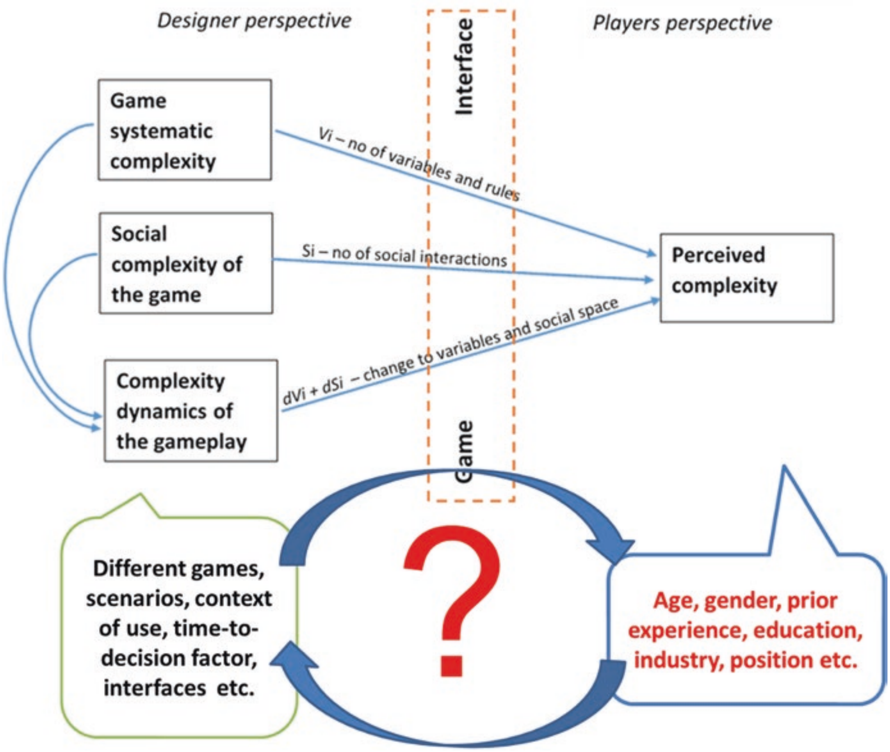

Fig. 2 The internal structure dilemma

3 Research Framework

In the case of two dynamic structures that coexist in the same space and time, we need to reduce one dimension to a constant or semi-constant. In this case, we need to build semi-constant values for a particular game and give it a score value in each of three dimensions: game systematic complexity, game social complexity, and complexity dynamics of gameplay. This score can work as a mediator value to the perceived complexity of the players [23]. Each dimension of the score will have a score value of 10. Scores will be assigned and validated based on the average score of the game experts and facilitators who are familiar with such a game. One of the problems of such a scoring system is that game systems can have multiple scenarios or scenario editors, so the scoring has to be applied to the particular game and the scenario be played with that particular group of players (Table 1).

Each game can be validated and presented with a high level of consistency within the scoring framework. The scoring model serves two purposes from the research outcomes perspective. The first is a confrontation of the designer's and player's perceptions on the game. Such a comparison can give a lot of valuable insight and serve as a reality check of the designer's perspective. The second purpose will add weight to the results from the player's perspective and, with this, allow us to compare games regarding complexity levels. This can create a better understanding of gaming and a stronger basis for future comparative studies in general.

4 Research Model and Procedure

The perceived complexity study based on quasi-experimental studies [24, 25] has been conducted with a series of short questionnaires regularly distributed during the gameplay asking questions about different aspects of gameplay complexity and followed by a more sophisticated questionnaire on the player's background and demographics. The questionnaires are short, composed of nine questions directed at each type of complexity. Additionally, the first questionnaire collected the demographic and independent variable data (sex, age, work experience, etc.), while the last one collected the data on the overall satisfaction from the course and the learning experience. The questionnaires were delivered after the decision rounds but before the results and debriefing. As the research procedures will involve a sequential data collection process, rigorous coding of the questionnaires has to be applied [25]. All students were informed about the aim of the study beforehand and consent to participate was obtained together with the first questionnaire. The research group was divided into five teams of similar size and they played the same business simulation game with four decision rounds of the non-deterministic four-decision rounds scenario with steadily growing complexity (Fig. 3).

Table 1 Example of the game score

Game type	Systematic complexity	Social complexity	Complexity dynamics of gameplay
Scale depth			
Minimal score description	A simple game with very few variables and simple rules	Game played by one person against the system with no social interaction	No dynamics; game is played with the same setting from the beginning to the end, e.g., coin toss game
Maximal score description	Multi-agent, open-world simulation games with a large number of included systems or fuzzy logic and procedurally generated content	A game with many unique roles and many dynamic interactions in different configurations, e.g., complicated negotiation game with many parties and iterations	Game and rules evolve quickly from one iteration to another; the game also requires interaction with another player as their agendas and positions change in the game process
Example evaluation			
Strategic management game – basic 6-period scenario	*8*	*4*	*5*
The rationale behind the score	The game features a relatively high number of variables and many complex dependencies. It features the full model of the company and the competitive market model	The game is played in teams of 4–5 people. However, the interactions between teams are non-existent	The game scenario features a fairly dynamic economic scenario. The game also features an increasing number of decisions and relevant variables, around 2–3 per decision round. The social dynamic is high at the team level but low at the group level (as the game is more team-focused)
Hotel stars [21]	*5*	*5*	*8*
The rationale behind the score	The game features a moderately complex number of variables and has a limited number of rules and complexity	The game is played in 2- to 3-person teams, but can be played with a large number of teams at the same time; the game also features negotiation elements between teams	The game features a highly dynamic scenario regarding game variables, decisions, and events surrounding the game. Also, interactions become more intense; firstly, in-game ranking increases the competition between students and then the negotiation mini-game is present with multi-party negotiation mechanics
SysTeams-Change©	*4*	*7*	*3*
The rationale behind the score	The game is relatively simple to play with a limited number of rules and variables	The game relies strongly on interactions between team members and between teams and facilitators. The number of interactions is high	The game features changes to the basic model introduced during the game or based on the team's decisions but at a relatively low level

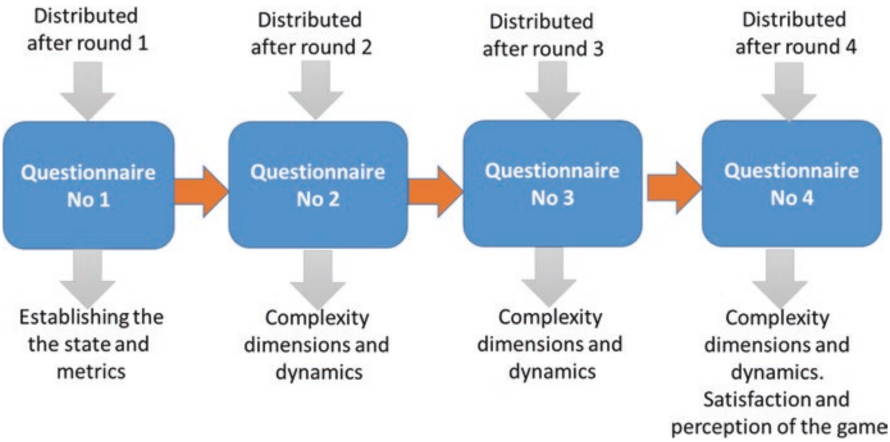

Fig. 3 The data collection procedure

The collected data allow observations on how the game complexity perception changes throughout the game and can be combined and weighted through the game scoring system.

Assuming such a structure will allow the establishment of a basic research model (see Fig. 4).

Treating a particular game as a constant will allow building the whole scoring framework that can work as a semi-constant matrix which can serve as a reference weight to the perceived complexity result on the player side.

This structure will allow us to build the first assumption on nature and create the model, in which we can validate the series of internal and external variables and their influence on the perceived complexity. The validated model can serve as a reference model for simulation game designers and instructors delivering their games to the public.

5 Results

The sequential data collection procedure is very complicated and requires a very strong methodology and code of conduct in order to be valid. There were 126 students involved in the study procedure from groups on MBA and part-time MA courses with a simulation game. However, after elimination of the missing data (student not present or questionnaire not delivered) and questionnaire coding errors (wrong code or code missing), 73 data streams were included in the study. The high rejection rate was expected due to the sequential nature of the data collection process (Table 2).

The group was quite well balanced regarding gender and age distribution. More than half of the players had some managerial experience (more than one year) and all of them had some work experience (more than one year). In those terms, the group was fairly homogenous.

Fig. 4 Internal research model structure

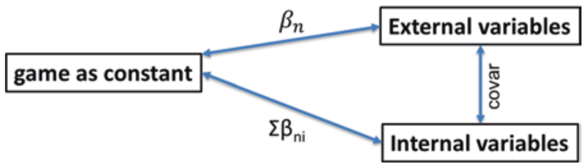

Table 2 Group composition

	No.	%			
Gender distribution					
Female	31	42.47			
Male	42	57.53			
Type of studies					
MBA students	23	31.51			
Part-time MA students	50	68.49			
Managerial experience					
Yes	45	61.64			
No	28	38.36			
Previous experience with simulation games					
Yes	29	39.73			
No	44	60.27			
	Avg.	SD	Mean	Min.	Max.
Age distribution (years)	31.33	8.05	29	22	53

The main body of the study was built in three parts and to each type of complexity measure, three questions were attached. However, in the first round, the questions had to be formulated slightly differently, as there was no comparison to the previous round, but the groundwork of understanding was established in this round, which is critical for the game (Table 3).

The data are inconclusive. The majority of the players in the study were fairly comfortable with the level of complexity in the game. Additionally, if they established an opinion about the game in the beginning, they maintained it until the end of the game. One positive aspect from this is that it can be confirmed that the level of the systematic complexity in the base game scoring model was correct, as the game was scored as moderately complex (Table 4).

The social complexity is quite straightforward in this game. The game is a competitive scenario and relies on the competition mechanics with no cooperation. Therefore, the game scoring model is correct in the sense that the number of interactions in the game is set and it does not have many dynamics in the social aspect (Table 5).

The results regarding the complexity dynamics came with a little surprise; there are no social dynamics of play and this was to be expected. The changes to the systematic complexity are quite substantial; in two cases, the number of decisions in the game almost doubles between rounds and there are also changes to the game's internal rules. However, the majority of the students do not see the changes as substantial.

Table 3 Game systematic complexity

Decision round	1	2	3	4
Q1. The number of decisions was (1 – definitely too small to 5 – definitely too large)				
Mean	3.07	3.14	3.27	3.18
SD	0.79	0.67	0.65	0.54
Median	3.00	3.00	3.00	3.00
Q3. The number of decisions should be (1 – definitely smaller to 5 – definitely larger)				
Mean	2.95	3.07	2.85	3.05
SD	0.81	0.65	0.68	0.66
Median	3.00	3.00	3.00	3.00
Q8. Number of changes to the game (1 – is definitely too much to 5 – should definitely be more)				
Mean	2.18	2.96	3.00	2.93
SD	0.92	0.56	0.53	0.56
Median	2.00	3.00	3.00	3.00

Table 4 Social complexity of the game

Decision round	1	2	3	4
Q2. How often did you communicate with the group (1 – rarely to 5 – very often)				
Mean	4.64	4.63	4.47	4.48
SD	0.63	0.75	0.77	0.69
Median	5.00	5.00	5.00	5.00
Q4. How often did you communicate with other groups (1 – rarely to 5 – very often)				
Mean	1.52	1.45	1.37	1.48
SD	1.18	0.96	0.83	0.91
Median	1.00	1.00	1.00	1.00

Table 5 Complexity dynamics of the gameplay

Decision round	1	2	3	4
Q7. Did an increased number of decisions influence your understanding of the game (1 – I understand much less to 5 – I understand much more)				
Mean	3.33	3.56	3.38	3.33
SD	1.03	0.80	0.74	0.99
Median	4.00	4.00	3.00	3.00
Q9. Compared to the previous round, how much did you communicate during the round (1 – definitely less to 5 – definitely more)				
Mean	3.84	3.36	3.27	3.33
SD	0.99	0.63	0.69	0.76
Median	4.00	3.00	3.00	3.00
Q6. After the changes, the game became (1 – definitely more difficult to 5 – definitely easier)				
Mean	2.90	2.90	3.07	3.14
SD	1.11	1.11	0.65	0.93
Median	3.00	3.00	3.00	3.00

This observation might come from two sources; the first one is the learning curve. In this case, the increase of the game's systematic complexity may not influence the complexity perception, as long as it matches the pace of learning of the game mechanics. The second reasoning is more pessimistic. If students did not understand the game from the beginning, then changes do not influence their level of knowledge of the game rules. Thus, changes to the game do not influence the understanding of the game rules.

Looking at the independent variables, there were several statistically significant differences found when comparing subgroups in the divisions of gender, type of students (MBA or MA), managerial experience, and previous experience with simulation games. However, due to the small number of respondents and a large difference in the sample numbers, none of those can be considered trustworthy and further analysis is needed.

6 Discussion

The complexity of simulation gaming is not easy or trivial to measure. This research model is the author's first attempt to capture the dynamic and correlated nature of priced game complexity. The pilot study showed that the scoring model for the systematic and social complexity could be validated. However, the nature of dynamic complexity is difficult to measure. The study faces a lot of limitations. First of all, it has been conducted on a quite homogenous group and with the use of only one simulation game. Secondly, the group was not sufficiently diversified regarding age, gender, and nationality. The students were of Polish citizenship. The sequential data gathering process is also very complicated and difficult to sustain. A large number of data have to be rejected in the process of analysis due to the lack of full data streams.

The pilot study gave the author a lot of information and improvement ideas. The questionnaire needs to be refined and recalibrated for a better understanding of the nature of complexity. Additionally, a more effective method for data gathering has to be implemented in order to obtain more reliable data. Other different games need to be covered by the research. Safe in the knowledge that the game complexity scoring system has a solid grounding, we can apply the scoring system to and compare the results from different sources.

References

1. Duke RD (1974) Gaming: the future's language. Sage, London
2. Mayer IS (2009) The gaming of policy and the politics of gaming: a review. Simul Gaming 40:825–862
3. Oțoiu C (2014) Details of complexity. In: Duke RD, Kriz WC (eds) Back to the future of gaming. W. Bertelsmann Verlag, Bielefeld, pp 40–49
4. Lukosch HK, Bekebrede G (2014) The future of gaming: challenges for designing distributed games. In: Duke RD, Kriz WC (eds) Back to the future of gaming. W. Bertelsmann Verlag, Bielefeld, pp 142–153
5. Wardaszko M (2018) Interdisciplinary approach to complexity in simulation game design and implementation. Simul Gaming 49(3):263–278. https://doi.org/10.1177/1046878118777809
6. Feinstein AH, Cannon HM (2001) Fidelity, verifiability and validity of simulation: constructs for evaluation. Dev Bus Simul Exp Learn 28. www.absel.org
7. Feinstein AH, Cannon HM (2002) Constructs of simulation evaluation. Simul Gaming Interdiscip J Theory Pract Res 33(4):425–440
8. Klabbers JHG (2018) On the architecture of game science. Simul Gaming 49(3):207–245. https://doi.org/10.1177/1046878118762534
9. Van Gigch J (2002) Comparing the epistemologies of scientific disciplines in two distinct domains: modern physics versus social sciences. Syst Res Behav Sci 19(6):551–562
10. Cannon HM (1995) Dealing with the complexity paradox in business simulation games. Dev Bus Simul Exp Exerc 22:96–102
11. Whitton N (2009) Learning with digital games: a practical guide to engaging students in higher education. Routledge, New York
12. Meijer SA (2015) The power of sponges: comparing high-tech and low-tech gaming for innovation. Simul Gaming Interdiscip J Theory Pract Res 46(5):512–535
13. Klabbers JHG (2000) Learning to handle complexity in social systems. In: McCarthy IP, Rakotobe Joel T (eds) Proceedings of the international conference on complexity and complex systems in industry. University of Warwick, Warwick, pp 616–638
14. Klabbers JHG (2006) A framework for artifact assessment and theory testing. Simul Gaming Interdiscip J Theory Pract Res 37:155–173
15. Klabbers JHG (2006) The magic circle: principles of gaming & simulation, vol 1. Sense Publishers, Rotterdam
16. Girard C, Ecalle J, Magnan A (2012) Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. J Comput Assist Learn 29:207–219
17. Bekebrede G, Lo J, Lukosch HK (2015) Understanding complex systems through mental models and shared experiences: a case study. Simul Gaming Interdiscip J Theory Pract Res 46:536–562
18. Lankveld G, Sehic E, Lo JC, Meijer SA (2016) Assessing gaming simulation validity for training traffic controllers. Simul Gaming Interdiscip J Theory Pract Res 48(2):219–235
19. Diehl E, Sterman JD (1995) Effects of feedback complexity on dynamic decision making. Organ Behav Hum Decis Process 62(2):198–215. https://doi.org/10.1006/obhd.1995.1043
20. Sterman J (2015) Learning for ourselves: interactive simulations to catalyze science-based environmental activism. In: Stoknes PE, Eliassen KA (eds) Science-based activism. Bergen, Fagbokfolaget, pp 253–279

21. Wardaszko M (2016) Building simulation game-based teaching program for secondary school students. Simul Gaming 47(3):287–303. https://doi.org/10.1177/1046878116635467
22. Burgess TF (1995) Cycle time, decisions, and complexity in business simulation/games. Simul Gaming Interdiscip J Theory Pract Res 26(3):376–383
23. Boumas M (1999) Built-in-justification. In: Morgan MS, Morrison M (eds) Models as mediators. Perspectives on natural and social sciences. Cambridge University Press, New York
24. Cook TD, Campbell DT (1979) Quasi-experimentation: design and analysis issues for field settings. Houghton Mifflin, Boston
25. Creswell JW (2014) Research design: qualitative, quantitative, and mixed method approaches, 4th edn. Sage, Los Angeles

How to Describe a Large Business on a Business Board Game: An Illustration of Construction Company

Ryoju Hamada, Kriengsak Panuwatwanich, Tomomi Kaneko, Masahiro Hiji, Kantamas Burunchai, Guntapol Choompolanomakhun, and Chattavut Sri-on

Abstract Following a request to gamify construction company's business model, the authors' group (BASE) discussed whether it was possible to represent such a large industry in a business board game. We defined two principles, "cutoff branch" and "gradualism." By applying them, we have succeeded in developing three different game sets called BASE Construction Game (BCG). We tested all games at Sirindhorn International Institute of Technology (SIIT), Thammasat University, from February to April 2018. To evaluate their teaching effectiveness, we conducted four questionnaire surveys. The results showed that BCG satisfied all learning goals and can be further improved in the future.

Keywords Business game · Board game · Construction industry · Cutoff principle · Gradualism principle · Sustainability

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1 Introduction

It is critical to develop high-quality engineers. However, the wave of active learning shaking many universities in Thailand has not extended into engineering education. Even though engineers must obtain knowledge through hands-on experience and practical lessons, most of their lectures are textbook-based traditional lectures.

In 2017, we received a request to create a new business game to let students learn the business model of general construction company. The authors (Hamada, Kaneko, and Hiji) have been developing business games since 2007 under the brand name BASE Management Games. However, due to the physical limitations and complicated rules, we have never created any games that describe a large company's nature. BASE's defining characteristic is the analog feeling of its products, which emphasize learning through human senses rather than computerized processes. We asked ourselves a question: Wasn't it possible to develop a board game that described a huge industry while maintaining the strengths of analog games? This was the origin of our project in 2017, which led us to create a new game called BASE Construction Game (BCG).

2 Literature Review

The primary purpose of engineering education is to produce next-generation engineers. Engineering is mainly theoretical and focuses on the delivery of knowledge from teacher to student. Moreover, technology is always moving ahead of ordinary people, and engineering students are no exception. There are not many means of letting these students learn by simulation/gaming. Instead, traditional lectures based on textbooks are still commonly used. Deshpande and Huang [1] argue that the number of simulation games in the engineering profession is lower than in other disciplines. They list and taxonomize 50 simulation games in engineering education. Of these, there are only two related to the civil engineering field. Wall and Ahmed [2] explain that business games contribute considerably to continuing professional development (CPD) in the construction industry. Nassar [3] reviews the history of construction management games. According to the author, the development of these games started in the 1960s. The first famous game is the Construction Management Game invented by Au, Bostoleman, and Parti [4]. It is a 3-year game that progresses based on the player's monthly decisions. Their choice often contradicts rivals' decisions. It is computer game; players input decisions every month and the computer generates the result.

The real construction process is broken down into a timeline, with specialists handling individual processes. By focusing on this stream, Tommelein, Choo, Riley, and Howell [5] and Choo and Tommelein [6] created the Parade Game. This game separates a construction process into six steps (parades) and lets participants learn how construction is affected by the condition and performance of downstream parades. It is possible to play face-to-face [5] or using a computer [6].

Negotiation and communication skills are necessary in construction projects. Accordingly, Dubziak and Hendrickson [7] introduced a new game called Negotiation Game. This game is focused on negotiations in construction projects and lets two parties discuss the conditions of work. Beliveau [8] introduced the Road-Building Negotiation Game. In this game, players construct and extend a road, but there are many barriers, called "spots," and the players must then discuss with stakeholders within a limited time.

Many external factors create problems for the project manager on a construction site. To train people to deal with these factors, Halpin and Woodhead [9] created a game called CONSTRUCTO. It is a computer game for construction project management, which requires considering weather- and labor-related damages. Meanwhile, the Marketing Game by Bichot [10] and Superbid by AbouRizk [11] encourage marketing and sales skill development.

So far, we have learned that the idea of gamifying construction management has a long history. However, there have been few games in the recent years, despite the fact that active learning is currently very much encouraged in higher education. Construction Management Game is over 50 years old; Parade Game was made over two decades ago. As these facts suggest, there are few ideas to use in making business games that fit the requirements of the modern university's civil engineering education.

3 The Nature of the Construction Industry

3.1 The Construction Industry as a Complex System

The construction industry is the backbone of a country's economic development. It is one of the largest industries worldwide and has historically accounted for around 10% of the world's gross product. It is considered a goods-producing sector but at a much larger scale than the manufacturing industry. The demand for human resources in this sector is relatively high, driving the need for the education sector to ensure a ready supply of qualified graduates capable of supporting a wide range of organizations and projects within the industry.

The construction industry itself is diverse and complex. In general, the sectors within the construction industry can be categorized as follows:

- Residential (condominiums, apartments, freestanding dwellings/townhouses, etc.)
- Commercial (office buildings, schools, stores, hotels, etc.)
- Industrial (manufacturing plants, refineries, pipelines, high-tech facilities, etc.)
- Heavy/civil infrastructure (highways, dams, canals, bridges, etc.)

Different sectors require different business models, types of technical knowledge, and skill sets. The construction projects in these sectors can be carried out in the form of either public or private projects or as public-private partnerships. Key participants in a construction project include:

- Owners: Make decisions, set requirements, finance, and oversee the project. Project owners can be either public or private entities or some of each.
- Consultants: May represent the owners and provide advice/assistance to them in the delivery of the project. Consultants can offer technical or business services or both.
- General contractors: Bid for projects. If successful, they are awarded contracts and will be responsible for carrying out projects according to the owners' requirements. They may subcontract portions of the work to subcontractors.
- Subcontractors: Specialize in certain portions of the work.
- Designers, architects, and engineers: Responsible for the design, calculation, and supervision of projects to ensure compliance with the relevant technical requirements.
- Construction managers: Manage construction projects but may work for different parties.
- Trades: Skilled laborers (electricians, plumbers, carpenters, steel fixers, etc.).
- Labor unions: Look after the benefits and welfare of their members.
- Insurance companies: Provide bid, performance, and payment bonds, which contractors require in a bidding process.
- Banks: Provide working capital to contractors and short-/long-term financing to the project owners.
- Suppliers of construction materials: Can also assist designers in material/equipment selection and contractors in preparing construction documents.
- Permit agencies and building authorities: Represent public safety interests.

These key players form the so-called construction value chain. In the industry, value is mainly generated through construction projects, whereby funding is injected to produce certain infrastructure assets, facilities, buildings, etc. to fulfill the needs of a particular sector. These players can benefit from the value generated by a construction project throughout its different phases, which are known collectively as a "construction project lifecycle." A construction project lifecycle is a collection of generally sequential and sometimes overlapping construction activities. It provides the basic framework for managing a project, regardless of the specific work involved. A typical construction project life cycle consists of the following phases:

- Conception/initiation: This phase is concerned with the initiation and conceptual development of the project, including the feasibility study and the preparation of the project proposal.
- Definition/development: This phase is concerned with the definition of project scope, the identification of the tasks and resources required, and the subsequent compilation of the plan.
- Implementation/execution: This phase deals with the actual construction/building of the project according to the plan. Project control is also the main managerial function required in this phase.
- Closeout/termination: This phase is concerned with activities undertaken to ensure that the project meets the client's requirements upon its delivery. This phase includes such activities as project commissioning, acceptance tests, and project audits.

In fact, the life cycle of a construction project follows that of a typical project in other sectors. Therefore, when supplemented with additional technical knowledge of construction work, generic project management skills can be applied to the management of a construction project.

In higher education, construction management is mainly taught in civil engineering and architecture programs, with the aim of equipping students with basic project management knowledge and skills. Due to the fact that most employment opportunities for graduates are in construction project site environments, project management skills, as well as knowledge of construction techniques, are considered essential for these types of students. In a more business-focused program, such as real estate management or quantity surveying, construction management education provides students with exposure to numerous technical aspects of construction work, in addition to business and project management skills. Given that the construction industry encompasses numerous players and economic activities along its value chain, construction management can be integrated into instruction in various degree programs to prepare graduates to serve in the construction industry.

3.2 Implementations for Construction Management Gamification

The development of a business game to teach construction management should be guided by learning outcomes that will enable students to develop the required competencies to work effectively in the construction field. Due to the diverse and complex nature of construction industry, it is also essential to identify which skill areas (i.e., business versus engineering) and phases of the construction project life cycle need to be emphasized in the objectives of a game.

The students who participated in the game tested in this study were mainly enrolled in a management technology program. Almost none of them had exposure to a formal civil engineering education. For a targeted group of students such as this, it is important to focus on providing a basic understanding of fundamental construction activities and then linking these activities with the business aspects of a construction enterprise. Basic construction project management (i.e., during the execution phase of the project) thus became relevant in this case, as a result of its focus on business and managerial concepts such as planning, cost controlling, and risk mitigation. Accordingly, an important aim of the game was for the students to learn time and resource planning and their implications for construction costs. The students were also expected to be able to appreciate the impacts of risks and how to orient their decisions to cope with the present risks.

The game needed to be realistic in order to engage students and enable them to develop the skills required in real-world contexts. Designing a product that meets the necessary learning objectives was a challenge, as the construction industry is highly complex (i.e., it comprises numerous key players and multiple life cycle phases, with each project having unique characteristics that depend on the specific sector within which the project is being developed). If a game is too complicated, the students may lose the ability to perceive the cause-and-effect relationships associated with the decisions they make during the game. As these cause-and-effect relationships become obscured, the game may lose its meaning, which in turn will demotivate the students to complete the game. This "complexity paradox" was one of our key considerations when designing the game presented in this paper.

A set of rules and assumptions were implemented to contextualize the game and to achieve an appropriate level of realism. A simulation was also used to create various scenarios, which represented opportunities for the students to capitalize on and the obstacles for them to overcome. Given that these different scenarios had an impact on the outcomes of the game played by each student or group of students, simulation enhanced the gamification aspect of the exercise (through competition), requiring the students to devise various strategies in response to the presented scenarios. Further details of the design of the game are presented in the following section.

4 Two Principles for Gamifying Construction Industry

As explained in the previous section, the real construction industry has a complex nature. However, we insisted on optimizing it as a tabletop business game. To achieve the purpose, we adopted two essential principles. These are the "cutoff branch principle" and the "gradualism principle."

4.1 Cutoff Branch Principle

As Teach and Murff [12] state, some claim that an emphasis on realism makes games much too complex and inhibit students' understandings. They argue, "Let's investigate simple games again." Our BASE project has already solved this issue. Increases in complexity occur at two different points: one is during the initial development, and the other is during improvements made following student feedback. A BASE business game has two guiding policies:

1. Not to institute too many rules at the beginning, even if we skip or ignore the minor customs of the target industry
2. Not to add new rules except to amend critical mistakes

We named this doctrine the "cutoff branch principle" (Hamada, Kaneko and Hiji [13]). Every game creation process starts from observation of target industry, without any prejudice. Literature is used to confirm our direction is correct. Since we know we do not have the expertise of personnel in the field, we gain only ideas through observation. We study hard to know what we see, understand it perfectly, and make a blueprint of the game.

For instance, we know that general construction companies undertake any construction, not only of buildings but also of infrastructure. However, these are different activities, and mingling the two is harmful to beginners. So we cut off infrastructure and focus only on buildings. During development, we account for the fact that weather has effects on the progress of skeletons and exteriors but none on interior work. However, we do not include a rule outlining this, because it is not a major issue.

4.2 Gradualism Principle

To imitate a large industry like the construction industry, we have to input many ideas. However, if we include everything at the beginning, learners cannot follow, so we decided to create several different types of games, which gradually involve new rules. It takes a long time to learn complicated story; this is the nature of learning. We do not make students hurry, to avoid adding pressure, but instead let them enjoy the gameplay. In this game, we decided to provide enough time (4–5 h), to have three separate games, and to play them gradually. Following the principle, we create three stages, as shown in Table 1.

4.3 Implementation of Two Principles in the Development of BCG

We saw and visited many construction sites, to get the basic idea of construction. Any building construction starts from installing pilings and making a basement and proceeds from the ground floor to the roof. When it is raining at the construction site, there are no workers. On sunny, hot days, the workers' motivation levels are very low. Many posters argue the importance of safety. Some personnel see a chart to control the process, and in the temporary office, there is a computer on which to compare the plan and the actual progress, which might be represented on a Gantt

Table 1 Comparison of specifications for games 1, 2, and 3

	G1, G2	G3
Duration	1 year	4 years
Length of work	3–6 months	4–12 months
WV (min.)	120	800
WV (max.)	2000	50,000
Share capital	$200,000	$1,500,000
Raw materials	Cement, steel, grass, wood, brick, marble	Cement, steel, pile, board, lift, wood, glass, brick, marble

chart. These are the observations of an amateur, not a professional, but we were sure that there was truth in them. We believe that we included most fundamental information necessary to understand basic concepts in the construction industry, and there was no need to add any more for average students. That was the cut-off point. Even though we simplified as much as possible, it was still tricky for beginners. Accordingly, we separated the story into three parts and let students learn gradually.

5 Development and Operation of BCG

5.1 Development Philosophy

We considered the five Ws (and one H) when developing BCG. Here, we will discuss only the essentials.

Target Learners (Who) BCG is a business game for everyone who is interested in construction and project management. It is easy to understand and user-friendly, to support people who want to play this game but who may not be engineers. BCG is targeted to fourth-year students at SIIT who have no previous knowledge of civil engineering or the construction business.

Learning Goals (What) We set six learning goals for BCG. These were ultimately cut off, as it became impossible to make the game any easier.

(a) Students understand the importance/necessity of a basic Gantt chart.
(b) Students understand construction is affected by external factors.
(c) Students understand a large project must have a plan and follow the plan strictly.
(d) Students understand relations between customers correctly.
(e) Students understand the proper process of building construction.
(f) Students understand strategy is essential to making a company grow.

Learning Method (How) Following the gradualist principle, the authors separated the complete game into three independent games: Game 1 (basic, G1), Game 2 (advanced, G2), and Game 3 (final, G3). The game played depended on the students' level of understanding. The students had to form a group (company) and manage its operation through discussion. The student authors of this paper became teachers and taught their friends. This idea is also a tradition of the BASE project. Each game takes place over an imagined duration of 1 year. G1 and G2 take 4 h of real time to complete, and G3 takes 12 h.

5.2 Components of the Three Games

BCG contains a paper company board, cards, and stars.

Company Board Figure 1 shows the whole set of BCG.

Sheets Players have five different kinds of tables, as follows:

(a) Table A = Cash flow management sheet
(b) Table B = Gantt chart

For G1 and G2: Plan, result, and overtime
For G3: Plan, result, and overtime for each step, including base, skeleton, interior, and exterior

(c) Table C = Sheet for miscellaneous calculations
(d) Table D = Income statement (P/L)
(e) Table E = Balance sheet (B/S)

Cards BCG has four types of cards, as shown in Fig. 2.

(a) Construction cards: Nos. 1–100 for building projects. Each team draws up to three cards every month.
(b) Resource cards:
    G1 and G2: grass, cement, and steel only
    G3: cement, steel, board, glass, pile, and lift
(c) Design cards: wood, marble, and brick
(d) Risk cards:

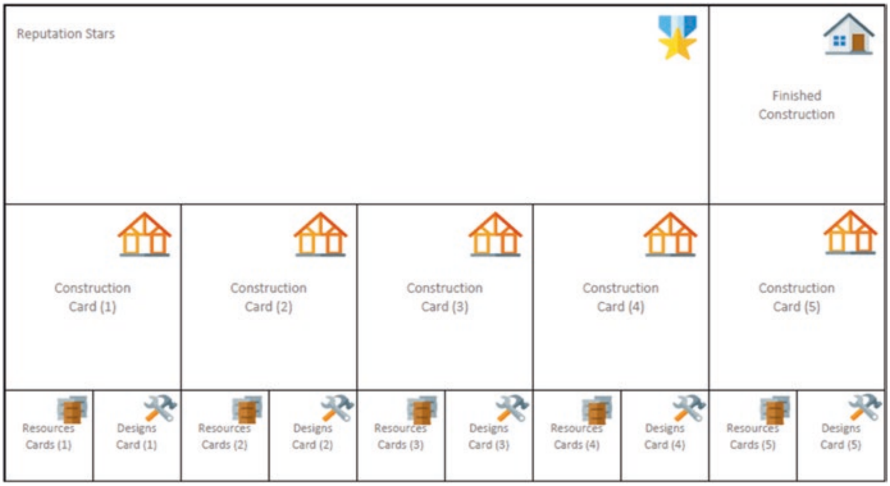

Fig. 1 Paper board for G1, G2, and G3

Fig. 2 Expense card and stars in G1 and G2

G1: weather and labor only
G2: weather, labor, and safety
G3: weather, labor, and safety

Stars When a team completes a project, they can gain a star (lower right in Fig. 2), which represents their experience and reputations. To get more difficult, profitable projects, they must hold a certain number of stars.

Work Volume (WV) In the construction industry, there is a common measure called a "man-month." One man-month represents the amount achieved when an average worker works in normal conditions for a month. We applied this idea but called it "work volume (WV)" instead, to be consistent with previous BASE business games. In our game, work volumes are reduced or increased by risk cards. For example, if WV = 5000, a team must hire 5000 workers for the duration of the project. One work volume unit is $250. If the weather is always fine, labor's attitude is average, and there are no incidents, labor cost will be $1,250,000. If the weather is bad and causes a 20% WV reduction, a company must compensate for the delay with overtime work at $500 per unit. If a team hired 5000 workers but actual progress was 4000 WV, they have to pay for 1000 units of overtime work, as indicated by the following formulas:

5000 (person) × $250 = $1,250,000
1000 (overtime hours) × $500 = $500,000
Total labor cost is $1,250,000 + $500,000 = $1,750,000

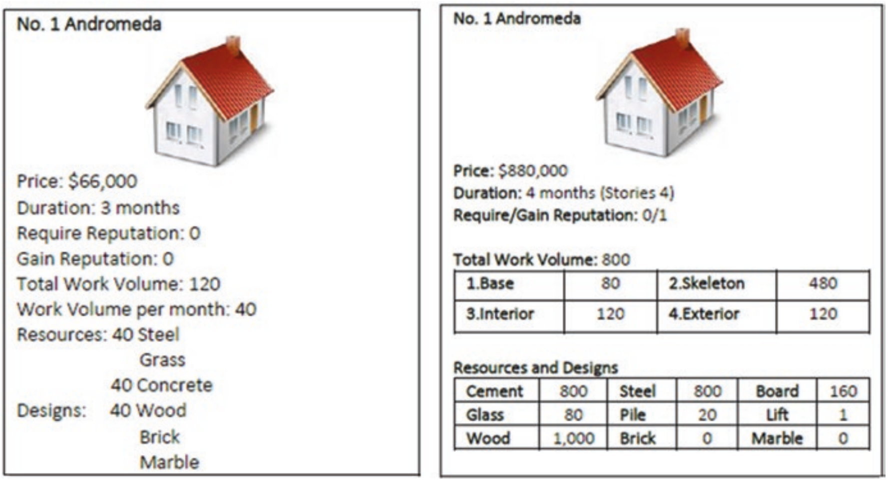

Fig. 3 Construction card for G1/G2 (left) and G3 (right)

5.3 How to Play BCG Game 1

Students' companies construct a building using a six-step play process.

1. Receive share capital of $200,000, and record it in Table A.
2. Pick three construction cards (Fig. 3), considering the following points:
   (a) Check the requirements of a reputation star to ensure they have the required stars (e.g., if the work students aim to do requires nine stars, they must have more than nine stars).
   (b) Project costs start from $150,000 and end at $1000,000.
   (c) It is possible to do up to five projects in parallel.
3. Hire the number of workers suggested on the construction card, and record their plan on the digit line of the Gantt chart, with the expected rate of progress in brackets.
4. Purchase all raw materials, following the order of the cards.
5. Pick risk cards: weather and safety (there are no safety cards in the basic game). Depending on the results of the risk cards, construction might be delayed. In such a case, the team must ask laborers to compensate with overtime work; its cost is twice as much as the original load.
6. Record income and expenses in Table A.
7. Gain reputation stars after finishing building.
8. Every 12 turns (months), compile a financial statement.
9. The winner is the team whose sales revenue is highest.

5.4 How to Play BCG Game 2

Game 2 is an advanced version of Game 1 and has the same six stages. However, there are four additional rules added.

1. Players are introduced to a new category of risk cards called safety cards. To boost learning, we increased the ratio of risks compared with G1.
2. The team can hire more workers or fewer to prevent overtime costs or hedge risks related to weather, labor, and safety.

For example, in a case where the team must complete 600 WV jobs in a month and the risk card shows 20% delay from the original timeline, they can reduce the risk by hiring more than 600 workers. Table 2 shows an example.

In this case, we can see course c is most efficient, enabling the team to save money. Since all decks have the same contents and the same number of risk cards, players can forecast future incidents to a certain extent. So in this case, team C has the most success in saving labor costs. Meanwhile, team B hired too much and wasted money.

On the other hand, sometimes, risk cards promote progress, by introducing good weather, for example. If students forecast they will get a good card on their next turn, they can decrease their resource allotments, as Table 3 shows.

In this case, team C saved more labor costs than others. Team B decreased too much and consequently wasted money. Through such experiences, students learn how to reduce damage from foreseeable risks and how to manage human resources effectively.

5.5 How to Play Game 3

Outline Game 3 is the version that includes the proper sequence of a real construction process. There are significant differences between Game 1 and Game 3, as shown in Fig. 4.

G3 covers a period of 4 years and uses a different set of construction cards. The winner has to complete "the last boss project" within 48 months. We use different risk cards, which create more chance to get severe risks compared to G1 and G2.

Process The process for G3 is same as for G1 and G2, except in the following ways:

1. The Gantt chart for each project is separated into four parts to reflect the nature of the construction industry (see Figs. 4 and 5).
2. Players skip the financial statement for Y1 to Y3 and include everything in Y4.

Table 2 Increasing workers and the resulting effect (delay)

	Course	Required WV	Set WV	Weather	Labor	Safety	Total delay ratio	Actual progress	Required overtime	OT cost	Regular labor cost	Total cost
A	Default	600	600	0.8	1	1	0.2	480	120	60,000	150,000	210,000
B	+30%	600	780	0.8	1	1	0.2	624	0	0	195,000	195,000
C	+10%	600	660	0.8	1	1	0.2	528	72	36,000	132,000	168,000

Table 3 Decreasing workers and the resulting effect (efficiency)

	Course	Required WV	Set WV	Weather	Labor	Safety	Total progress ratio	Actual progress	Required overtime	OT cost	Regular labor cost	Total cost
A	Default	600	600	1.2	1	1	1.2	720	0	0	150,000	150,000
B	−30%	600	420	1.2	1	1	1.2	504	96	48,000	120,000	168,000
C	−10%	600	540	1.2	1	1	1.2	648	0	0	135,000	135,000

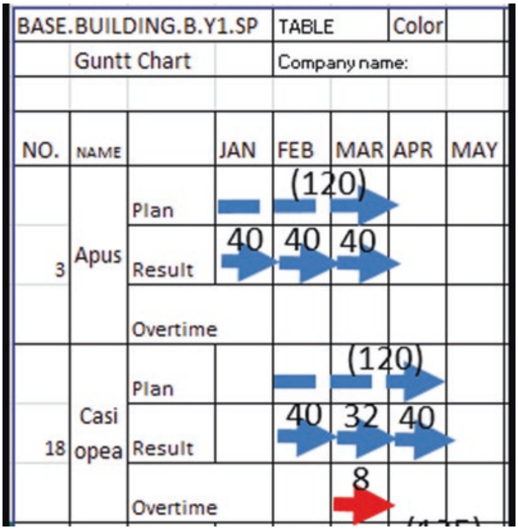

Fig. 4 Gantt chart for G1, G2

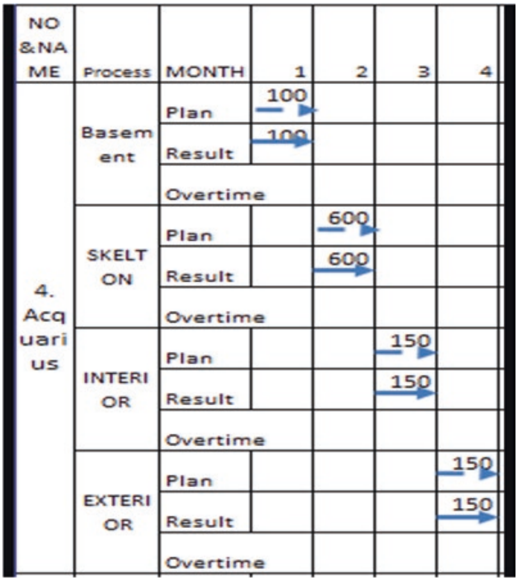

Fig. 5 Gantt chart for G3

Gantt Chart The authors revised the Gantt chart significantly. In G1 and G2, we treat construction as a continuous, linear process, as Fig. 4 shows. On the real construction sites, we observed that there are four stages: Basement, Skeleton, Interior, and Exterior. We never saw a building without a stable basement, nor a construction process that ran from the ground to the roof. By implementing our findings, we changed the format drastically, as Fig. 5 shows.

Following Chronological Order and Keeping the Deadline The work is separated into four processes (Basement, Skeleton, Interior, and Exterior). The players must finish those processes in order; otherwise, they cannot proceed to the next phase. Real construction takes time, and individual processes are done by different subcontractors. Accordingly, it is necessary to stick to the time allotted for each process. In the example in Fig. 5, the whole WV is 1000. It can be separated out as follows:

- Basement = 10% of total WV
- Skeleton = 60% of total WV
- Interior = 15% of total WV
- Exterior = 15% of total WV

There are some additional rules for G3. Here, “N” means the last month.

1. In the first month, a team must create a basement. In case of delays, they have to pay for overtime work to complete it. If they do not do this, they cannot proceed to the next stage.
2. Skeleton work starts from the second month and can extend to N-2 months.

Players have to complete some stories above the ground floor. Otherwise, they cannot start interior work. Delays are not permitted; and they must achieve their targets through overtime work.

3. Interior work begins from the third month and can extend to N-1 month. For the same reason as above, delays are never accepted.
4. Exterior work starts from the fourth month and can continue into the last month. Delivery must be made within the contracted period, so delays are never permitted.

In this game, in most of the months, skeleton, interior, and exterior work proceeds in parallel. It must go at the same speed regardless of weather-, labor-, and safety-related risks. Moreover, students plan the different projects in the same month. By continuing to manage such a project for a long time, they learn the importance of Gantt charts, process management, and time management.

Financial Statements Student welcome that they are free from composite sheets for Y1 to Y3, but when they try to compile a final B/S, they recognize that even one mistake on cash balance makes the last B/S unbalanced. They learn that creating a P/L statement and B/S every year is essential.

6 Results

In February 2018, 27 students at Thammasat University (SIIT student) completed questionnaires before and after playing the simulation game. The surveys consisted of questions about the six learning goals mentioned in 5.1.2. The Likert scale was used to assess the questionnaire (1 = do not understand at all; 5 = understand

Table 4 Result of questionnaire before/after G1 and G2

No.	Related learning goal	Question	Before	After	A/B	T-value
1	d	Construction process starts after the contract with the customers	3.52	4.11	1.17	0.00530*
2	c, d	Delivery limit is the absolute promise to the customer	3.33	4.15	1.25	0.000192***
3	b, c, d	Estimation of raw materials, labor, and time must often be adjusted	3.52	4.22	1.2	0.000531**
4	b, c	Weather condition is quite an important factor	3.52	4.37	1.24	0.000153***
5	a	The Gantt chart is the most important tool for project management	3.4	4.33	1.27	0.0000267***
6	a, c	Production planning is important	3.3	4.26	1.29	0.0000729***

$N = 27$, $*p < 0.05$, $**p < 0.005$, $***p < 0.0005$, one-tail

completely). The students who participated in this experiment were from various faculties, and all were beginners at the business simulation game.

6.1 Teaching Effectiveness of G1 and G2

Table 4 summarizes questions and answers before/after G1 and G2.

Any jobs came from customers. A delivery limit is absolute. A company procures enough raw materials and sometimes obligates laborers to do overtime work. We include this principle in the card-drawing system, star system, and overtime work rule in this game. Questions 1, 2, and 3 relate to this problem. Therefore, we can say that learning goal (d) is satisfied.

A Gantt chart is commonly used to plan and review a project. The responses to questions 5 and 6 show students' increased understanding of this fact. Thus, learning goal (a) is satisfied.

Once the company makes a plan, the plan must be respected. The responses to questions 2, 3, and 4 show students' understanding of this point. Therefore, we achieved learning goal (c).

There are external factors that are uncontrollable, like the weather. We represented such external problems through the risk card system in our game, and it affected actual processes directly. According to feedback on questions 3 and 4, students understood the existence of risk and its effects. Therefore, we can say that we met learning goal (b).

Table 5 Result of questionnaire before/after G3

No.	Related learning goal	Question	Before	After	A/B	T-value
1	d, f	Construction process starts after the contract with the customers	3.53	4.35	1.23	0.004223**
2	e	Construction takes a certain time and is impossible to complete at once	3.65	4.47	1.22	0.001277**
3	e	Any process must be followed step by step	3.18	4.47	1.40	0.0000538***
4	c	Even if projects are late of bad weather or accident, we must follow our original plan	3.59	4.3	1.19	0.009018*
5	d, f	To gain a good job, it is crucial to gain the customer's confidence	3.65	4.11	1.12	0.028183*
6	f	There are some barriers that the company must overcome on the way to growth	3.64	4.18	1.15	0.017138*

$N = 17$, $*p < 0.05$, $**p < 0.005$, $***p < 0.0005$, one-tail

6.2 Teaching Effectiveness of G3

By April 9, 2018, 17 students had answered a second questionnaire focusing on G3. Table 5 summarizes the questions and answers given before/after G3 was played.

The questionnaire for G3 focused on advanced learning goals (e) and (f). Responses showed that students understand the rules. For example, they know that they must finish the Basement phase to proceed to the Skeleton one. Questions 2 and 3 track the implementation of those rules, and Q3 shows significant growth (40%). Accordingly, we can say that learning goal (e) has been successfully achieved.

To win the game, players need an understanding of the rules and the right plan for maintaining cash, customers, and fair projects. We addressed these ideas in questions 5 and 6, and those numbers are improved. Therefore, we can say that we met learning goal (f). If we consider all the points above, it is clear all our learning goals were achieved.

6.3 Satisfaction Level

At the end of the lecture, we inquired whether students were satisfied with our game. Responses are summarized in Table 6.

We can see that more than 95% of surveyed students enjoyed our game and more than 93% would recommend learning by business game. Moreover, all but one student answered they like active learning. We suspect they had never attended such lectures and believe we must increase opportunities for them to do so.

Table 6 Students' satisfaction levels after playing all games

No.		Strongly yes	Yes	Maybe	No	Never
1	Did you enjoy our games?	14 (45.1%)	16 (51.6%)	1 (3.2%)	0 (0.0%)	0 (0.0%)
2	Do you like active learning?	—	30 (96.7%)	1 (3.2%)	0 (0.0%)	—
3	Would you recommend this course to junior students?	12 (38.7%)	17 (54.8%)	1 (3.2%)	1 (3.2%)	0 (0.0%)

N = 31

7 Conclusions

We introduced our board game, BCG, to simulate building constriction. As our survey results demonstrate, our work is an effective teaching tool and provides potential opportunities to increase students' motivation.

7.1 Reconsidering the Potential of Board Games

Our target industry is huge and has many traditions, rules, customs, and protocol. Since most of the authors are not construction industry professionals, our game has limitations. However, by applying the "cutting-off branch" principle, we simplified learning goals to the minimum. Our gradualist strategy also worked well to train students without hurrying them. We believe it is possible to create an effective board game by compromising to the reality, and tabletop games still have potential regardless of the scale of the target industry.

7.2 Discussion

Table 6 shows us quite high satisfaction, but in two cases, "strongly yes" was selected less often than "yes." We propose that this is because of the number of errors on the game sheets and the methods through which instructions were communicated. We must continue this project to improve the operation. The application level of "cutting-off branch principle" is still not clear. Despite we cut off many branches bravely, we still saw many students struggling with the complex Gantt chart. On the other hand, there were many teams that feel no difficulty. How to adjust the level of simplification is an important issue.

There were many teams that brought their laptops and used them to manage cash and process correctly and effectively. The authors recommend including a computer as a support tool; students can learn more while maintaining fantastic communication.

7.3 *BCG: Toward the Era of Neo-simulation and Gaming*

The BASE project does not retain student members. The student authors of this paper and the student teacher who worked in operations will leave the university. However, the teacher authors wish to invite newly motivated students and train them to reform BCG continuously to contribute in the coming era, by spreading our findings.

References

1. Deshpande AA, Huang SH (2011) Simulation games in engineering education: a state-of-the-art review. Comput Appl Eng Educ 19(3):399–410
2. Wall J, Ahmed V (2008) Use of a simulation game in delivering blended lifelong learning in the construction industry: opportunities and challenges. Comput Educ 50(4):1383–1393
3. Nassar K (2002) Simulation gaming in construction: ER, the equipment replacement game. J Constr Educ 7(1):16–30
4. Au T, Bostleman RL, Parti EW (1969) Construction management game-deterministic model. J Constr Div 95:25–38
5. Tommelein ID, Riley DR, Howell GA (1999) Parade game: impact of workflow variability on trade performance. J Constr Eng Manag 125(5):304–310
6. Choo HJ, Tommelein ID (1999) Parade of trades: a game for understanding variability and dependence. In: Construction engineering and management program, civil and environmental engineering department. University of California, Berkeley
7. Dubziak W, Hendrickson C (1988) A negotiation simulation game. J Manag Eng 4(2):113–121
8. Beliveau Y (1991) Road building negotiation game, company and project management lectures. Blacksburg
9. Halpin DW, Woodhead RW (1973) Constructo: a heuristic game for construction management. University of Illinois Press, Champaign
10. Bichot T (2001) The construction marketing game: master thesis. Bradley University, Peoria
11. AbouRizk S (1992) A stochastic bidding game for construction management. Proceedings of second Canadian conference on computing in civil engineering, pp 576–587
12. Teach RD, Murff E (2014) Are the business simulations we play too complex? Dev Bus Simul Exp Learn 35:205–211
13. Hamada R, Hiji M, Kaneko T (2015) BASE business game creation charter. Proceedings of JASAG national conference, Japan Association of Simulation and Gaming, 2015 Autumn: 56–61 (In Japanese)

Virtual Lesson Game for Prompting Teachers to Change Their Instructional Style to Promote the Integration and Utilization of Knowledge in Problem-Solving

Toshiki Matsuda

Abstract The new Japanese National Course of Studies intends to cultivate generic skills with the cooperation of each subject area in a "Period for Integrated Study." To achieve this purpose, this study aims to develop a virtual lesson game for teacher education to improve teachers' instructional style. The game engages teachers into two lessons, an introductory lesson and an advanced lesson. To design and conduct appropriate lessons, teachers need to understand a student model that represents the mental model of learners who achieve the instructional goal. To do so, this study adopts my "Warp and Woof model of problem-solving" and provides teachers with feedback by changing the situation according to teachers' choices in the game.

Keywords Warp and Woof model · Virtual lesson game · Student model · Teacher education · Period for integrated studies

1 Introduction

According to the research outcomes of learning science [1], general strategies, metacognitive skills, and domain-specific knowledge are all elements of human intelligence and expert performance. Moreover, instructions for general strategies should be metacognitive aware and informed.

Although people tend to list various all-purpose competencies necessary to cultivate as twenty-first-century skills, Matsuda [2] stated that these can be integrated with problem-solving abilities and proposed the "Warp and Woof model" of problem-solving (Fig. 1). The model clearly describes a framework for utilizing ways of viewing and thinking, and acquiring domain-specific knowledge by

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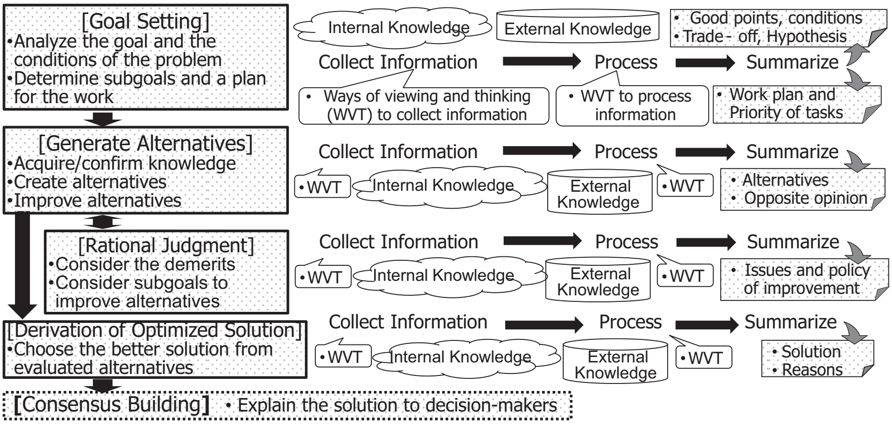

Fig. 1 The warp and woof model of problem-solving: the common framework

associating these with a problem-solving procedure and will play the role of metacognitive knowledge. His team clarified the elements of the model in each subject area based on the model and developed gaming instructional materials; the resulting educational effects were then examined.

However, the effectiveness of the model is associated with its being understood and utilized by teachers. To achieve this purpose, I adopted a similar approach for equipping teachers to use my instructional method based on the model for students. Specifically, I developed a virtual lesson game for teacher education according to the framework of the gaming instructional materials designed for students.

To develop the virtual lesson game, I have developed the "Instructional Activities Game (IAG)" system [3]. The IAG has two modes for performing virtual lessons, and although the goal of the study is to develop a game board for a "Simulated Teaching Game" carrying out virtual lessons based on teachers' lesson plans, in this paper, I design a sample game by using the "Decision-Making Game" to carry out lessons by choosing options in the given lesson plans.

2 Basic Design Principles of a Virtual Lesson Game

Twenty-first-century skills are generic skills, and it is necessary to cultivate them by cooperation among subject areas while raising problems in daily life and carrying out problem-solving activities in each subject area. To this end, it is necessary to set a lesson where students can perform problem-solving activities in a unit plan before changing the instructional method to individual lessons and to provide instructions on how to solve problems independently by using the learning outcomes of each lesson beforehand.

To emphasize the necessity of cooperation between lessons, a virtual lesson game consists of two lessons, an introductory lesson that emphasizes knowledge acquisition and understanding and an advanced lesson that involves problem-solving activities. I consider two methods to provide teachers with experience in these two lessons. The first one is to show the process of changing the student model by carrying out an introductory lesson and to let teachers know how much students can carry out problem-solving activities independently in an advanced lesson or require assistance by reviewing how much of the introductory lesson should be improved. The second method is to carry out an advanced lesson to clarify the required preconditions for students to perform ideal problem-solving activities and then to let teachers consider devices of instruction in the introductory lesson to satisfy such preconditions. In this method, teachers are prompted to recognize that the objectives of an introductory lesson are too high to achieve if they want to conduct an ideal advanced lesson, such that students perform problem-solving activities independently without instructions or support. They also understand the necessity of stepwise instructions and devices to support individuals according to the various levels of students' goal achievement.

The difficulty of the instructions depends on individual differences in a class; its degree is changed by instruction in the introductory lessons, and this affects the difficulty of instruction in the advanced lesson. Therefore, to emphasize the necessity of cooperation among subject areas, students' situations at the beginning of an introductory lesson should change according to whether a teacher assumes such cooperation. There are further options to determine students' situations at the beginning of an introductory lesson, such as emphasizing the necessity of preparing for entrance examinations, showing examples of problems in daily lives, and explaining how to utilize ways of viewing and thinking in each subject area.

Although one of the two lessons may mainly consist of explanation and exercises for knowledge acquisition and skill training and the other may be a student-centered and problem-solving type of lesson, this should not necessarily be assumed. Therefore, both types of methods should always be offered as instructional choices. The choice of instructional content is the same because it will be necessary to conduct the instruction again in the advanced lesson if students did not retain the learning outcomes of the introductory lesson. After all, it is not necessary to design two different games for two lessons, but to design a game so that the two types of lessons may be changed anytime. In dividing a game into two parts, the mode is to make a unit plan before conducting the virtual lessons that will be required instead.

3 Design of a Virtual Lesson Game

To design and evaluate a lesson, some model of the teacher's knowledge about lesson plans is required. Thus, this study refers to the model of Matsuda et al. [4] to realize the computer simulation of lessons by integrating outcomes of cognitive science into Yoshizaki's "Teacher's Decision-making Model in a Class" [5]. In their models, a lesson plan is understood as a series of lesson flows, sections, and five elements organized hierarchically, as shown in Fig. 2.

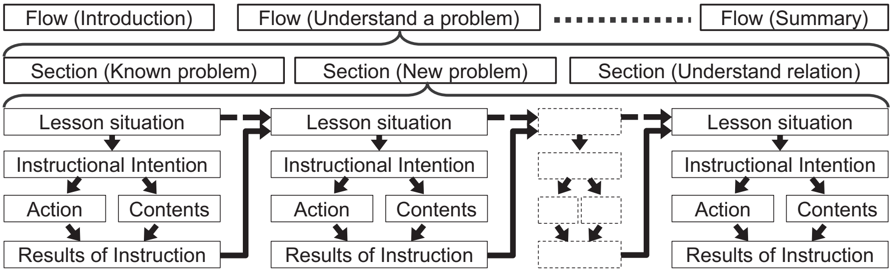

Fig. 2 Matsuda's model of lesson plan: series of five sets

According to this model, the difference between the introductory and the advanced lesson will be expressed as a difference in lesson flows. Although a game board of the Decision-Making Game consists of a series of states corresponding to five elements, it is necessary to consider the design of the game at the level of the lesson flow. Because teachers using this game do not understand the Warp and Woof model sufficiently, they may use a traditional lesson style. Therefore, the game should permit teachers to choose either the usual lesson style or one corresponding to Fig. 1.

3.1 Lesson Flow Pattern Corresponding to the Warp and Woof Model

The easiest way to match the models of Figs. 1 and 2 is to match the woof to sections, after matching the warp to the flows depicted in Fig. 2. Although the woof is common among warp processes and subject areas, the model for each subject area should be shown in more detail by paraphrasing [6]. Moreover, in an introductory lesson, a guidance activity may be performed at the beginning of the woof activities, or a review activity may be performed at the end. If those activities are not performed in the introductory lesson, it may be necessary to do them in an advanced lesson.

3.2 Traditional Lesson Flow Pattern

Lesson plans familiar to Japanese teachers adopt the common lesson flow, "introduction => main activity => summary." A lesson plan described in this form is called an "abbreviated plan" and includes only some steps corresponding to the five elements in Fig. 2. On the other hand, a lesson plan that includes many steps of detailed information is called a "detailed plan." The flow of an abbreviated lesson plan is common to all of the lessons and does not clarify the type of activity, such as teacher-centered and explanation-based or learner-centered and oriented to problem-solving.

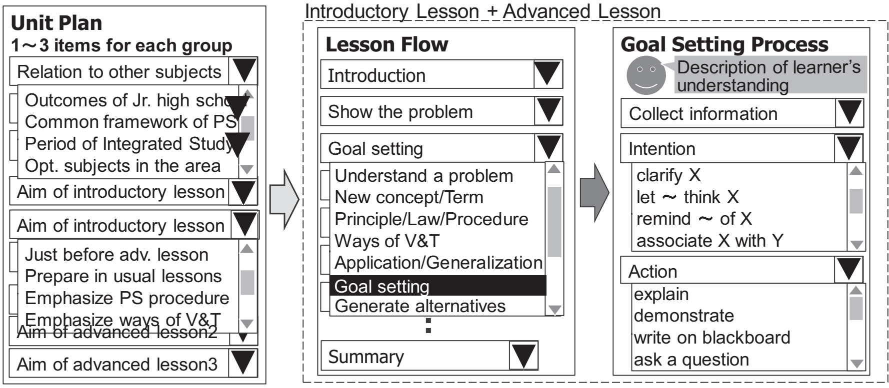

Fig. 3 Flow of the virtual lesson game

Therefore, in this paper, I use flow and sections in the lesson flow script [6] to enable student teachers to make lesson plans for the Simulated Teaching Game. Flows in Fig. 2 consist of "Understanding a problem," "New concept/Term," "Principle/Law/Procedure," "Ways of viewing and thinking," and "Application/Generalization," as well as "Introduction" and "Summary." They correspond to the classification of lesson contents or the target level of objectives. Sections in the script express the properties of information presented to students to prompt them to utilize specific ways of thinking. A combination of a flow and its sections indicates a principle of instruction for each main item of content in the textbook. If the problem-solving procedure is included under "Principle/Law/Procedure," the scene for instruction of procedure in Fig. 1 can be clarified in the lesson plan.

The teacher who has written only abbreviated lesson plans to this point may be unable to describe sections explicitly. Therefore, section descriptions are optional. Moreover, the description of sections is better done with descriptions of a series of five elements as a virtual lesson game progresses (Fig. 3).

3.3 Mechanism for Changing Learner's Situations

When teachers make lesson plans, they predict lesson situations as shown in Fig. 2; they then set out instructional intentions that indicate how they want to change the situation. After that, instructional actions and contents are chosen to achieve the intentions. However, in this game, lesson situations, such as learners' situations and remaining time, are anticipated by the game and shown to teachers by asking for their decision-making (Fig. 3). The gaps in the expected lesson states among teachers and within the game should be considered as clues to improve the lesson. To review the gaps clearly at the end of the virtual lesson, teachers are prompted to clarify the expected results of instruction at the end of each step.

Most important learners' situations are expressed as the acquisition status of each element in Fig. 1. In the Simulated Teaching Game so far [7], the learners' situation has been expressed as an achievement level corresponding to Bloom's taxonomy of educational objectives [8]. However, the "Warp and Woof model" assumes that knowledge is kept in the form of a frame [9]. As slots of the frame, the 5W1H (what, who, when, where, and why and how) and merit/demerits necessary to search appropriate knowledge for realizing the target good points identified in the goal-setting process are required to utilize knowledge [2].

The reason for expressing knowledge in the form of frames is the close relation between activating knowledge and associations of knowledge. As relations to objective levels of the cognitive domains in Bloom's taxonomy, the model assumes that "knowledge => comprehension => application" levels are the stages in which to fill in the slots in each frame, and "analysis => synthesis => evaluation" levels are the stage at which to create associations among frames. Relations are considered not to be binary but to have an intensity of degree according to cognitions concerning necessity and importance. In this model, the instilled knowledge is kept at a low-intensity level and is hard to activate. To retain knowledge in long-term memory and make it easy to activate, students are required to search and learn elements of knowledge independently and make positive associations between them and other elements and knowledge to reconstruct, organize, and retain learning outcomes.

To expect students to perform learner-centered activity in an advanced lesson, the elements in Fig. 1 should be mutually connected to achieve the level of analysis. This is the goal of the introductory lesson. However, the procedure of problem-solving and ways of viewing and thinking should be taught not in a specific lesson but in everyday lessons. In an introductory lesson, if a teacher focuses on instructing the students on new internal knowledge and associating it with each factor of Fig. 1 to help students utilize it, students are expected to achieve the goal. In contrast, it is too late if a teacher starts instruction on elements apart from internal knowledge (in Fig. 1) in the introductory lesson.

3.4 Designing States of a Game Board at the Level of the Five Elements

As mentioned previously, this game prompts a teacher to choose four elements out of five. When an instructional intention is described in its direct form, it designates the specific element of Fig. 1 and the required operation of the specific slot value, as well as other frames and slots that can be optionally associated. Another form is to specify an element and its target level in Bloom's taxonomy. In these cases, it is better described when a teacher explains the target slot value and links it to other elements or prompts the students to find and consider them. The consistency of intentions with actions and contents is evaluated for providing feedback.

The choices in instructional actions are constituted according to the items used in the training system for lesson design and the Simulated Teaching Game so far [9].

However, in this study, evaluation of teaching skill is not required. Therefore, the categories of instructional actions, “explain,” “demonstrate,” “write on the blackboard,” “ask questions,” “promote,” “direct,” evaluate,” “provide feedback,” and others (check absence, distribute prints, etc.) are used with optional parameters, such as target students (all, one who raises their hand, and so on), devices of expression (show as a figure, use colored chalk, and so on), and subsidiary actions (while referring to a textbook/blackboard).

Instructional contents are classified into procedures of problem-solving, ways of viewing and thinking, internal knowledge, external knowledge, metacognitive knowledge and study skills, problem topics, and others (method of computer use, etc.). These choices are shown as abstract messages classified by the above categories in the form of a hierarchical menu. The selected contents are evaluated as to whether they are useful to realize metacognitive aware and informed instruction, i.e., whether they explicitly explain the 5W1H to help students utilize knowledge practically.

For example, “when” points out the activity in Fig. 1 that requires utilization of the knowledge acquired. “Where” refers to the example cases and its problems as well as devices for applying the knowledge to them. “Why” explains the reason and purpose for using the knowledge. These questions are related to the slot names of a knowledge frame and chosen as instructional intentions. Therefore, if the game system has information about the frame name and the slot name corresponding to each choice of instructional content, the game system can evaluate the appropriateness of the selected contents to the instructional intention.

3.5 A Sample Game: Problem-Based Learning in Mathematics

3.5.1 Introductory Lesson

Ito and Matsuda [10] developed e-learning game material for problem-based learning in high school mathematics. It guides the method of utilizing learning outcomes of the unit “quadratic function” for everyday life through considering “Which choice leads to more profit: employment immediately following secondary school or after graduating from university?” This question promotes students’ utilization of mathematical ways of viewing and thinking as shown in Fig. 4 [11]. The processes for solving problems in keeping with this figure correspond to the warp processes in Fig. 1.

This instructional material prompts students to replace “profit” with other concepts such as “incomes” in the real world and makes them easy to formulate in a mathematical world. It also teaches how to use functions to interpolate unknown parts of collected quantitative data corresponding to the replaced concept. Moreover, it promotes utilization of spreadsheet software for visualization and numerical computation. It teaches a method to use to gain not only knowledge of quadratic functions but also knowledge of various functions learned so far, and those one recently learned.

In contrast, the typical example in many textbooks asks for the price of a good that will gain the maximum sales under the assumption of a linear function between prices and the expected number of sales. Because the condition is set up so that sales

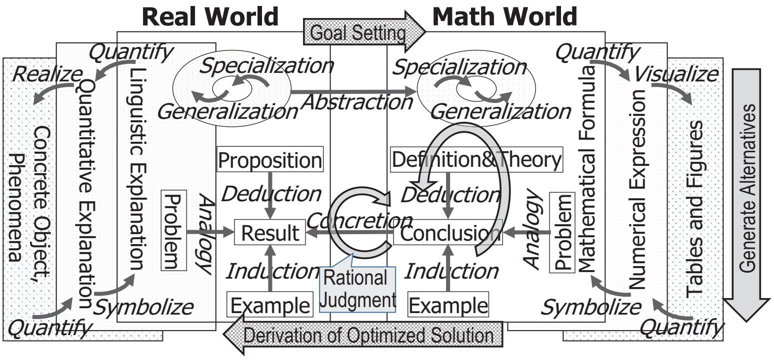

Fig. 4 Relation of warp process to framework of mathematical ways of viewing and thinking

may become a quadratic function of prices, it can be solved only by applying knowledge of "max/minimum value of quadratic functions." Use of quadratic functions becomes the main purpose of this problem, and it does not intend to change the relation between prices and the expected number of sales in order to examine new problems. Therefore, a method to find a new problem by oneself is not taught, and it does not cultivate the ability to utilize functions in daily life.

Most mathematics teachers will teach the abovementioned typical problem in an advanced lesson. On the other hand, I assume that Ito and Matsuda's problem can be taught in the introductory lesson, and students will find and solve new and similar problems in an advanced lesson. Therefore, in order to prompt teachers to understand the necessity of lesson improvement, one requirement is to perform two virtual lessons not only in the sequence "introductory lesson => advanced lesson" but also as "advanced lesson => introductory lesson" to clearly show the required achievement level of the advanced lesson.

3.5.2 Advanced Lesson

In an advanced lesson, unlike an introductory lesson, it is insufficient for students to just solve a problem given by the teacher. The students need to be prompted to find problems by themselves, derive their solutions using mathematical methods, and consider their validity and feasibility in the real world.

Each student will solve a different problem because each problem is self-discovered. Therefore, problem-solving can be performed individually as homework assignments, and teachers do not need to assign time for these activities within a lesson. Teachers need to help students set up appropriate and challenging problems, provide opportunities to discuss their solutions as the consensus building process in Fig. 1, and prompt them to review the processes used to derive the solutions as preparation for the next session. Especially since even teachers cannot set up appropriate problems as mentioned previously, support for setting up good problems is the most important issue in the lesson.

Moriwaki and Matsuda [12] proposed an instructional method aimed at addressing the abovementioned need, developed it as an e-learning material, and verified its educational effects. It comprises the following checklist of questions for judging the appropriateness of each problem, explains their necessity and validity by applying them to examples, and asks students to judge the appropriateness of other examples based on these items.

- Is the problem in the mathematical world or one already modeled mathematically?
- Does the problem have a specific correct answer and only require calculation of its value?
- Does the problem enable us to gain understanding from various perspectives by introducing a different postulation or situation?
- Do you focus on one hypothesis extracted out of various possibilities?
- Is a simple conclusion reachable without debate?
- Is the problem unsolvable unless it uses information sources and a mathematical method difficult to understand?

These checklist items were specialization of Takuma's [13] seven viewpoints of inadequate themes for general research papers shown in his lesson for high school students. Moriwaki and Matsuda confirmed the effectiveness of their e-learning material not only by conducting the practice lesson at a high school but also by prompting student teachers who took the "Instructional method of mathematics" course to use it before designing a problem-based lesson plan.

On the other hand, the elements of the advanced lesson proposed by the student teachers who took the "Instructional methods of mathematics" course were to provide students with time to find problems and discuss them collaboratively, to teach problem-solving techniques, such as brain-storming and KJ method, and to introduce examples of problems and ways to solve them. However, no element contributes to prompt students to consider the appropriateness of each problem by associating with the mathematical thinking process (Fig. 4). Student teachers are not conscious both about offering instructional contents peculiar to a mathematical lesson and about the metacognitive aware and informed instruction.

According to the above situation, the purpose of the virtual lesson game for the advanced lesson should be to prompt students to explicitly understand the difference between the abovementioned ideal and typical methods of instruction and their influences and then recognize the necessity for adopting a suitable method of instruction. To this end, it should be clarified that the knowledge that can be studied by ideal problem setting will be missing or disconnected in the model when a problem setup is carried out without understanding the abovementioned checklist items. The knowledge that may be unable to be studied is concerned with utilization of mathematical ways of viewing and thinking, such as use of collected data, the method of utilizing functions and statistics, the method to study new mathematical knowledge while performing problem-solving tasks, and the method to apply the concepts of other subject areas to mathematical ones.

4 Summary and Future Perspectives

This study designed a virtual lesson game to prompt teachers to change their teaching style. Teachers carry out two lessons, an introductory lesson and an advanced lesson, in a game. While playing the game, they are provided feedback information as learners' situations based on my "Warp and Woof model of problem-solving."

After implementing some sample games, the effects need to be verified through their practical application in our university. During this application, I will pay attention to the effect of showing learners' understanding based on the model. It is also necessary to reorganize a category system to describe lesson plans in order to construct evaluation rules in a game board of the Simulated Teaching Game.

References

1. Bruer JT (1993) Schools for thought: a science of learning in the class-room. The MIT Press, Cambridge, MA
2. Matsuda T (2018) Teaching an instructional design method to cultivate learners' problem-solving abilities in the "period for integrated study" by interconnecting with each subject area. Proceedngs of the 16th Hawaii international conference on education, pp 2191–2202
3. Matsuda T (2005) Instructional activities game: a tool for teacher training and re-search into teaching. In: Shiratori R, Arai K, Kato F (eds) Gaming, simulations, and society: research scope and perspective. Springer, Tokyo, pp 91–100
4. Matsuda T, Tago K, Sakamoto T (1992) An instructional activity model for developing a computer simulation system. Jpn J Educ Technol 15(4):183–195
5. Yoshizaki S (1988) Development of a model for teachers' decision making. Jpn J Educ Technol 10(2):51–60
6. Matsuda T (2009) Constructing a category system to describe lesson plans: teachers' professional development supported by Vygotsky's theories. Proceedings of SITE 2009. AACE, Chesapeake, 3677–3684
7. Matsuda T, Noda T (2004) Development of a web-based micro-teaching system. Proceedings of international conference of computers in education 2004. RMIT, Melbourne, pp 1995–2000
8. Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR (1956) Taxonomy of educational objectives: the classification of educational goals, handbook I: cognitive domain. David Mckay, New York
9. Barr A, Feigenbaum EA (eds) (1981) The handbook of artificial Intel-ligence, vol 1. William Kaufmann, Los Altos
10. Ito Y, Matsuda T (2013) Design framework of problem-based instruction in mathematics and development of a lesson plan and an e-learning material for the lesson. Proceedings of the 11th annual Hawaii international conference on education, pp 2106–2117
11. Matsuda T (2008) Using instructional activities game to promote mathematics teachers' innovative instruction, US-China. Educ Rev A 5(3):24–30
12. Moriwaki S, Matsuda T (2015) Development of a gaming material to encourage the improving of student's theme in problem-based learning in mathematics and application to teacher training. Research Report of Japan Society for Educational Technology Conference, JSET15-1, pp 331–338
13. Takuma K (2008) Introduction to a method of report writing: ask questions for your better life. Nittyuu Syuppan

The Effects of Debriefing on the Performance and Attitude of Austrian University Students and Cultural Differences to Japanese Students

Toshiko Kikkawa, Willy Christian Kriz, and Junkichi Sugiura

Abstract The present study examined the effects of debriefing on 132 Austrian university students as part of an international collaboration between Austria and Japan. There were eight experimental conditions. After pre-treatment, groups of four participants played the Highway Planning Game, which deals with cooperation and conflict. In addition to the analyses of the effects of the different debriefing methods on Austrian students, an intercultural comparison with Japanese students' data (Kikkawa et al. 2018) was also done. The Austrian students showed the same pattern of results as the Japanese students in the previous study: task performance in the groups that played a game and then received a debriefing was better than that in the groups that either did not play the game or played the game but did not receive a debriefing. Austrian students showed significantly better performance under all conditions and higher scores on the leadership and own interests dimension compared with Japanese students.

Keywords Conflict · Debriefing · Intercultural difference · Learning · Negotiation

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1 Introduction

1.1 Previous Study and Its Implication for Cultural Differences

The present study examined the effects of debriefing on Austrian university students as part of an international collaboration between Austria and Japan. Our research has focused on the effects of different types of debriefing using the Highway Planning game [1], which involves conflicts that must be solved through negotiation. This is our second report examining the effect of debriefing. After 3 years of international study, we noticed cultural differences in the attitudes of the participants, especially in terms of competition and conflict and negotiation during game play. An attitudinal difference may lead to differences in the effects of debriefing, whether direct or indirect. Therefore, in the present study, we focused on the effects of debriefing and cultural differences in attitudes during game play.

The main results of our first study of Japanese students can be summarized as follows [2]:

1. Task performance on the game did not differ significantly among eight different experimental conditions, and the results were as expected, indicating that the groups that played a game and then received a debriefing exhibited better performance than those that either did not play the game or played the game but did not receive a debriefing. The reason why the results did not reach significance could be attributed to the small number of groups in some of the experimental conditions.
2. Attitudes toward taking a leadership role became significantly stronger after playing the game, which was interpreted as a sign of greater participant involvement in the game. In addition, the degree of cooperation significantly decreased from a very high level before game play to a medium level after the game.

The results of the questionnaire data provoked intriguing speculation about cultural differences between the Austrian and Japanese students, as we assumed that cooperation would have increased after the game, particularly under the debriefing condition. However, we found a decrease in cooperation. One possible interpretation could be drawn from our observations of game play during the second and third studies [3], the latter of which has not been published. One of the observations was that the Japanese students seemingly avoided conflicts in the Highway Planning Game, even if the game structure necessarily involved conflicts among the different roles assigned to the players, such that negotiation was necessary to accomplish the goal.

Although we know of three studies that directly compared the attitudes and behaviors of Austrian and Japanese participants from the perspective of game theory, they did not consider the interactions among the players during play. One study found no significant difference in the three-person coalition formation ultimatum game [4], while the remaining two investigated trust and reciprocity using modified trust games [5] and found several cultural differences [6, 7].

Although we are unaware of any intercultural study that directly tested the abovementioned assumption, i.e., comparison between Austrian and Japanese participants regarding conflict resolution style, there are some studies that were conducted from the perspective of intercultural differences.

First, according to Hofstede's six-dimension model, Austria and Japan are different in the following six aspects [8]: Japan has a higher power distance, masculinity, uncertainty avoidance, and long-term orientation than Austria. In contrast, Austria has higher indulgence and individualism than Japan.

Second, although it was a comparison between Japan and the USA, not between Austria and Japan, Barnlund reported that conflict is far less common in Japanese society [9]. He also indicated that the Japanese manage differences through avoidance or rely more on accommodation, meaning that confronting differences directly would be an extremely hazardous way of addressing a difference of opinion in Japan. These points might be outdated considering the fact that the book was published in 1989; however, a subsequent study agreed. Obuchi and Takahashi [10] compared conflict management strategies between Japanese and American students according to Falbo and Peplau's two-dimensional model [11]. They found a strong tendency to avoid conflicts among participants. Additionally, they pointed out that the decision of whether to overtly enter into a conflict by the Japanese may be more critical than choosing the conflict management strategy. In other words, the Japanese are reluctant to make the conflict overt and tend to try to keep it covert, if possible.

Third, Japanese participants showed the highest tendency toward a win-win negotiation style among 12 countries, i.e., France, the USA, the UK, Germany, Spain, Mexico, Argentina, Brazil, Nigeria, India, China, and Japan [12]. In that study, ten negotiation factors varying between two polar extremes were identified and used to describe cultures. They were negotiating goals (contract or relationship), attitudes toward the negotiation process (win-win or win-lose), personal styles (formal or informal), styles of communication (direct or indirect), time sensitivity (high or low), emotionalism (high or low), agreement form (specific or general), and agreement building (bottom-up or top-down). In addition to attitudes toward the negotiating process, Japanese are characterized by indirect communication and general agreement.

1.2 Effects of Debriefing

This second international study was done with identical procedures to the previous study. Our main interest was in the effects of different types of debriefing. Debriefing can be defined as "the process in which people who have had an experience are led through a purposive discussion of that experience" [p. 146; 13]. Gaming simulations without adequate debriefing are often considered ineffective, and it is widely understood that effective learning is dependent on reflection during the debriefing process [14–16]. Learning stems from debriefing rather than from the game itself [17, 18].

Although many good arguments have been derived from theories of learning and instruction regarding why and how debriefing is an important factor for learning during gaming, remarkably few studies have empirically researched this crucial element. A review of the literature revealed two major weaknesses of past research. First, few systematic studies with sound methodologies have been conducted. Second, many studies utilized only questionnaire data to measure the outcomes of gaming, and, as a result, performance data are lacking.

The aim of our studies has been to address these gaps in the literature and overcome the weaknesses of previous studies. The present study examined the effects of different types of debriefing, using a no-debriefing condition as a control. All debriefing sessions employed a written answer sheet. In other words, the debriefing process was performed by the participants themselves, after following written instructions, to remove the possibility of experimenter effects.

In the following Methods section, we tried to explain the procedure as concisely as possible, since the details have already been described by Kikkawa et al. [2].

2 Methods

Participants The present study included 132 university students from Dornbirn, Austria, aged between 19 and 34 years (mean age = 23.23 ± 4.03 years); there were 68 females and 64 males.

Procedure The procedure was identical in all experimental conditions. First, the participants filled out a questionnaire (hereafter referred to as the pretest questionnaire), completed the activity for their condition, and were either then debriefed (or not, depending on the condition). Next, as a test scenario, the participants played the Highway Planning Game in groups of four, and individual and group performances were measured. Finally, the participants filled out another questionnaire (hereafter referred to as the posttest questionnaire). The overall length of the experiment was 90 min, which included the briefing and debriefing procedures.

Experimental Design and Manipulations The present study utilized a between-subject design and eight experimental conditions (Table 1).

Treatments Five treatments were used: two involved game playing, and the remaining three conditions included no games.

In the "fun game" condition with the no-debriefing element, the footstep game [19], played in pairs, was included, and in the prisoner's dilemma (PD) game condition, a modified version of the Baregg Tunnel game was used [20]. This educational game is concerned with conflict and cooperation and was also played in pairs.

The present study included three conditions without games. The first of these conditions involved pairs of participants reading a text about cooperation and conflict

Table 1 Summary of the experimental design

Condition	(5) Pretest questionnaire	(15) Treatment	(5) Debriefing	(30) Test-scenario game	(5) Posttest questionnaire
1	Yes	Fun game	No	Yes	Yes
2	Yes	PD game	No	Yes	Yes
3	Yes	PD game	Self-completed	Yes	Yes
4	Yes	PD game	Written guidelines	Yes	Yes
5	Yes	PD game	Written guidelines + conceptual frame	Yes	Yes
6	Yes	Text	No	Yes	Yes
7	Yes	Picture (comic)	No	Yes	Yes
8	Yes	No	No	Yes	Yes

Note: Numbers in parentheses indicate time in minutes

[pp. 362–367; 21], where the participants were asked to underline the most important points. The second non-game condition involved pairs of participants looking at an image related to cooperation and conflict. The third condition was the "control group without treatment" condition.

Debriefing The study included four debriefing categories. The first category did not involve debriefing (no debriefing); the second involved self-completed debriefing; the third involved debriefing with written guidance; and the fourth involved debriefing with written guidance and a conceptual frame.

In the self-completed debriefing condition, the participants were asked to discuss the gaming experience freely in pairs. In the debriefing condition with written guidance, pairs of participants discussed the following four questions, which were written on an instruction sheet: "how did you feel during the game?"; "describe your feelings during the game"; "what happened during the game?"; and "talk about your perceptions, observations, and current thoughts about the game."

The participants were given a conceptual frame, or theory, via which to interpret their experience of the game, in addition to the four abovementioned questions presented in the debriefing condition along with the written guidance and the conceptual frame condition.

Test-Scenario Game (Highway Planning Game) Groups of four participants played the Highway Planning Game, which requires communication, teamwork, cooperation, and conflict. The Highway Planning Game is played by groups of players with different roles (i.e., archeologist, resident, storekeeper, and city engineer). Each of the four students in each group assumed one of the roles during the game, the ultimate goal of which was to agree on a common route for a highway that was advantageous for each individual. Each participant received a map featuring hexagons (representing land) and symbols (representing houses, shops, mountains, and cultural and archeological sites). Each student was required to pay different penalties, according to their assumed role, for building the highway through hexagons with symbols that were relatively more or less important from their particular perspective.

There were four groups (of four participants) in each condition, aside from condition 5 (five groups).

Dependent Variables This study measured two types of dependent variable to evaluate the effects of the games and debriefing. The first type of dependent variable encompassed performance indices, which were calculated according to the number of hexagons that the highway passed through (the use of hexagons carried a land cause penalty), the route used, and the penalties (for destroying objects situated on the land) that were incurred. The second type of dependent variable encompassed the questionnaires assessing cooperation and leadership, which were completed before and after the activity, i.e., the pre- and posttest questionnaire.

The study also measured learning effects, teamwork behavior, and satisfaction regarding the results of the game using a five-point Likert scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Additionally, items assessing playing experience, the experience of the group, and several demographic variables were included in the posttest questionnaire.

3 Results

3.1 Preference

No performance differences were observed among the eight experimental conditions. This was due to insufficient data, as there were only four or five groups (of four students) per condition. Therefore, to allow an initial appraisal of the study, the data were merged into two conditions: Condition A, in which the participants either did not play an educational game (PD game) or played a game without debriefing (original conditions 1, 2, 6, 7, and 8), and Condition B, in which the participants played an educational game and received some form of debriefing (original conditions 3, 4, and 5).

The group results are shown in Table 2. Groups that played a game and received a debriefing exhibited significantly better performance than those that either did not play a game or played a game without debriefing (*t*-test, $p \leq 0.01$). Better performance was indexed by the following:

- Less total land use (i.e., fewer hexagons used on the game board)
- Lower total cost to the group (calculated by summing the costs incurred by all four [or five] participants in the group)

Table 2 Means of performance indices

Performance indices	A: No game or no debriefing ($N = 20$)	B: Game with debriefing ($N = 13$)
Number of hexagons	16.75 (0.77)	16.00 (0.89)
Total cost	454.20 (19.40)	439.62 (17.99)

Note: Numbers in parentheses show standard deviation.

Table 3 Means of self-reported learning effect

	A: No game or no debriefing ($N = 80$)	B: Game with debriefing ($N = 52$)
Learning	3.60 (0.59)	3.91 (0.45)

Note: Numbers in parentheses show standard deviation.

3.2 Learning

We included seven items in the post-questionnaire to measure the learning effect (e.g., "through the game I think I will be able to transfer gained knowledge into other group situations," "by paying the game I know more about factors involved in effective cooperation"). We calculated a new variable as the mean of these seven items. The group results are shown in Table 3. Groups that played a game and received a debriefing showed a significantly better learning effect compared with those that either did not play game or played a game without debriefing (t-test, $p \leq 0.01$).

3.3 Changes in Attitudes Toward Cooperation and Leadership

We applied t-tests to the paired samples to compare pre- and post-questionnaire answers regarding leadership ("if I work in a team, I prefer to take a leadership role instead of being a follower"), importance of own interests ("I prioritize my own interests over helping others"), and cooperation ("it is important to cooperate to achieve a goal"). The results showed a significant increase in the positivity of players' attitudes toward leadership and the importance of their own interests and a significant decrease in the positivity of their attitudes toward cooperation (Table 4). However, the total mean score for cooperation was higher compared than that for leadership and own interests in the pre- and post-data.

3.4 Comparison Between Austria and Japan

An important general result is that we saw the same patterns in attitudes in players from both Austria and Japan: performance in the game and debriefing conditions was significantly better compared with that in the non-game and non-debriefing

Table 4 Means of attitude changes

	Before	After	*N*
Attitude toward leadership	3.14 (0.71)	3.32 (0.67)	132
Priority of own interests over others	3.06 (0.59)	3.30 (0.62)	132
Cooperation to achieve a goal	4.45 (0.61)	4.12 (0.72)	132

Note: Numbers in parentheses show standard deviation.

Table 5 Performance indicators in Austria and Japan

	Austria	*N*	Japan	*N*
Number of hexagons	16.45 (0.89)	132	16.76 (2.28)	172
Total cost	448.45 (20.10)	132	456.77 (43.57)	172

Table 6 Attitude changes in Austria and Japan

	Austria	*N*	Japan	*N*
Pre-attitude toward leadership	3.14 (0.71)	132	2.80 (0.95)	169
Post-attitude toward leadership	3.32 (0.67)	132	2.99 (0.98)	167
Pre-priority of own interests over others	3.07 (0.59)	132	2.71 (0.75)	169
Post-priority of own interests over others	3.30 (0.62)	132	2.89 (0.78)	167
Pre-cooperation to achieve a goal	4.45 (0.61)	132	4.41 (0.68)	169
Post-cooperation to achieve a goal	4.12 (0.72)	132	4.22 (0.75)	167

Note: Numbers in parentheses show standard deviation.

conditions. Attitudinal changes (pre- vs. posttest) showed increased emphasis of the players on their own interests and taking a leadership role and a decrease in cooperation.

However, there was also a significant difference between the Austrian and Japanese students. The Austrian students had significantly better performance results under all conditions and also generally higher scores in leadership and their own interests on the pretest and posttest compared with Japanese students (Tables 5 and 6).

4 Discussion

The pattern of the data of the Austrian students in this study was similar to that of Japanese students in a previous study [2]. Task performance in the groups that played a game and then received a debriefing was better than that of the groups that either did not play the game or played the game but did not receive a debriefing.

The study with Austrian students showed a significantly better evaluation and perception of learning effects in the groups that played a game and received a debriefing compared with the groups under the no-game and/or no-debriefing conditions. These results are in accordance with the general hypothesis that gaming, and especially gaming with debriefing, leads to better learning gains [22].

The results of the present study were similar to those of a previous study including Japanese students: all participants under all conditions showed a more favorable attitude toward taking a leadership role after playing the Highway Planning Game. In addition, the propensity to give priority to one's own interests over helping others increased significantly. Furthermore, the degree of cooperation significantly decreased, from a very high level (pregame) to a medium level (post-game). However, a significant difference was also observed between the Austrian and Japanese students. The Austrian students showed significantly better performance under all conditions and had generally higher scores on the leadership and own interests dimension on the pre- and posttests compared with Japanese students.

Therefore, our conclusions are the same as those of the previous study including Japanese students: participants were more involved and engaged in the game and debriefing conditions and were actively contributing to the resolution of the predetermined role/conflict scenario of the Highway Planning Game. Through playing the game, the individual players (and groups) were more engaged in negotiation and bargaining and actively attempted to resolve conflicts. They engaged in different forms of cooperative behavior while trying to resolve the conflicts and had to deal with conflict in an "authentic" way, leaving their comfort zone to ensure equality among group members in terms of penalties. They also had to consider their own interests and take a leadership role in the discussions and decision-making process. The decrease from inappropriately high levels of cooperation to a more appropriate degree of conflict during the game is actually a positive sign with respect to maximizing group performance. According to previous research on conflict levels and group performance [p. 409; 23], very high and very low levels of conflict are signs of dysfunction leading to low group performance. Thus, a medium level of conflict may be optimal, where such functional conflict can lead to higher group performance. In the present study, a significant shift was observed toward this functional level of conflict within the groups, but the level of conflict did not become excessive.

It also appears that, for the Highway Planning Game, a strategy is needed that incorporates both conflict and cooperation to ensure the best performance. Participants and groups must balance cooperation and individualistic profit maximization. The Austrian students' performance was better because of their more positive attitude toward leadership and taking care of their own interests, which well-suited the requirements of the game.

The results of this study are in accordance with research on cultural influences and differences in handling group situations requiring cooperation and negotiation.

Debriefing seemed to help both the Japanese and Austrian students to move toward an optimal balance between cooperation and conflict and between egotistical and collective strategies during negotiations.

Our group has several plans for future research. First, the number of participants and groups in the experiments will be increased to explore the effects of different debriefing methods in more detail. Second, additional oral debriefing methods will be assessed.

References

1. Meadows D, Seif A (1995) Creating high performance teams for sustainable development: 58 initiatives. The Institute for Policy and Social Science Research, University of New Hampshire, Durham
2. Kikkawa T, Sugiura J, Kriz W (2018) The effects of debriefing on the performance and attitude of Japanese university students. In: Lukosch H, Berkebrede G, Kortmann R (eds) Simulation games for sustainable cities and smart infrastructures. Springer, Cham, pp 173–180
3. Kriz W, Kikkawa T, Sugiura J (2018) The effects of debriefing on the performance and attitudes. In: Proceedings of the 2018 JASAG (Japanese Association of Simulation and Gaming) spring conference, pp 58–59
4. Okada A, Riedl A (1999) When culture does not matter: experimental evidence from coalition formation ultimatum games in Austria and Japan. KIER DP No. 497, Kyoto University
5. Berg J, Dickhaut J, McCabe K (1995) Trust. Reciprocity, and social history. Game Econ Behav 10:122–142
6. Netzer RJ, Sutter M (2009) Intercultural trust. An experiment in Austria and Japan, working papers in economics and statistics, University of Innsbruck, No. 2009-05
7. Akai K, Netzer RJ (2010) Trust and reciprocity among international groups: experimental evidence from Austria and Japan. Discussion paper of Institute of Social and Economic Research, Osaka University, No. 737
8. Hofstede Insights. https://www.hofstede-insights.com/country-omparison/austria,japan/
9. Barnlund DC (1989) Communicative styles of Japanese and Americans: images and realities. Wadsworth, Inc, Belmont
10. Obuchi K, Takahashi Y (1994) Cultural styles of conflict management in Japanese and Americans: passivity, covertness, and effectiveness of strategies. J Appl Soc Psychol 24:1345–1366
11. Falbo T, Peplau LA (1980) Power strategies in intimate relationships. J Pers Scoc Psychol 38:618–628
12. Salacuse JW (1998) Ten ways that culture affects negotiating style: some survey results. Negot J 14:221–240
13. Lederman LC (1992) Debriefing: toward a systematic assessment of theory and practice. Simul Gaming 23:145–160
14. Decker S, Fey M, Sideras S, Caballero S, Rockstraw L, Boese T, Borum JC (2013) Standards of best practice: simulation standard VI: the debriefing process. Clin Simul Nurs 9:S26–S29
15. Pavlov OV, Saeed K, Robinson LW (2015) Improving instructional simulation with structural debriefing. Simul Gaming 46(3–4):383–403
16. Van den Hoogen J, Lo J, Meijer S (2016) Debriefing research games: context, substance and method. Simul Gaming 47:368–388
17. Crookall D (2010) Serious games, debriefing, and simulation/gaming as a discipline. Simul Gaming 41:898–920
18. Crookall D (2014) Engaging (in) gameplay and (in) debriefing. Simul Gaming 45(4–5):416–427
19. Footsteps (Author unknown). http://www.gamecabinet.com/rules/Footsteps.html
20. Capaul R, Ulrich M (2003) Planspiele: simulationsspiele für Unterricht und Training mit Kurztheorie: simulations- und Planspielmethodik. Tobler Verlag, AG, Altstätten
21. Johnson DW, Johnson FP (1994) Joining together: group theory and group skills, 5th edn. Allyn and Bacon, Needham Heights
22. Tipton E, Leigh E, Kriz WC, Crookall D (2016) Debriefing: the real learning begins when the game stops: 1–5. In: Kaneda T, Kanegae H, Toyoda Y, Rizzi P (eds) Hybrid simulation and gaming in the networked society. Springer, Singapore
23. Furnham A (2005) The psychology of behavior at work. Psychology Press, New York

What Business Simulations Teach: The Effect of Debriefing

Richard Teach and James Szot

Abstract This is the initial report of a multi-university study of students participating in business simulations. The study's purpose is an attempt to determine what skills students learn while taking part in business gaming. This study defined a set of 16 primary learning skills that had been previously suggested by a variety of authors. University students were surveyed immediately upon completion of a business simulation that was included in their coursework. The results presented here are limited to US students enrolled in US universities. Future analysis will explore whether the data suggests international students learn the skills differently than US nationals. This study found that debriefing had a substantial and measurable impact on the student's learning; however, debriefing alone was not the primary variable in learning. It was important only after the student considered the debriefing to be important and their instructor had the ability to facilitate the debriefing.

Keywords Instructor ability · Debriefing · Business simulations · Learning · Survey · US students only

1 Background

1.1 Learning

Many researchers have attempted to measure learning when students participate in business simulations.

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Achilles Armenakis et al. [1] studied the performance of teams participating in the 1974 Emory University Intercollegiate Business Game (IBG). They wanted to see what differences existed between the best performing teams and the poorer performing teams. Their four primary hypotheses were:

1. Do successful teams employ more quantitative methods than unsuccessful ones? No statistically significant differences were found.
2. Does the experience in participating in the IBG distinguish between teams that are successful and unsuccessful? No statistically significant differences were found.
3. Does previous experience participating in business games differentiate successful and unsuccessful teams? No statistically significant difference was found. While one might expect that prior business simulation experience would improve future performance on other business simulations, this suggests that no transferable learning occurred.
4. Do successful teams devote more time to making decisions than unsuccessful teams? No statistically significant differences were found.

Fritzsche [2] studied the relationship between learning styles, student perceptions of learning, simulation performance, and course grades. The learning styles, defined by Kolb and Goldman [3], are:

The Diverger…is best at Concrete Experience (CE) and Reflective Observation (RO). His/her greatest strength lies in his Imaginative ability.
The Assimilator's dominant learning abilities are Abstract Conceptualization (AC) and Reflective Observation (RO). His/her greatest strength lies in his ability to create theoretical models.
The Converger's dominant learning abilities are Abstract Conceptualization (AC) and Active Experimentation (AE). His/her greatest strength lies in the practical application of ideas.
The Accommodator "has the opposite strengths of the Assimilator. He/she is best at Concrete Experience (CE) and Active Experimentation (AE). His/her greatest strength lies in doing things, in carrying out plans and experiments and involving himself in new experiences". (Fritzsche, p. 457)

Fritzsche [2] found "very little relationship was found among learning style, perceived learning and course performance" (p. 461). While "there is some variation among the mean student grades by learning stlyle, this variation is not significant [$p = 0.25$] when subjected to an analysis of variance" (p. 457).

Miles, Biggs, and Schubert [4] surveyed 16 studies that used student self-judgment of skill acquisition as dependent variables. They concluded that the mixed results uncovered were difficult to interpret.

Whiteley and Faria [5] searched the literature and concluded that "despite the proliferation, and widespread use of business simulation games, …the pedagogical value of such games remains unclear" (p. 78). They attempted to measure learning from a marketing simulation by comparing final exam performance of students participating in simulations with students who sat through lectures only. They found "the results suggest that simulation games are an effective means by which to improve quantitative skills but are not an effective means by which to improve the acquisition of applied or theoretical knowledge" (p. 78).

Teach [6] suggested that better measures of managerial ability would be forecasting errors and the allocation of resources to areas with the greatest marginal returns.

Washbush and Gosenpud [7] studied the relationship between learning and simulation performance. They "found no direct, positive linear correlations between learning and simulation performance" and observed "the data suggest that learning is associated with the extent to which a team struggles to improve its performance rating" (p. 141).

In the following year, Washbush and Gosenpud [8] restudied the same relationship, but this time they divided the teams into three groups: top performers, teams that finish in the middle, and the poorest performing teams. They found "top simulation performers did not obtain higher learning scores. In fact, they consistently exhibited the poorest learning performance" (p. 85) and suggested not incorporating simulation performance standing into the calculation of course grades. Despite there being no correlation between simulation performance standing and the amount of learning, they did validate the simulation as a learning experience by finding "that players learned, and they learned what the game intended to teach" (p. 85).

Gee [9] wrote:

> The learning principles that good games incorporate are all strongly supported by contemporary research in cognitive sciences – the science that studies human thinking and learning through laboratory research, studies of the brain, and research at actual learning sites like classrooms and workplaces. Beyond using the learning principles that good games incorporate, I also argue that schools, workplaces, and families can use games and game technologies to enhance learning. Further, I believe that use of games and game technologies for learning content in schools and skills in workplaces will become pervasive (p. 1).

However, Gee did not elaborate on *how* that learning could be measured.

When examining the degree of learning by a simulation participant, one must consider the complexity of the simulation. Some authors contend that complexity and realism may not be an advantage. Springer et al. [10] wrote that "The power of a model in solving a problem comes precisely from its not corresponding to reality except in those details pertinent to the problem at hand" (p. 178). Frazer [11] commented, "playing many different [simple] games in a course with students on different teams for each game is now a viable alternative to the traditional management simulation umpired in batch mode and played over a prolonged period" (p. 3).

Wolfe [12] investigated the link between game complexity and the acquisition of business policy knowledge. Wolfe reported:

> The simple game increased knowledge in two of the emphasis areas – the need for reappraisal and flexibility, and the effects of individual and group factors in policy and decision-making situation. The IG [intermediate complexity game] improved only one area, while the CG [complex game] improved a player's knowledge in all five areas (p. 149).

However, Wolfe's observations may have resulted from the difference between the two simulations rather the difference in complexity.

Role overload [13] often occurs in large-scale simulations. Teach [14] identified this problem as *analysis paralysis*. Teach and Murff [15] assessed the problem of complexity and recommended that the preparation time needed before the students started the simulation and the playing time required between rounds may be effective measures of simulation complexity.

Hall and Cox [16] confronted the concept that complexity was needed to create educationally effective business simulations and discussed complexity in the context of two mechanisms. The first was the assertion that "realism is a key determinant of educational effectiveness and that realism is produced through complexity" (p. 30). The second is "the amount of cognitive processing performed by participants relates to the simulation's complexity. In turn, the simulation's duration relative to cognitive processing produces cognitive pressure that may lead to role overload" (p. 30). They found this role overload is negatively related to the level of adult learning.

Teach [17] suggested testing a set of 20 skills students might learn while participating in a business simulation. This project investigates learning of 16 of these skills while participating in a business simulation. These skills are the ability to:

- Set goals.
- Make competitive decisions.
- Differentiate important information from unimportant information.
- Work well in teams.
- Do marginal analysis.
- Work under uncertainty.
- Forecast outcomes such as cash flows, units of ending inventory, unit demand, etc.
- Analyze reports and financial results.
- Create budgets.
- Understand the interactions among two or more decision variables.
- Analyze quality control measurements.
- Anticipate competitive reactions to our firm's decisions.
- Consider possible competitors' decisions when making my (our) firm's competitive decisions.
- Relate the effect of one decision variable upon a different decision variable.
- Be innovative.
- Be creative.

1.2 Debriefing

Dennehy, Sims, and Collins [18] define "debriefing as the processing of the learning experience from which the learners are to draw the lessons to be learned (Greenblat and Duke 1975; Lederman 1984, 1992b)" and advise "a debriefing process… must be planned as rigorously as the exercise itself to complete the learning experience" (p. 10).

The debriefing process is based on two assumptions: first, that "the experience of participation has affected the participants in some meaningful way. Second, that a processing (usually in the form of a discussion) of that experience is necessary to provide insight into that experience and its impact" (Lederman [19], p. 146).

Lederman [19] asserts that "debriefing is not ancillary. It is a required part of the process of experience-based learning" (p. 154). Although the outcomes of this process may not be predictable, "the process itself is predictable and can be reviewed and assessed" (p. 157).

Although there are volumes of literature touting debriefing as a necessary component of simulation and games, there are an amazingly small number of articles that test the hypothesis that debriefing increases participant learning. One of these cautioned that "the research does not always show enhanced learning from debriefing" (Bredemire and Greenblat [20], p. 311). In an editorial, Crookall [21] suggested, "the serious gaming community has much to offer the discipline of simulation/gaming and that debriefing is vital both for learning and for establishing simulation/gaming as a discipline" (p. 898). This editorial cites an important body of literature about debriefing.

Andrade-Santo, Oliveira-Neto, and Reith [22] found:

> Debriefing had a direct impact on the evaluation of the facilitator. On average, about 70% of the members of the groups that received a formative and custom debriefing considered as good, very good or excellent, the efficiency of the facilitator. Also, 50% of these groups improved financial performance in the next round. (p. 2322)

They concluded, "The proposed model of debriefing has the potential to increase student learning in undergraduate courses using SM, but we emphasize that the training of the facilitator is the key to success for this model" (p. 2322).

2 The Research Process

Most studies of business simulations and games are done by faculty members studying the students in their classes during their participating in a single simulation. Findings based on a single simulation or a single classroom experience are insufficient for generalization, no matter how significant the findings. Our research used a Qualtrics-hosted anonymous survey to go beyond the single classroom experience to a multi-university environment that includes multiple simulations and examination of the effect of international students, gender, grade levels, and debriefing.

This study primarily used Likert-like-scaled variables. Many questions stated a position and asked the subject to respond with his/her level of agreement with the statement using a six-point scale of *(1) Strongly Disagree*, *(2) Disagree*, *(3) Disagree slightly*, *(4) Agree slightly*, *(5) Agree*, and *(6) Strongly agree* to avoid neutral responses. The 16 learning skills were evaluated using an 8-point scale, where 1 equaled "was worse than before" and 8 equaled "was tremendously better." A few questions used different scales as needed, such as gender and those requiring a yes/no response, e.g., "did debriefing take place during the game playing?"

The Georgia Tech and UT Dallas Institutional Review Boards (IRBs) both approved the survey. The IRB is a federally mandated panel that is charged with safeguarding the rights and welfare of human subjects in research. IRB approval is necessary for all surveys given to students at universities in the United States. The IRB requires that we tell each student that they may reject the survey outright or leave the survey at any time without completing it.

At the end of the survey, we included a question asking students if they would permit the researchers to share their anonymous responses with their instructor. The students responded by entering their instructor's name if they agreed to that stipulation. If the student did not submit their instructor's name, no sharing of the collected information outside the research team members was allowed.

We contacted faculty members at universities across the United States and asked, "Do you use a business simulation in your class or classes?" If they answered yes, we contacted them again and asked if they would allow the research team to survey their students and included a link to the electronic survey for their approval. If they responded affirmatively, we asked, "What is the planned date of the final round of the simulation?" Then, 3–5 days before their final round, we sent an anonymous link to the survey for the faculty member to forward to the students in their class. Student responses were collected and stored by Qualtrics and made available to the research team in spreadsheet form. After the team received the data from each university, the researchers separated the "approved to share their responses" surveys, grouped them by the faculty members' name, and sent the responses to the appropriate faculty members. This process is ongoing.

A pilot project completed at the end of the summer 2017 term was described by Teach and Szot [23] at the ABSEL 2018 Conference. This research can be found online in the ABSEL Proceedings found under Resources on https://absel.org.

In addition to the 16 learning skills listed in Table 1, additional questions analyzed in this study included "did the simulation experience include debriefing discussions about what was learned?" (yes or no), "the debriefing discussion(s) enhanced my learning; it (they) were a valuable component of the overall experience" and "the instructor did a great job facilitating the debriefing discussions" (using the six-point Likert-like agreement scale).

Table 1 Number of surveys processed

Action	Count
Submitted surveys	679
Exclude: student decided not to participate	42
Exclude: international students responding	192
Exclude: students completing in less than 5 min	58
Exclude: faculty members reviewing the survey	10
US students processed	377
Exclude: patterned responses	95
Available for analysis	282

3 Preparing the Data

The actual number of participants that received the survey is unknown. However, the number of students that opted not to participate in the data collection process, the number of students who quit the survey before completing it, and the number that completed the survey are known. Also, we know the number of faculty members who scanned the survey before allowing their students to participate in our study.

Only a few of the questions presented were required to be completed by the students, and some questions included a not applicable response. The reason for allowing many of the questions to be ignored by the student was that the researchers thought to force a participant to answer questions that he or she did not desire to answer would result in nonsense responses and no response would lead to better information.

Some respondents like to mess up surveys with nonsense answers such as reporting a constant value (e.g., 55555555), alternating response values (26262626), providing sequential values (12345123451), or other nonsensical responses. We excluded these participants' data from the analysis after careful examination of each student's record. Students that opted out were simple to eliminate. We omitted the responses from students that appeared to be patterned, but we retained clusters of non-patterned data from the same student in the data set. Table 1 lists the number of surveys processed and excluded.

4 Results

The 16 learning variables used an 8-point scale, where 1 represented the least amount of learning and 8 represented the greatest amount of learning. In addition, a question in the survey asked: "Did your simulation experience include a debriefing session about what was learned?" The students that answered yes were asked for their level of agreement with two follow-up questions using the previously described six-point agreement scale: (1) "The debriefing discussion(s) enhanced my learning and were a valuable component of the overall experience." and (2) "The instructor did a great job facilitating the debriefing discussions." Table 2 lists the means and standard errors of the survey responses.

The responses show students reported substantial levels of self-perceived skill development from participating in a business simulation.

Table 2 Analyzed sample response means and standard errors

Learning skill (The ability to…)	*N*	Mean	Standard Error
Set goals	282	4.72	0.106
Make competitive decisions	271	5.29	0.098
Differentiate important information	267	5.11	0.103
Work well in teams	243	4.90	0.103
Do marginal analysis	253	4.95	0.107
Work under uncertainty	263	5.19	0.098
Forecast outcomes	267	5.30	0.106
Analyze reports and financial results	268	5.40	0.104
Create budgets	248	4.92	0.112
Understand decision variable interactions	272	5.45	0.105
Analyze quality control measurements	254	5.03	0.114
Anticipate competitive reactions to our decisions	266	5.31	0.110
Consider possible competitors' decisions when making own decisions	266	5.46	0.107
Relate the effect of one decision variable upon a different decision variable	266	5.38	0.030
Be innovative	263	5.16	0.107
Be creative	260	5.17	0.114

To determine the differences in the degree of perceived learning between those who underwent debriefing and those who had not, tests of the equality of means were conducted using the assumption of interval data. Table 3 lists the results of these analyses.

Using the classical significance level of $p < 0.05$, Table 3 shows no significant differences in perceived learning skills associated with debriefing. The most significant difference observed was with "the ability to anticipate competitive reactions to our firm's decisions," and that difference was only at a p-value of 0.177. How can we account for this finding? It must be something more than the debriefing alone.

We explored student perception of the quality of the debriefing experience and attitude regarding the importance of debriefing with two hypotheses.

4.1 Hypothesis 1

What role does the quality of the instructor's abilities to debrief play? This question led to **Hypothesis 1**: T*he quality of the debriefing session is an important component of the amount of learning that takes place during the simulation.*

The statement "The instructor did a great job facilitating the debriefing discussion" was included in the survey to determine the impact of better debriefing. Using only the surveys of the students claiming debriefing took place, the data were split into two groups: those that disagreed with the statement (16–20 students responding

Table 3 Learning skill perception means with and without debriefing

	With debriefing		Without debriefing		
Learning skill (The ability to…)	*N*	Mean	*N*	Mean	*p*-value
Set goals	174	4.87	95	4.44	0.633
Make competitive decisions	175	5.41	95	5.05	0.962
Differentiate important information	172	5.16	95	5.00	0.530
Work well in teams	162	5.04	81	4.59	0.236
Do marginal analysis	167	5.06	86	4.73	0.739
Work under uncertainty	176	5.24	92	5.07	0.183
Forecast outcomes	174	5.44	93	5.01	0.763
Analyze reports and financial results	176	5.53	92	5.07	0.583
Create budgets	164	5.09	84	4.47	0.913
Understand decision variable interactions	176	5.58	96	5.21	0.407
Analyze quality control measurements	172	5.19	87	4.87	0.276
Anticipate competitive reactions to our decisions	173	5.39	94	5.15	0.177
Consider possible competitors' decisions when making own decisions	173	5.60	93	5.18	0.274
Relate the effect of one decision variable upon a different decision variable	174	5.49	93	5.15	0.753
Be innovative	171	5.41	92	4.68	0.436
Be creative	189	5.41	91	4.64	0.325

disagree slightly, disagree, or disagree strongly) and those that agreed with it (91–98 students responding agree slightly, agree, or agree strongly). Table 4 lists the results of one-way analysis of variance tests for each learning skill.

We found significant differences ($p < 0.05$) for 9 of the 16 learning skills based upon the instructors' abilities to conduct debriefing sessions. Thus, we accept H_1, at least for nine of the learning skill variables.

4.2 Hypothesis 2

What else could have affected the degree of learning that takes place while participating in business simulations? Do some students not mentally participate in the debriefing process? This question led to **Hypothesis 2**: *Students actively engaged in the debriefing sessions of business simulations will learn more than the students who do not actively engage in the debriefing sessions*. To measure the degree of student engagement, we considered responses to the level of agreement question "The debriefing discussion(s) enhanced my learning." Seventeen to 21 students experiencing debriefing and answering the 16 learning skills questions disagreed with the statement. Between 143 and 158 students experiencing debriefing and answering the 16 learning skills questions agreed. Table 5 shows the numerical results of the one-way analysis of variance analysis on this set of questions.

Table 4 Differences in means of the 16 learning skills under the condition of debriefing and using the disagreement or agreement with the statement: *The instructor did a great job facilitating the debriefing discussions*

	Disagree		Agree		
Learning skill (The ability to…)	*N*	Mean	*N*	Mean	*p*-value
Set goals	19	4.74	96	4.97	0.618
Make competitive decisions	19	5.11	96	5.63	0.205
Differentiate important information	19	4.68	95	5.43	0.084
Work well in teams	17	4.59	86	5.06	0.336
Do marginal analysis	19	4.05	90	5.34	0.002
Work under uncertainty	19	4.89	96	5.40	0.181
Forecast outcomes	20	4.90	95	5.51	0.175
Analyze reports and financial results	19	4.79	97	5.65	0.043
Create budgets	16	4.50	91	5.19	0.153
Understand decision variable interactions	20	4.75	95	5.51	0.010
Analyze quality control measurements	18	4.23	94	5.34	0.028
Anticipate competitive reactions to our decisions	19	4.68	95	5.65	0.028
Consider possible competitors' decisions when making own decisions	18	4.56	95	5.95	0.001
Relate the effect of one decision variable upon a different decision variable	19	4.53	94	5.83	0.002
Be innovative	19	4.53	98	5.57	0.015
Be creative	20	4.45	97	5.63	0.007

Fourteen of the 16 learning variables were statistically significant with p-values ranging from $p < 0.0005$ to 0.012. There were only two learning skills that had p-values above 0.05, and they both were below 0.100. Thus, H_2 is accepted for 14 of the learning skills. Debriefing is believed to have enhanced learning for 14 of the 16 skills.

5 Conclusions

Debriefing is almost worthless without considering how to convince the student participant that the debriefing process is critical to the learning process and it is important for instructors to be skilled at debriefing.

Business simulations used in US business schools tend to have aspects of US culture built into them, and we chose to limit this initial study to a sample of US students without considering the responses of any international students. This exclusion was a conscious decision to eliminate noise to the data that may have been caused by the mixture of cultures from the wide varieties of international students attending US business schools. This project is ongoing, and future analysis will attempt to measure the effects of a variety of international cultures upon the learning

Table 5 Differences in means of the 16 learning skills under the condition of debriefing and using the disagreement or agreement with the statement: *The debriefing discussion(s) enhanced my learning*

	Disagree		Agree		
Learning skill (The ability to…)	*N*	Mean	*N*	Mean	*p*-value
Set goals	18	3.61	157	5.03	0.001
Make competitive decisions	19	4.37	158	5.54	0.002
Differentiate important information	20	3.80	153	5.35	<0.0005
Work well in teams	21	4.10	142	5.19	0.005
Do marginal analysis	19	4.05	149	5.19	0.005
Work under uncertainty	21	4.24	156	5.33	0.001
Forecast outcomes	20	4.85	155	5.52	0.097
Analyze reports and financial results	21	4.57	156	5.71	0.006
Create budgets	17	4.00	143	5.22	0.006
Understand decision variable interactions	21	4.62	156	5.71	0.006
Analyze quality control measurements	17	4.41	151	5.28	0.066
Anticipate competitive reactions to our decisions	20	4.50	153	5.51	0.012
Consider possible competitors' decisions when making own decisions	20	4.65	154	5.73	0.006
Relate the effect of one decision variable upon a different decision variable	20	4.00	155	5.69	<0.0005
Be innovative	19	4.53	153	5.54	0.006
Be creative	19	4.26	151	5.60	0.003

Table 6 Contributing faculty

Professor	University
Dr. Larry Chasteen	The University of Texas at Dallas
Dr. Michael Nugent	SUNY Stony Brook University
Dr. Eric Kinnamon	Alabama A&M University
Dr. Blaine Lawlor	The University of West Florida
Dr. Stuart Graham	Georgia Institute of Technology
Dr. Shawn Carraher	The University of Texas at Dallas
Dr. Mihail Motzev	Walla Walla University
Dr. Raghu Kurthakoti	Arcadia University
Dr. Frances Fabian	The University of Memphis

of important managerial skills. To be successful in this quest, the data needed to undertake this examination will require the inclusion of many more business schools and student responses.

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References

1. Armenakis A, Feud H, Holley W (1974) Correlates of satisfaction, learning and success in business gaming. In: Simulations, games and experiential learning techniques, vol 1, pp 272–278
2. Fritzsche D (1976) On the relationships of learning style, perceived learning and performance in an experiential learning environment. Comput Simul Learn Theory 3:455–462
3. Kolb D, Goldman M (1973) Toward a typology of learning styles and learning environments: an investigation of the impact of learning styles and discipline demands on the academic performance, social adaptation and career choices of MIT seniors, M.I.T. Sloan School working paper #688-73
4. Miles WG Jr, Biggs WD, Schubert JN (1986) Student perceptions of skill acquisition through cases and a general management simulation: a comparison. Simul Games 17(1):7–24
5. Whiteley TR, Faria AJ (1989) A study of the relationship between student final exam performance and simulation game participation. Dev Bus Simul Exp Exerc 16:78–83
6. Teach R (1990) Profits: the false prophet in business gaming. Simul Gaming 21(1):12–26
7. Washbush J, Gosenpud J (1993) The relationship between total enterprise simulation performance and learning. Dev Bus Simul Exp Exerc 20:141–147
8. Washbush J, Gosenpud J (1994) Simulation performance and learning revisited. Dev Bus Simul Exp Exerc 21:83–86
9. Gee J (2003) What video games have to teach us about learning and literacy. ACM Comput Entertain 1(1):1–4
10. Springer CH, Herlihy RE, Beggs RI (1965) Advanced methods and models. Richard D. Irwin, Inc, Homewood
11. Frazer JR (1976) Time-sharing business games. Comput Simul Learn Theory 3:3–9
12. Wolfe J (1978) The effects of game complexity on the acquisition of business policy knowledge. Decis Sci 9(1):143–155
13. French JRP Jr, Caplan RD (1972) Organizational stress and individual strain: 33–36. In: Marrow AJ (ed) The failure of success. AMACOM, New York
14. Teach R (1990) Designing business simulations. In: Gentry GW (ed) Guide to business gaming and experiential learning. Nichols/PB, East Brunswick/London
15. Teach R, Murff E (2008) Are the business simulations we play too complex? Dev Bus Simul Exp Learn 35:205–211
16. Hall JSB, Cox BM (1994) Complexity, is it really that simple. Dev Bus Simul Exp Exerc 21:30–34
17. Teach R (2018) Why is learning so difficult to measure when “playing” simulations. Dev Bus Simul Exp Learn 45:55–63
18. Dennehy R, Sims R, Collins H (1998) Debriefing experiential learning exercises: a theoretical and practical guide for success. J Manag Educ 22(9):9–25
19. Lederman LC (1992) Debriefing: toward a systematic assessment of theory and practice. Simul Gaming 23(2):145–159
20. Bredemire ME, Greenblat C (1981) The education effectiveness of simulation games: a synthesis of findings. Simul Games 12(3):307–332
21. Crookall D (2010) Serious games, debriefing, and simulation/gaming as a discipline. Simul Gaming 41(6):898–920
22. Andrade-Santos A, Oliveira-Neto JD, Reith RL (2013) Formative and custom debriefing in business simulations. In: Proceedings of the 10th international conference on information systems and technology management, Brazil, 10, pp 2322–2336
23. Teach R, Szot J (2018) How students “play” business simulations and what they learn: the preliminary report. Dev Bus Simul Exp Learn 45:89–97

Gaming Simulation Validation: Matching Participants' Worldviews with Their Decisions

Maksims Kornevs, Jannicke Baalsrud Hauge, and Sebastiaan Meijer

Abstract Gaming simulation is a successful approach to many issues where a holistic view is important. However, to use results from gaming simulations, the game has to be validated. This paper proposes a two-step approach for process validation of behavior for the gaming simulation by comparing decisions that players make in a game with the perceptions that affect their real-life decisions. Two case studies, where this approach was applied, are presented, and the results are analyzed and discussed. A strong correlation between behavior during the games and in the real world was observed. This correlation indicates that gaming simulations in these cases are validated and represent the real system in an accurate manner. Thus, these cases show that the proposed approach works and can be used for validation of gaming simulations.

Keywords Gaming simulation · Process validity · Q methodology · Attribution theory

1 Introduction

Gaming simulation creates environments in which human participants can interact, allowing incorporation of multi-stakeholder perspectives with multidisciplinary and multi-scale problems [1]. It is used in many fields where there is a need for a holistic view of the system. However, these games require that a behavior of participants in the game is similar to their behavior in the real world [2]. Thus, one of the big challenges with the gaming simulation is its validation based on decisions that participants make [3–5].

There are opportunities to validate some gaming simulations using agent-based modeling and other approaches [6–8]. But it is still challenging to validate that the choices that participants make in the game will match choices that participants

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would make in real life [9, 10]. This is especially true for gaming simulations where people bring in their own behavior and expertise, such as games related to case studies and field work.

This paper suggests process validation of behavior for the gaming simulation by comparing decisions that players make in a game with perceptions that affect their real-life decisions.

Process validation of behavior for a gaming simulation is important for several reasons. First, understanding the perceptions that participants have about the system helps to address better the needs in a game and to understand the situation from different angles. Second, learning about causes behind decisions in a game makes it easier to analyze the results of the game. And most importantly, validation based on an understanding of the perceptions and causes behind decisions helps to validate a game, which is important for a proper game design, for the interpretation of the results, and in applying the lessons learned in a real system.

To achieve this validation, a two-step approach is proposed. Firstly, Q methodology is applied. The main purpose of this methodology is to research the subjectivity of viewpoints. Q methodology is used to systematically study opinion, beliefs, or attitudes to determine typical clusters of viewpoints that participants have regarding the topic. These clusters, or factors, represent participants who share common worldviews. Then, decisions or choices that all participants made in the game are considered, and the causes behind these decisions are investigated. It is done using the attribution theory. This theory tries to understand what causes people to make certain decisions. A comparison of the nature of these causes with the factors from Q methodology allows determination of how well actions in the game correlate to actions that people most likely do in real situations and allows validation of the game based on this correlation.

Two case studies related to service procurement are described in this paper. One case is focused on road maintenance procurement in Sweden, while the second case is from maintenance contracts within an airport in the Netherlands. For each case, Q methodology was applied, and after game sessions, all decisions that players made were analyzed to determine their causes and were compared with factors of participants.

A strong correlation between participants' worldviews and their decisions in the game was observed. This correlation indicates that gaming simulations in these cases represent the real system in an accurate manner. It also shows that the use of the suggested two-step approach works for validation of gaming simulations based on decisions that participants make.

This paper starts with a brief description of the problem of validation in gaming simulations in Sect. 2. After this, the approach is described with emphasis on each of the steps. Then two cases studies and their results are presented in Chap. 4. It is followed by a discussion and conclusion about the approach.

2 Problem Statement

Gaming simulation is used to achieve a specific objective or a set of objectives. Hence, gaming simulation has to be useful. Robinson [11] suggests that effective simulation has to fulfill four requirements. The first requirement is validity. Validity is a perception from a perspective of the modeler that a model is sufficiently accurate. The second requirement is credibility. It is similar to the validity; however, it looks on accuracy from the perspective of the client. The third requirement for effective simulation is utility. The utility is a perception that a model is useful to aid to decision-making process. The fourth requirement is feasibility, which is a perception that a model can be developed using available resources and data. A gaming simulation can be a measurement of usefulness for different types of games. However, different gaming simulations can have a different level of fulfilling these requirements to be successful.

Gaming simulations that rely on outcome data from the games, among other requirements, have to have a high level of validation. Validation is a process of checking or proving the accuracy of the model's representation of the real system. In gaming simulations, validation is a process of checking how accurate the simulation model is. Since all simulations represent reality only in the context of the specific purpose or objective of the game, the validation is also keeping a specific purpose in mind [12]. Internal validity, roughly speaking, addresses the extent to which a simulation functions in an intended manner.

The validity of gaming simulation is based on four criteria [3, 4]. These criteria are (1) psychological reality when providing a game environment that is realistic to the players, (2) structural validity when structures in the game are similar to the structures in the real system, (3) process validity when processes in the game are similar to the processes in the real system, and (4) predictive validity when the game can have outcomes that are similar to those of a system in the past or predict how a system will change in the future.

Process validity is usually addressed based on debriefing, questionnaires, and/or self-validation to an extent that is satisfying for the organization [10, 13]. However, these approaches do not give a full picture of how much a participant's behavior in a game is similar to his or her behavior in a real system and, thus, how well requirements for process validity are satisfied.

To properly investigate how well a gaming simulation is valid based on choices and decisions of participants, we need to know how accurate the causes behind choices and decisions are in the game compared to causes in the real world [14]. Hence, validation based on behavior or behavioral validation is performed by comparing attributions during the game with perceptions of individuals.

Such validation provides empirical evidence of how well behavior in a game is comparable with the real system. It also gives an understanding of what elements of the gaming simulation work properly to achieve the objectives and purposes of the game.

3 Proposed Approach

To be able to evaluate game's external validation, an approach is developed that is based on the behavior of participants during the game and their perceptions in real life. Because perceptions of reality directly affect the choices that a person makes, it is possible to observe such effects in games also.

In order to do so, the first step is to learn how participants perceive the real system. This can be done by grouping participants based on their worldviews regarding the research object of the game using Q methodology [15], as is described in Sect. 3.1. This methodology looks at how participants rank different statements regarding a specific topic and then groups the results based on the correlations between the answers of different participants. Later, the observed correlations are analyzed, and replies are clustered into factors based on similarity of opinions. People in common groups (factors) share common beliefs or attitudes toward a specific topic; the factors show a set of important values and principles for participants in this group.

When the factors are known based on analysis of Q methodology and the game is finished, all decisions in the game are analyzed to see what type of behavior pattern causes them to make such decisions, because not all decisions are caused by the participant's worldview. The analysis is done with attribution theory [16]. This theory is described in Sect. 3.2. It is applied because it helps to understand what decisions are really coming from the beliefs and ideas of a participant and which decisions are situational and are affected by the game itself, other situations, or organizations. It is important to identify what causes are internal and external because only internal decisions, which come from perceptions and ideas of a participant, affect process validity. Observing the decisions of all participants during the entire game, models in attribution theory allow determination of what causes are internal and what causes are external (Fig. 1).

Once decisions with internal causes are found, they are evaluated using factors with corresponding sets of values and principles as identified with Q methodology. Next, these results are compared with the group to which the game's participants who made these decisions belong. This comparison shows the level of validity of the game. If the ratio of the internal causes matching with the perceptions of the participant is higher, then the behavioral validation and the game's validation are higher too.

3.1 Q Methodology

Q methodology aims to study how people perceive the world regarding specific topics [15]. This methodology is used in cases where there are different opinions to group these opinions into factors. This allows analysis of these factors for better investigation of how participants perceive the system. It also allows some patterns

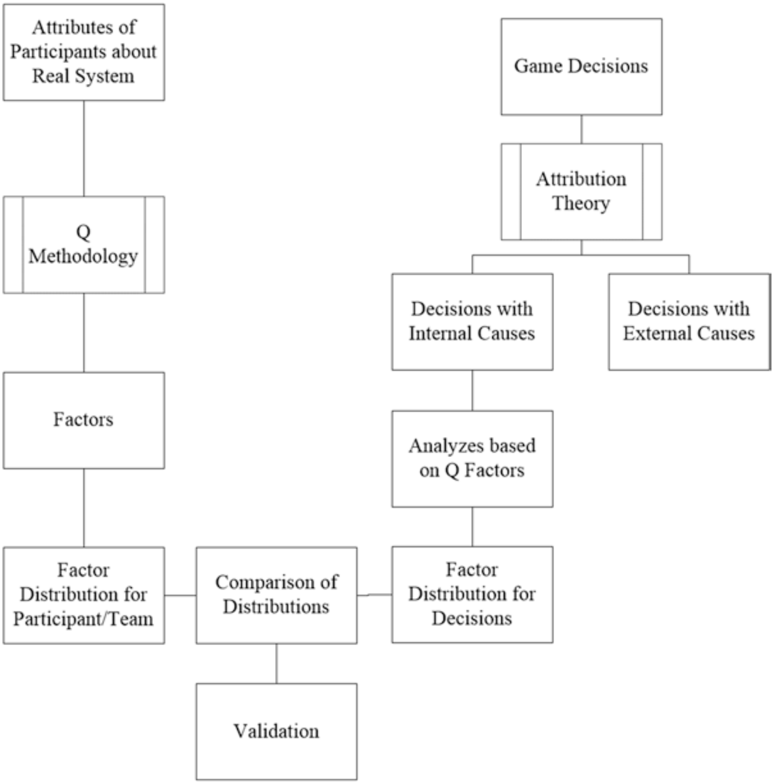

Fig. 1 The flow of the proposed approach

to be found that determine the choices and decisions that these participants would make in real cases.

The basic process of Q methodology has several steps, starting with developing a set of statements on the topic of research to the final interpretation of the found groups, as seen in Fig. 2.

The concourse is a broad set of different opinions, ideas, and beliefs about the system. Typically it is based on literature and interviews with key stakeholders. It also might include some hypotheses or feedback about a design of the gaming simulation.

Once the concourse is defined and includes all the important elements, it needs to be reduced to a set of 30–50 statements, which is the typical number of statements for Q methodology [15]. It is important too that the final set of statements includes the whole spectrum of opinions.

When the final statements are selected, a response grid needs to be defined. This grid contains several columns, usually ranging from "strongly disagree" to "strongly agree." Each column has a predefined number of placeholders where participants can sort the statements. The response grid typically has a bell-shaped normal

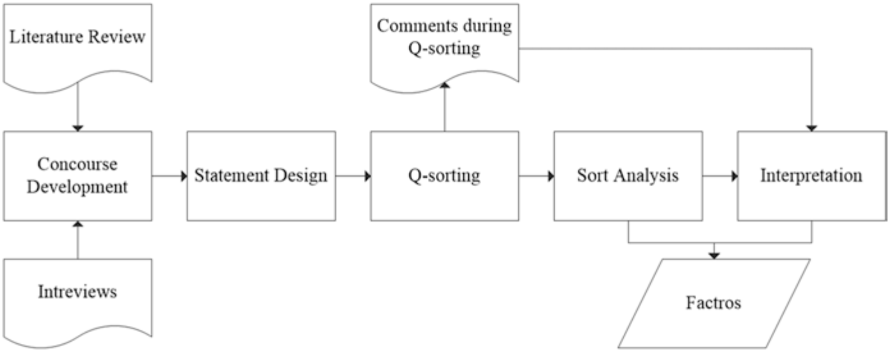

Fig. 2 Process of Q methodology

Fig. 3 Example of Q response grid

distribution as seen in the example in Fig. 3. Participants are asked to fill in this grid, and such forced distribution helps to achieve better results during the analysis.

After the statements are known and a response grid is defined, Q-sorting starts. During Q-sorting participants are asked to read and sort all statements based on how much they agree with each of the statements. After sorting, participants are asked about their choices regarding the most left and most right piles because they represent extremes in opinions and, thus, contribute more to the grouping process.

When all the sorts are done, they are analyzed based on how each sort correlates with other sorts. The sorts that are similar are clustered into factors, and the centroids in these clusters are used for interpretation.

When these centroid factors are found, the patterns in the sorting are examined and, together with the comments from the sorting, are used to form the final descriptions of the factors.

3.2 Attribution Theory

Attribution theory deals with how the social perceiver uses information to arrive at causal explanations for events. It examines what information is gathered and how it is combined to form a causal judgment [16]. Based on this theory, behavior has causes.

These causes can be internal or external. Internal, or dispositional, attributions are related to the person's inner factors, such as perceptions, traits, and skills. External, or situational, attributions are caused by some factors relative to the situation, something that is outside of the person's immediate control.

One of the central models within the attribution theory is Harold Kelley's covariation model [17]. His model is based on three types of causal information: (1) distinctiveness that deals with the extent to which we act differently in different situations, (2) consensus that refers to the extent to which we act in a similar way to other people in similar situations, and (3) consistency that considers the extent to which we act similarly over time. Each type can have high value, where causes can be explained by external attribution, or low value, where causes can be explained by internal attribution (Fig. 4).

For example, if in the gaming simulation one participant chooses to use different variable values for different scenarios, then distinctiveness is high, and it can be explained by external attribution, such as values that are related to the context of the scenario or some instructions. However, if another participant chooses to use the same values for different scenarios, then distinctiveness is low, and it is explained by internal attribution – the participant relies on personal experience or knowledge and his or her own perceptions.

In a similar way, if all teams make the same decision for the same case or scenario, the consensus is high, and it is caused by external attribution. But if one team chooses to make a unique decision, then the consensus for this team is low. Also, if a team uses the same strategy over a prolonged period of time, such as several rounds or turns, then consistency is high, while changes in the strategy over time would show that consistency is low. Choices with low distinctiveness, consensus, or consistency have internal causes and should be in line with the perceptions of participants.

4 Results

Two case studies related to service procurement are described in this paper. Both cases represent complex reality where process validation is important to interpret results in a proper manner. One case is focused on road maintenance procurement in Sweden, while the second case is from maintenance contracts within an airport in the Netherlands. The aim of both case studies is to determine how procurement can promote innovation without losing its purpose. For each case, Q methodology was

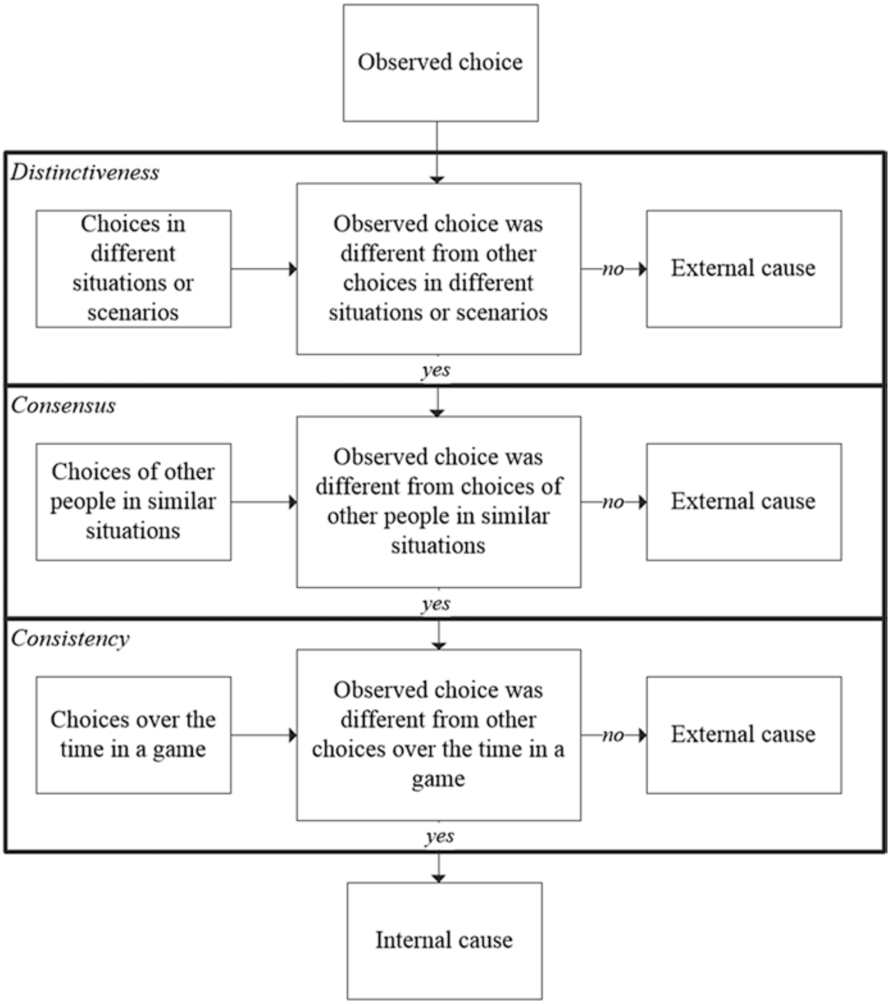

Fig. 4 Process of attribution theory

applied, and games were designed and played, in which participants needed to create new procurement contracts based on standard procurement procedures from their organizations.

4.1 Road Maintenance Procurement in Sweden

Road maintenance in Sweden is the responsibility of the Swedish Road Administration, who procures services from private companies. All maintenance procurement contracts are highly standardized across all of Sweden, and they contain a large number of technical specifications and regulations on how maintenance has to be carried out. A contract is typically signed for 4 years with the opportunity to prolong it for up to 2 more years. Every project receives around 3–5 tenders, and the tender with the lowest cost is awarded.

However, maintenance contracts are seen as a type of contract with the lowest amount of innovation, and that raises many concerns for the Swedish Road Administration. The main issues usually mentioned for this are the high standardization level, the low attractiveness of the contracts, and the low transparency about the amount of work.

In order to test some policies and ideas on how the situation can be improved, a gaming simulation was used. The objective was to create environments where procurement specialists from the Swedish Road Administration could experiment with procurement documents to see how changes will affect the outcomes of the contracts.

Participants were instructed to make any changes they wished in the documents, in order to produce a request for tenders that could exist in reality with the aim to decrease costs by 40% within the next 20 years. The game had two rounds, where participants continued to work with the same area of roads during the game.

4.1.1 Findings from Q Methodology

Prior to the game, Q methodology was performed. Twenty-one people who worked with maintenance procurement from the Swedish Road Administration and private construction companies were selected to participate in Q methodology to find clusters of perceptions. Each person was asked to sort 43 statements regarding maintenance procurement. Based on their replies, Q methodology identified three groups: factor 1 (administration-oriented), factor 2 (business-oriented), and factor 3 (service quality-oriented). Each factor represents a set of attributes and values based on how participants in these factors perceive the road maintenance project procurement.

Participants within factor 1 looked at project procurement from the administration point of view. They are concerned with market structures, organizations, structures within organizations, the experience of stakeholders, and cooperation between companies in the market. They check that all processes are running smoothly and all management is done properly.

Participants within factor 2 looked at individual contracts and related aspects rather than the administration aspects. They wanted to have contracts with the lowest costs. They were interested in procurement, finance models, innovation, and incentives.

Participants in factor 3 emphasized statements about service quality, such as the environment, quality, road characteristics, and work process. They looked not as much at the management processes but rather into the goals of the project and how well the final work was performed.

4.1.2 Teams and Their Strategies

Nine people participated in the session, and they were divided into four teams: three teams of two and one team with three people.

Team A mainly focused on using incentives as a bonus that entrepreneurs can get paid when they come up with an innovation.

Team B chose to customize documents to the local conditions and to stimulate the market of the European Union to dare them to bid more.

Team C made the contract to be procured based on the most economically advantageous tender in terms of the criteria of innovation, the environment, service, and safety. Small changes were made to the appendix such as removing some report forms.

Team D tried to achieve innovation in order to get increased productivity, efficiency, and so on. They were trying to get incentives for the contractors to try new materials, new methods, and new ways of working in order to get even better.

4.1.3 Internal Decisions

All teams started with typical documents for procurement and then they could make changes. Each change was a decision, and it was recorded and analyzed based on distinctiveness, consensus, and consistency.

Team A had made two changes in the first round and four changes in the second round. Two changes were the same in both rounds, which indicated that consistency was high and the causes were external. One change was the same as other teams', which had a high value for consensus, meaning that the cause was external. Three other changes were internal changes. The first change was about relocating some specifications to different files. This change was purely administrative, so it correlated to factor 1 from Q methodology. The second change was to separate contractor fees from other fees. This change was also administrative, and it correlated to factor 1 too. The third change was to reward contractors for extra high-quality work. This change had aspects of business because it provided business incentives and aspects from service because the change intended to improve service quality. Therefore, the third change correlated to factors 2 and 3 from Q methodology.

Team B had a total of 18 changes, but only 8 of them were internal. Five changes were administration-oriented (coordinate work with municipalities, make communication during the procurement process more flexible, refer more to international standards instead of local ones, translate documentation into English, increase visibility of the request for tender), one change was business-oriented (some of the attachments were rewritten to make cost calculations easier), one change was between administration-oriented and service quality-oriented (some changes from the technical specification to the functional specifications), and one change was between administration-oriented and business-oriented (contract can be divided into lots).

Team C made six changes with three internal causes. One change was administration-oriented (removed some attachments describing administrative work), one change was business-oriented (changed the award criteria), and one change was service quality-oriented (rewrote some of the requirements on how service work has to be performed).

Team D had 15 changes with 7 internal ones. Five changes were administration-oriented (split the contract into two contracts based on geography, changed the start date of the contract, accepted contracts in other languages, made it a recurrent procurement, and removed some of the qualification questions regarding administrative experience), one was business-oriented (accepted alternative solutions), and one change was between administration-oriented and business-oriented (changed the type of procurement to a competitive dialogue).

4.1.4 Validation

After the gaming simulation, each participant was asked to complete a Q sort to determine the group to which he or she belongs. While the majority of participants had one defined factor, one participant had a high correlation with two factors.

Team A had one person who belonged to factor 1 (administration-oriented) and the second person to factor 2 (business-oriented). Team B had two people belonging to the administration-oriented factor. Team C had one person who belonged to the administration-oriented factor, while the second one had attributes from the business-oriented and service quality-oriented factors. Team D had two people who were administration-oriented and one who was business-oriented (Table 1).

The standard error of the estimate is a measure of the accuracy of the predictions made. Based on this, 82% of the causes of the changes that participants made matched the results from Q methodology.

Table 1 Distribution of factors between participants and committed changes for each team

	Participants			Changes		
Team	Administration oriented (%)	Business-oriented (%)	Service quality-oriented (%)	Administration-oriented (%)	Business-oriented (%)	Service quality-oriented (%)
A	50	50		67	17	17
B	100			75	19	6
C	50	25	25	33	33	33
D	67	33		79	21	

4.2 Airport Management

Schiphol airport is the main international airport of the Netherlands. Its work is governed by Schiphol Group. This group makes sure that all activities are carried out properly, from serving passengers and airlines to handling agents and logistics service providers to having a range of shops, catering facilities, and services to taking care of buildings and equipment.

Most of this work and services are procured according to European and Dutch public procurement acts. However, it has some issues with daily interaction, because airport staff are sometimes too involved in the work of contractors, particularly in making technical judgments themselves about, e.g., the condition of an asset and the work needed on it. The goal of Schiphol Group is to shift this attitude toward a more distant relationship and to make the working relationship more of a partnership.

This change is mainly seen to be done through a procurement process, where some conditions and specifications need to be adjusted in order to make it true. However, it is unclear what parts need to be changed and to what extent to make it happen. Also, it is important to find a way to change how the employees of the Schiphol Group perceive their jobs and how to interact on a daily basis with contractors.

Gaming simulation was chosen to investigate deeper these changes. Although the entire solution was based on a series of games, the first game in this project was about procurement for safety clothing maintenance.

Participants were instructed to modify an existing contract in order to make it cheaper and in line with the new vision, where the awarded contractor is a strategic partner, rather than merely an aide.

4.2.1 Findings from Q Methodology

Prior to the game session, all participants were asked to participate in Q sorting. For this study, 26 statements were selected about different opinions regarding procurement policies and efficiency in the airport, as well as the relationships between different parties. Nineteen participants sorted these statements based on how much they agreed or disagreed with each statement, and based on their answers, three factors were found based on clustering of their replies and agreement level.

The first factor included people whose opinions were about more freedom for companies. This factor sees procurement merely as guidelines to help contractors do their job. They want contractors to have more freedom and focus more on functions that need to be done rather than some specific descriptions.

The second factor focused on imperfections in current procurement practices. Their opinions were that the current system is not effective and has many issues and they would like to see changes in these practices.

The third factor sees the airport and Schiphol Group as one with authority. They want contractors to listen to the airport since they merely work for Schiphol Group. Because of that companies need to do what the airport tells them to do.

4.2.2 Teams and Their Strategies

Twelve people only came to participate in the gaming session. They were divided into six teams, each group including two participants.

Team A focused on the clear definition of the goals and ambitions and connected them with the incentives. At the same time, they removed some of the less relevant parts from the contract, so it would be more attractive and open to bidders.

Team B decided to make many changes in the way procurement is done. In this, they tried to keep a balance between protecting the interests of Schiphol Group and making the request for tenders more appealing.

Team C aimed mainly to protect the interests of the airport. They added more specifications and criteria for bidders. They also made more references to the standards that currently exist in the airport.

Team D decided to keep the main contract with the specifications without changes but instead focused on the way procurement is done. They changed some legal, economic, financial, and technical information related to the bidding process. They also changed the procedure with different award criteria and object of the contract.

Team E tried to switch from technical specification to functional, making it easier for contractors to be more creative and have more liberties as long as a contractor will deliver the services on time.

Team F decided to make the criteria stricter for potential bidders and to include technical information about the service.

4.2.3 Internal Decisions

Each team had three forms to fill in, which is the typical procedure for real procurement projects. Each team needed to make all necessary changes in the forms to achieve the goals of the gaming simulation.

Since there was only one round of the game, all the decisions of participants were analyzed only based on the extent to which these decisions were similar to the decisions of other participants (consensus). The total number of all changes and also the number of internal decisions that correlated with each of the factors can be seen in Table 2.

Table 2 Total changes and internal changes based on their correlation with factors for each team

Team	Total changes	Correlation with factor 1	Correlation with factor 2	Correlation with factor 3
A	19	1	3	5
B	19	0	6	4
C	9	0	0	3
D	12	0	3	4
E	15	5	1	0
F	21	0	2	9

Table 3 Distribution of factors between participants and changes made for each team

	Participants			Changes		
Team	Factor 1 (%)	Factor 2 (%)	Factor 3 (%)	Factor 1 (%)	Factor 2 (%)	Factor 3 (%)
A	25	25	50	11	33	56
B	0	50	50	0	60	40
C	0	0	100	0	0	100
D	0	50	50	0	43	57
E	100	0	0	83	17	0
F	0	0	100	0	18	82

4.2.4 Validation

Once the internal decisions were analyzed, they were compared with the results from Q methodology.

Team A had one person who belonged to factor 3, while the second one had attributes from both factor 1 and factor 2. Team B had one person who belonged to factor 2 and the second person to factor 3. Team C had two people who belonged to factor 3. Team D had one person who belonged to factor 2 and the second person to factor 3. Team E had two people who belonged to factor 2. Team F had two people who belonged to factor 3 (Table 3).

The standard error of the estimate in this gaming simulation is 10.6%, meaning that almost 90% of all decisions matched the patterns found based on participants' perceptions prior to the game.

5 Discussion

Two gaming simulations in this paper focused on the procurement process in the administrative sector. In both games people brought in their own behavior and expertise. Hence, it is important to validate gaming simulation. Both games had similar rules and objectives, although they focused on different types of work and had different focuses and purposes. Because of focus differences and different cultures, participants in the games had different sets of perceptions.

The first case about road maintenance procurement revealed perceptions that were related to the organizational structure of work. It helped to see that the game played had a poor balance between participants that belonged to different factors. A game session with more participants that were business- or service-oriented could lead to other results. The second case had perceptions that were more focused on relations between stakeholders and the role of procurement in forming these relationships. Perceptions in both cases helped to steer the debriefing session and analyze the results from the games.

At the same time, it was observed in both cases that many choices were based on the policies and guidelines of the corresponding organizations, even when participants were told that they had freedom in their decision-making. Although participants chose to follow company guidelines partially because companies have best practices, in many cases participants were scared to take risky decisions even when they knew that there were problems related to such choices.

Finally, this approach showed that both cases have a high level of validity based on the standard error of the estimate. This validity makes it possible to measure and compare how well behavior in each game, or even in each team, correlated with reality. It gives more information for analysis of the game outputs. It also helps to improve game design and be aware of potential bottlenecks in the design; and it helps with the process validation criterion.

This proposed approach can be used for design or policy games where participants have their own roles in the game or other types of gaming simulations where participants have enough freedom to make a number of decisions based on their own experience. It is preferable to have a game (1) that is played by several teams or players to evaluate consensus, (2) that has several rounds to evaluate distinctiveness, and (3) that gives a choice between different strategy plans to evaluate consistency. However, these criteria are not mandatory, and in the provided cases, not all of them were implemented.

It is possible that the approach will have some limitations when players participate in the game individually rather than in teams. In this case, it is possible to evaluate each participant not merely based on his or her dominant factor but rather based on correlations with all factors. Also, it is hard to say how much each participant contributed to the general results when they were working in teams. This means that in a team of two participants that belong to different factors, where one of the participants is not actively taking part in the game, it would be unreasonable to expect that the changes will be split into equal halves between those two factors. This can explain why the standard error of the estimate is quite high.

6 Conclusions

This paper proposes an approach for process validation of gaming simulation. It is based on a comparison between the causes behind choices that players make in the game and their perceptions about the topic in real life.

This approach was applied to validate two games, and the results were described. A strong correlation between the worldviews of participants and their decisions in the game was observed. This correlation indicates that gaming simulations in these cases are validated and represent the real system in an accurate manner.

From our results, a combination of Q methodology and attribution theory appears a promising method for constructing a validity assessment of a gaming simulation.

This approach can be applied in games where participants play their own roles and can make multiple choices. Such games can be, but not limited to, policy games, design games, planning games, political games, etc. The results from this approach can help to see deeper reasons behind the choices that participants make for analysis of the results and real applications.

References

1. Duke R (1974) Gaming – the future's language. Sage, New York
2. Sterman JD (1989) Modeling managerial behavior: misperceptions of feedback in a dynamic decision making experiment. Manag Sci 35:321–339
3. Raser JR (1969) Simulation and society: an exploration of scientific gaming. Allyn and Bacon, Boston
4. Peters V, Vissers G, Heijne G (1998) The validity of games. Simul Gaming 29:20–30
5. Feinstein AH, Cannon HM (2003) A hermeneutical approach to external validation of simulation models. Simul Gaming 34:186–197
6. Yin RK (2003) Case study research: design and methods. Sage, Thousand Oaks
7. Hofstede GJ, Jonker CM, Verwaart T (2014) Cross-validation of gaming simulation and multi-agent simulation. In: Perspectives on culture and agent-based simulations. Springer, Cham, pp 31–47. https://doi.org/10.1007/978-3-319-01952-9_3
8. Gentile M, Guardia DL, Grande VD, Ottaviano S, Allegra M (2014) An agent based approach to designing serious game: the PNPV case study. Int J Serious Games 1:12
9. Wolfe J, Roberts CR (1993) A further study of the external validity of business games: five-year peer group indicators. Simul Gaming 24:21–33
10. Meijer S (2012) Gaming simulations for Railways: lessons learned from modeling six games for the dutch infrastructure management. Infrastruct Des Signal Secur Railway. https://doi.org/10.5772/35864
11. Robinson S (2008) Conceptual modelling for simulation. Part I: Definition and requirements. J Oper Res Soc 59:278–290
12. Robinson S (2003) Simulation: the practice of model development and use, Wiley, New York
13. Lo J, van den Hoogen J, Meijer S(2013) Using gaming simulation experiments to test railway innovations: implications for validity. In: Winter simulation conference 2013. https://doi.org/10.1109/WSC.2013.6721557
14. Fischbacher U, Gächter S, Quercia S (2012) The behavioral validity of the strategy method in public good experiments. J Econ Psychol 33:897–913
15. Watts S, Stenner P (2012) Doing Q methodological research: theory, method & interpretation. Sage, London
16. Fiske ST, Taylor SE (1991) Social cognition. McGraw-Hill Education, New York
17. Kelley HH (1967) Attribution theory in social psychology. Neb Symp Motiv 15:192–238

Educational Gamification: Challenges to Overcome and to Enjoy

J. Tuomas Harviainen and Mikko Meriläinen

Abstract This paper presents a critical viewpoint on educational gamification, an understudied field filled with hyperbole and hollow sales pitches, as well as solid research. By reviewing existing research in the context of Landers' theory of gamified learning, it discusses three underlying, important elements that need to be taken into account: engagement, challenge, and reflection, as well as the interconnections between them. As a result, it suggests ways for more efficient deployment of gamification for educational purposes.

Keywords Educational gaming · Gamification · Learning · Reflection · Simulation gaming · Gamified education

1 Introduction

Gamification is still gaining traction in educational contexts, both in schools and in business organizations, even as its veracity receives more critical analysis [1]. Applications include both the gamification of education and the gamification of learning, two things that are not the same. On the one hand, we can gamify the tools and processes that are used for learning, and on the other, people may gamify the processes they use to learn. In many cases, those two correspond, but not always. As things stand now, quite a lot is known about educational gaming but much less about the use of game elements for learning in nongame tasks. This paper looks at the current evidence and suggests ways for applying educational gamification in an effective manner. As noted by Harviainen [2], much of the current theory development in gamification of educational contexts relies on conjecture and extrapolation. To put it bluntly, we have great examples of it working but know little of why it actually works. This is a fact spotted decades ago already [3] but left unsolved. In the last 4 years since a similar claim was again made by Harviainen, Lainema, and Saarinen

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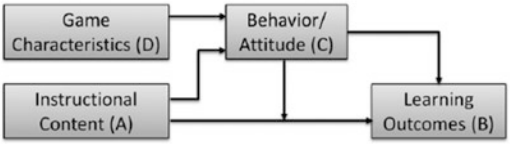

Fig. 1 Theory of gamified learning [6]

[4], it appears little has changed in that regard. This is no surprise, since we keep also getting similar statements about educational gaming, and have been getting those statements for decades before (e.g., [5]).

In a rare exception, Landers [6] (see Fig. 1), based on Deterding et al. [7] and Bedwell et al. [8], formed a theory of gamified learning, in which gamification is defined as "the use of game attributes, as defined by the Bedwell taxonomy, outside the context of a game with the purpose of affecting learning-related **behaviors** or **attitudes**." This is an important focus. As noted above, gamification can be applied for different purposes and in differing parts of the learning process, and those affect different factors that influence learning. Changing behavior is not the same as changing attitudes.

In the following sections, we examine some of the key attributes but ones distinct from those of Landers and Bedwell et al. Our focus is on understanding pre-requirements, rather than on singular attributes that contribute to learning. We concentrate on three points: engagement, challenge, and reflection.

2 The Role of Engagement

Engagement is necessary for learning, but how much engagement – or immersion – is optimal? Without engagement, the activity remains uninteresting, which prohibits learning [9]. With too much engagement, reflection may be lost [10]. What makes gamified activities more complex in this sense is that since there is no singular game to play, but rather goal-oriented real-life activities that have had game elements added to them, the potential for distractions is much higher. So is also the risk of the "chocolate-covered broccoli" effect, in which an educational purpose is just sugar-coated with play, the entertainment value of which may well be rather passing. When the players start considering the whole thing an annoyance hidden behind a bit of temporary fun, novelty will wear off (as per [11]), and the activity will be found even less interesting than it would have been without the gamification.

Engagement is elusive, in that it can sometimes be achieved by simply framing an activity as a game [12]. Other designers turn to much deeper tools (e.g., [13]), and when the entire activity is also storified through a shared narrative [14], engagement usually increases. Yet engagement is like hermeneutic pre-understanding: it is what makes the play meaningful, and the immediate feedback received valuable for the participants, but it also inevitably creates biased responses. Furthermore, not everyone likes to play for achievements [15] or to play games at all [16], so the classic gamification tools of "points, badges, and leaderboards" may be insufficient.

It is tempting, especially for classroom environments, to just form a pretense framework around a learning content. This is particularly true for one of the oldest gamification techniques, role-playing. By adding the component of roles to tasks, interest can indeed be increased [17, 18]. For certain topics (e.g., language learning; [19, 20]), it works well; for others it is just chocolate on that broccoli. With learning tasks and roles (or narratives) too far apart, connections become meaningless, and the play becomes uninteresting [21].

3 The Role of Challenge Level

Another factor that comes out in research time and again as significantly influencing learning is challenge level (e.g., [10, 22, 23]). Too difficult challenges create boredom, but likewise insufficient challenge makes people lose interest [24]. This factor therefore ties directly into the previous one, engagement. Optimal challenge creates engagement, possibly even flow, which in turn connects to learning [23].

Gamified challenges are problems and thus lead to problem-based learning with authentic activity (as per [25]). It is therefore not at all without significance what kinds of gamification elements are used. The tasks need to be meaningful, educational, and interesting at the same time. Especially important is that the challenges clearly relate to the intended learning task. It is not just a question of creating motivation through engagement but also an issue of achieving the desired educational goals. Incidental "stealth" learning cannot be trusted [16], and if a participant is highly competitive, they may learn completely wrong things while trying to win (or "win") the gamified activity [4, 26].

Challenge is, quite frankly put, very difficult to achieve in an educational game or gamified situation. Even in recreational games, optimizing gameplay-related skill learning curves is hard. In an educational game or gamified activity, to that equation is added the knowledge level of each player, which in even a single classroom or business school course can hugely vary. Optimized the right way, people can be enticed to transcend their self-set limitations (e.g., a student daring to start speaking broken English, carried away by the desire to win an argument in a role-play [20]). In other cases, pre-existing differences in competencies just lead some players to frustration and others to boredom. And with either situation, the learning curve probably vanishes.

4 The Role of Reflection

As with serious games, successful educational gamification furthermore requires reflection (see [4]). If the gamification is able to increase reflection above the level on which it would otherwise be (through, e.g., time-on-task or gamified note-keeping), learning is likely to be improved even further [6]. Excluding certain specific game types (see [27, 28]), reflection needs to be handled outside of play [4]. This is why simulation/gaming has so strongly focused on emphasizing high-quality debriefing [29]. If the participants have problematic attitudes, however, even a great debriefing will not help [30].

Reflection is difficult to embed directly into play, but not impossible. In contrast to games, gamification has the advantage that it is directly tied into real-world elements, instead of being a simulation or simplification of them (as per [31, 32]). Problems can therefore be built around the actual skills needed, issues can be resolved, and learning goals can be attained. This does not remove all of the risks of the learning remaining context-bound (see [30]) but strongly lessens the likelihood of that happening. This is especially important, if the gamification is meant to produce learning on an organizational level [33]. It is furthermore possible to embed moments of reflection into the activity itself, in a manner similar to the use of design games (see [27]). If that reflection can be placed in sequence with logically structured play elements (as per [24]), all the better. Nevertheless, here too Knotts and Keys' [34] observation that performance in an educational game does not equate learning rings true. At least we can make the two correlate better, through careful gamification, nowadays.

5 Discussion and Conclusions

The challenge in this combination is that it does not actually work. Optimal challenge is known to create high engagement [23], which is a detriment to the reflection necessary for learning something out of the play, rather than learning to just play that particular system [4]. With insufficient engagement, whether from a lack of good challenge or due to a lack of interesting content, the play remains boring, and thus not interesting to reflect upon (see Fig. 2). It is thus up to the designers to make sure that the gamified elements are optimized for this purpose and that even as the initial novelty effect of gamification may wear off or even turn against its original purpose [11], the challenge continues being balanced, and the engagement level remains enticing but not too strong. Games are able to do this [23], but for gamification it is much harder.

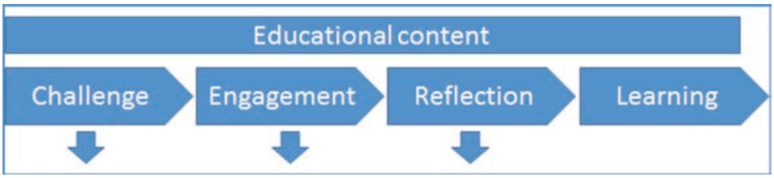

Fig. 2 The three factors, with risk of deviation in each, and the mandatory presence of instructional and educational content at all points

All of these factors are necessary, but they are complementary to the main goal. As Landers [6] notes, "The goal of gamification cannot be to *replace* instruction, but instead to *improve* it." The instructional content needs to be able to facilitate learning on its own, or gamification cannot help. Likewise, without paying attention to the three factors discussed in this paper, however, instead of improvement we will have just hindrances. If they work, players will be able to absorb the educational goals into their intrinsic motivations (as per [35]), and then it is up to tailoring the other elements (as per [6]) in line, to facilitate maximal learning potential. If they do not, play becomes a distraction from learning, rather than its advocate [16].

Gamified education often lacks one of the key advantages of serious games and other novel learning environments: the ability to experiment and fail safely. That ability has, for example, been seen as a key element in fostering innovation and creativity [36, 37] in studies discussing learning in game jams, a type of free-form game creation event. As a result, some of the knowledge of how educational games and novel, informal learning environments function cannot be directly applied to educational gamification.

This suggests that a key avenue of approach may be the exploration of playful mindsets and play states and their cultivation. Rather than concretely making learning into a game, by including an element of competition or rewards, for example, we can instead seek to cultivate some of the intangible things people enjoy in games and play, such as fun and creativity. Environments such as educational institutions or workplaces are often built around competition, goals, and rewards, either advertently or inadvertently, and care must be taken that gamification does not become a simple cosmetic makeover of this. The assumption of a playful mind-state is a fundamental shift from more traditional means of learning: the focus is less on the product and more on the process [38], with an emphasis on imagination, creativity, and collaboration [39]. The concept of "playification" has been suggested to either replace or extend beyond reward-based gamification [40, 41]. At the very least, it is an important, interconnected side of the same proverbial coin [14].

We therefore recommend that educational gamification should seek out a balance between engagement (which usually but not always may mean "fun" [42]) and reflection, feature a smooth task-based learning curve interspersed by short moments of fruitful reflection, have a challenge level that increases while teaching the skills and knowledge needed to enjoy the increases, and have enough room for experimentation that also some new positive effects may emerge. A playful approach emphasizing fun, creativity, and collaboration over tasks, rewards, and competition may help overcome some of the challenges discussed in this paper. Gamification has been shown to work for improving positive behavior better than other forms of motivational increasing [43], so it is logical that we also examine its educational applications further.

Promoting active learning and engaging learners is not a trivial task, and both have been and continue to be a key issue in both the science and practice of education. The learning process is always a complex interplay of situational and personal variables, and no pedagogical method guarantees that intended learning takes place (e.g., [44]). As a result, novel approaches to education will inevitably succeed in some areas and situations and fail in others. Instead of seeking to conclude whether a method categorically works or not, the focus should be on leveraging its strengths and avoiding its weaknesses while evaluating the method's suitability for achieving set goals and making notes of encountered problems.

Gamification is an imprecise tool, but despite its flaws, it is able to offer much to making learning more motivating, more effective. The aforementioned challenges should be seen as inspiring, enjoyable constraints, not as limitations. The use of gamification in educational context, in our opinion, forces educators to re-evaluate their subject matter and pedagogical methods, in order to gamify that matter. If it does not seem possible to gamify it, something must yield – not everything is learned best in a playful manner. Likewise, the learning of the right things cannot be guaranteed, in gamification, so the process also requires an examination of the methods used for debriefing and anchoring the desired results. Further research should therefore be conducted in this area, to find out which tools fit which subject matter and which parts of which curricula would benefit from being gamified.

References

1. Landers RN, Auer EM, Collmus AB, Armstrong MB (2018) Gamification science, its history and future: definitions and a research agenda. Simul Gaming 49:315–337
2. Harviainen JT (2014) Critical challenges to gamifying education: a review of central concepts. In: Vorobyov AV (ed) Digest of the international conference on digital game-based learning Game ON! Moscow
3. Kibbee JM, Craft CJ, Nanus B (1961) Management games: a new technique for executive development. Reinhold, New York
4. Harviainen JT, Lainema T, Saarinen E (2014) Player-reported impediments to game-based learning. T Dig Games Res Assoc 1:55–83
5. Keys B, Wolfe J (1990) The role of management games and simulations in education and research. J Manag 16:307–336
6. Landers RN (2014) Developing a theory of gamified learning: linking serious games and gamification of learning. Simul Gaming 45:752–768
7. Deterding S, Sicart M, Nacke L, O'Hara K, Dixon D (2011) Gamification: toward a definition. In: Proceedings of the CHI 2011 gamification workshop, Vancouver, British Columbia, Canada
8. Bedwell WL, Pavlas D, Heyne K, Lazzara EH, Salas E (2012) Toward a taxonomy linking game attributes to learning: an empirical study. Simul Gaming 43:729–760
9. Balzer M (2011) Immersion as a prerequisite of the didactical potential of role-playing. Int J Role-Play 2:32–43
10. Henriksen TD (2008) Extending experiences of learning games – or why learning games should be neither fun, educational or realistic. In: Leino O, Wirman H, Fernandez A (eds) Extending experiences. University of Lapland, Rovaniemi, pp 140–162
11. Koivisto J, Hamari J (2014) Demographic differences in perceived benefits from gamification. Comput Hum Behav 35:179–188
12. Lieberoth A (2015) Shallow gamification: testing psychological effects of framing an activity as a game. Games Cult 10:229–248
13. Seaborn K, Fels DI (2015) Gamification in theory and action: a survey. Int J Hum-Comp St 74:14–31
14. Deterding S (2016) Make-believe in gameful and playful design. In: Turner P, Harviainen JT (eds) Digital make-believe. Springer, Basel, pp 101–214

15. Warmelink H (2014) Online gaming and playful organization. Routledge, New York
16. Whitton N (2014) Learning with digital games: a practical guide to engaging students in higher education. Routledge, New York
17. Crookall D, Oxford R, Saunders D (1987) Towards a reconceptualization of simulation: from representation to reality. Simul Games Learn 17:147–171
18. Hyltoft M (2010) Four reasons why edu-larp works. In: Dombrowski K (ed) LARP: Einblicke. Zauberfeder, Braunschweig, pp 43–57
19. Cruaud C (2018) The playful frame design and use of a gamified application for foreign language learning. University of Oslo, Oslo
20. Harviainen JT, Savonsaari R (2013) Larps in high schools. In: Moseley A, Whitton N (eds) New traditional games for learning. Routledge, London, pp 134–145
21. Schrier K (2016) Knowledge games: how playing games can solve problems, create insight, and make change. Johns Hopkins University Press, Baltimore
22. Carlson JGH, Misshauk MJ (1972) Introduction to gaming: management decision simulations. Wiley, New York
23. Hamari J, Shernoff DJ, Rowe E, Coller B, Asbell-Clarke J, Edwards T (2016) Challenging games help students learn: an empirical study on engagement, flow and immersion in game-based learning. Comput Hum Behav 54:170–179
24. Graham RG, Gray CF (1969) Business games handbook. American Management Association, New York
25. Duffy TM, Cunningham DJ (1996) Constructivism: implications for the design and delivery of instruction. In: Jonassen DH (ed) Handbook of research for educational communications and technology. Macmillan, New York, pp 170–198
26. Hakulinen L, Auvinen T, Korhonen A (2013) Empirical study on the effect of achievement badges in TRAKLA2 online learning environment. In: Proceedings of learning and teaching in computing and engineering (LaTiCE) conference, March 21–24, 2013, Macau, pp 47–54
27. Hannula O, Harviainen JT (2016) Efficiently inefficient: service design games as innovation tools. In Morelli N, de Götzen A, Grani F (eds) Service design geographies: proceedings of the servdes 2016 conference, May 24–26, 2016, Copenhagen, Denmark, pp 241–252
28. Hannula O, Harviainen JT (2018) User perceptions of design games as settings for organizational learning: case Topaasia cards. In: Proceedings of the servdes 2018 conference, June 18–20, Milan, Italy
29. Crookall D (2010) Serious games, debriefing, and simulation/gaming as a discipline. Simul Gaming 41:898–920
30. Kim DH (1993) The link between individual and organizational learning. Sloan Manag Rev 35:37–50
31. Linderoth J (2011) Why gamers don't learn more: an ecological approach to games as learning Environments. J Gaming Virt Worlds 4:45–62
32. Thavikulwat P (2004) The architecture of computerized business gaming simulations. Simul Gaming 35:242–269
33. Vesa M, Hamari J, Harviainen JT, Warmelink H (2017) Computer games and organization studies. Organ Stud 38:273–284
34. Knotts US Jr, Keys JB (1997) Teaching strategic management with a business game. Simul Gaming 28:377–394
35. Deci EL, Ryan RM (2002) Overview of self-determination theory: an organismic dialectical perspective. In: Handbook of self-determination Research. University of Rochester Press, Rochester, pp 3–33
36. Arya A, Chastine J, Preston J, Fowler A (2013) An international study on learning and process choices in the global game jam. Int J Game-B Learn 3:27–46
37. Guevara-Villalobos O (2011) Cultures of independent game production: examining the relationship between community and labour. In: Proceedings of the digital games research association (DiGRA) conference: think design play, September 14–17, 2011, Hilversum
38. Grace L (2016) Deciphering hackathons and game jams through play. In: Proceedings of the international conference on game jams, hackathons, and game creation events, March 13, 2016, San Francisco, CA, pp 42–45

39. Kangas M (2010) Creative and playful learning: learning through game co-creation and games in a playful learning environment. Think Skills Creat 5:1–15
40. Nicholson S (2015) A RECIPE for meaningful gamification. In: Reiners T, Wood L (eds) Gamification in education and business. Springer, Cham, pp 1–20
41. Segura EM, Waern A, Segura LM, Recio DL (2016) Playification: the physeear case. In: Proceedings of the 2016 annual symposium on computer-human interaction in play, October 16–19, 2016, Austin, pp 376–388
42. Vahlo J (2018) In gameplay: the invariant structures and varieties of the video game gameplay experience. University of Turku, Turku
43. Lieberoth A, Jensen NH, Bredahl T (2018) Selective psychological effects of nudging, gamification and rational information in converting commuters from cars to buses: a controlled field experiment. Transp Res F 55:246–261
44. Kirschner PA, Sweller J, Clark RE (2006) Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educ Psychol 41:75–86