Translational Systems Sciences 25

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Simulation and Gaming for Social Design

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Translational Systems Sciences

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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, socio-information 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 trans-disciplinary context.

More information about this series at http://www.springer.com/series/11213

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Preface

This book, which is entitled "Simulation and Gaming for Social Design," is a collection of papers that cover the various aspects of simulation and gaming (S&G) research for social design.

S&G research is an interdisciplinary field that explores methodologies for obtaining active practical knowledge using simulations and games. This research has led to the holding of the annual academic conference of the International Simulation and Gaming Association (ISAGA) beginning in 1970. Moreover, 50 years ago, Sage first published the international academic journal "Simulation & Gaming," which has established a tradition of interdisciplinary research agglomeration.

The core characteristic of S&G is "communication of models," as Richard Duke later described. Interdisciplinary communication has been the subject of research, and recently, it has been expected to become a tool for translational communication that links theoretical knowledge and action knowledge.

Herein, we would like to focus on the fact that the environment of our knowledge activities itself has changed drastically in the past 50 years. From the personal history of one of the editors, Kaneda, who was born in the 1960s, we can see the "limits to growth" of the Club of Rome in 1972, the spread of PCs in people's daily lives in the 1980s, and the proliferation of cell phones and the Internet in the 1990s. In the twenty-first century, the openness of academic information and the decline of bookstores in cities in Japan were followed by the trend of remote work during the COVID-19 pandemic in 2020, which has brought about drastic changes in the environment of knowledge activities and in the scene of our living world, thereby resulting in the appearance of layered chaos.

Games, which have always been a component of our lifeworld, provide hints for our communication on knowledge. Shouldn't the mode of S&G that is adapted to the emerging environment of knowledge activities also be considered in the context of realignment into a new lifeworld? In light of this awareness of the problem, this book shows various methodological aspects of S&G research.

Next, we would like to explain social design. In this book, social design adopts the Japanese common sense of “planning how to build society,” but it also means connecting one’s own “awareness” and “questions” to society and designing ideas and systems for that purpose. We are expected to work with diverse people in society and use our ideas and concepts to solve today’s social problems with creative thinking.

Let us give you an example. In the summer of 2020, as we prepared this publication, Japan resembled a war zone. Although some differences in circumstances between countries and regions were present, the reports of deaths from COVID-19 and heat strokes from the summer’s extreme weather caused by global warming called for restraint in our daily activities.

Regardless of whether it was COVID-19 or global warming, the problem was essentially a “macro” one with a very contemporary aspect and with increasing interdependence on a global scale. In Japan, the “macro thinking” policy model of the “hammer and dance” strategy is now demanding “micro actions,” such as the sudden encouragement of individual remote work.

We live in an age in which the global community has access to ever-changing information and knowledge through the Internet, and we make decisions about our daily activities by estimating their relevance. What is often overlooked, however, is the necessity and possibility of our active, “micro” existence. The key word of this book, “social design,” is intended to include thoughts on the creation of “active paths or circuits.”

The future of social design requires a methodology that promotes a constant exchange between the “action knowledge” of our daily lives and the “theoretical knowledge” of various social problems, including global ones.

This book has three parts reflecting its subthemes, namely, “Theory, Methodology, and Perspective,” “Sustainability,” and “Social Entrepreneurship,” which were edited by Kaneda, Kumazawa, and Hamada, respectively.

Part I (Theory, Methodology and Perspective) deals with the theories and methodologies that have been proposed in S&G research. It also focuses on perspectives that are expected to be developed in future research based on today’s social design issues.

The Research Institute for Humanity and Nature (RIHN), which is located in Kyoto, Japan, is a national research institute with a number of authors and coauthors, including one of the editors of this book, Kumazawa. Due to the interdisciplinary or transdisciplinary nature of global environmental issues, young researchers have been working on S&G in recent years, with sustainability as the unifying axis. Part II (Sustainability) is a collection of papers that attempt to position serious games and gamification as tools for the implementation of sustainability.

Part III (Social Entrepreneurship) is about designing a future society and creating future people with leadership. It is not lacking in the aspects of future vision, creative education, and spontaneity. This paper discusses S&G research for social design based on these aspects.

Part I (Theory, Methodology and Perspective), which was edited by Kaneda, focuses on theory and methodology issues for future research development on the basis of the contemporary social design issues of S&G.

Although not widely known in the English-speaking world until now, S&G theory and methodology have progressed in three ways in the past 30 years by introducing formal systems theory.

The first development is a novel gaming model representation performed by introducing the social system concept of the multi-actor system, which was referred on by Jan Klabbers in the 1990s. This gave S&G a foundation as a technique of multi-agent systems along with agent-based social simulation, game theory, and conflict analysis.

The second is the establishment of the concept of "social design" in the 2000s. "Simulation and Gaming in Social Design," which was published in Japanese by the editor in 2005, characterizes social design as an extension of problem solving to policy vision search, institutional design, and the new modes of communication in the post-normal science age. Moreover, it positions S&G as its core technique and discusses the relationship of S&G with methodologies such as soft systems methodology and policy sciences.

The third is the methodological progress of S&G, which was triggered by some international transfer issues of urban redevelopment project systems in practical urban planning in Japan in the 2010s. This development shows that the application of action research in Peter Checkland's group's soft systems methodology is the key.

Over the course of a generation, S&G continues to offer its fair share of "hot" topics.

On the basis of accumulated research on S&G, Kaneda's "Simulation and Gaming as Instrument for Social Design" (Chap. 1) focuses on the "instrumentality" of games. Considering the basic principle of gaming, perceived reality, and its shared communication, this chapter shows gaming techniques from the viewpoint of process structure and examines their proper structure. Furthermore, it shows a perspective for gaming simulation for social design in comparison with game theory, conflict analysis, and agent-based social simulations in the contemporary multi-agent system theory.

Kaneda and Kitani's "A Learning Process Analysis on Hypergame for Understanding Cognitive Conflict" (Chap. 2) aims to describe the modeling of mutual learning processes by agents. Such modeling was conducted by the authors between 1997 and 1998 to analyze a collaborative planning formation process in which several agents cooperate to devise a plan such as an international partnership. The mathematical formalizations of the first-level hypergame and the monotonic learning process are also introduced in this chapter. It then discusses the contemporary importance of this analysis method by giving a hypothetical example of an international cooperation enterprise attraction project entitled "Actual LPAH."

Chapter 3 ("Designing a Right-Conversion Game for Affordable Housing in Addis Ababa" by Hirpo and Kaneda) focuses on an inner-city issue. This chapter is a report on a gaming case study dealing with affordable housing for district improvement in kebeles in Addis Ababa, Ethiopia. Rights conversion, which is an urban redevelopment method that transfers land and building rights to a proportional space for new constructions in a project area, is expected to become an "appropriate technology" in developing countries in the twenty-first century. Playtesting has shown that this approach is an effective way to provide affordable housing; it also suggests increasing the participation of residents in the decision-making process, efficient use of land, and the creation of designs for local lifestyles.

Chapter 4 ("Games to Change Perceptions of Social Norms: What Constitutes Serious Games?" by Ohtani) is a sociological discourse analysis that determines the constituent requirements of serious games. From the viewpoint of discourse analysis, this study examines the issues around the typical definition of serious games and extracts the requirements that bear the meaning of "serious." Otani presents two aspects as constitutive requirements: "real advantage" and "recursive." Using a sample game about gender and sexuality, he states that serious games are practices that make us realize that social norms have been broken down.

"An Agent-Based Framework for E-Government Service System Design" by Chang and Deguchi (Chap. 5) is presented from the perspective of a multi-agent (actor) system established in the 2000s. This chapter views the use of the Web in government services as e-government. New perspectives and approaches are needed to capture the divergent characteristics of divergent stakeholders involved and their adaptive behaviors toward an environment. A framework for the agent-based modeling of innovation diffusion in service sciences is also proposed.

Part II discusses global environmental issues. What role do serious games and gamification (hereinafter called "game-like activities") play in ensuring the sustainability of the global environment and society? Can game-like activities lead the socioecological systems of the earth and a region to sustainability? To answer these questions, professional researchers in environmental studies, international law, and cultural anthropology introduce the examples of board games, gaming simulations, and game design placemaking produced from the perspective of the local governance of climate change and energy and resource management.

Part II was established in response to the growing awareness of serious games at the RIHN, where one of the editors works. The idea for this activity came from the question of what each RIHN research project would exhibit at the RIHN's open house to help the visitors understand the essences of their research themes or particular environmental issues. After much deliberation, a plan to design and offer serious games as participatory events equivalent to hands-on experiments in natural sciences was proposed; these games included "Fish & Chips" (Chap. 8; introduced in 2016) and the "Nexus Game" (a board game developed by Tomohiro Oh in 2017 that focuses on the energy—food nexus). These game-making efforts were the result of the pursuit of projects that would allow participants to enjoy and understand interdisciplinary issues in socioecological systems. Serious games are tools for structurally and visually understanding trade-off issues and synergies that provide clues to overcoming them, and the serious game event was the venue for this. This is what the researchers at the RIHN exploratively discovered through their experiences in the previous open houses of the institute. The chapters in this part reflect an attempt to systematize their experiences as a form of sustainable social design to come.

Chapter 6, Kumazawa's "Towards Explicating Gamification Types for Motivating Sustainability Action," aims to understand the trends that make the chapters in this part worthwhile. This chapter extends the significance of gamification to include the elements of "imaginative play," ranging from role-playing to simulation, but the discussion assumes that gamification functions as knowledge that motivates action. After analyzing original and review articles on this basis, the paper attempts to discuss the functional types of gamification that are possible in the entire sustainability domain.

Chapter 7, which is Suzuki's "The Unique Value of Gaming Simulation as a Research Method for Sustainability-Related Issues," discusses the unique value of gaming simulation in the study of sustainability issues by comparing different methods. Suzuki argues that the unique value of gaming simulation is that it encourages players to discover hypotheses and observe dynamic changes in their subjective reality by applying models that accurately represent complex issues in real-world technological, social, and environmental systems. In this case study, he implements a gaming experiment focusing on the transition from fossil fuels to renewable energy. From the results, he argues that free riding and a competitive worldview among players are two factors that hinder the energy transition in competitive markets.

Miki, Kitamura, and Fukushima's "Fish & Chips: Simulation of a Simple Problem That Is Not Easy to Solve" (Chap. 8) introduces "Fish & Chips," a serious game created to understand how to manage fishery resources in an overall sustainable manner while maintaining multiple fishing grounds. This game, which is designed by the staff of RIHN's research project "Creation and Sustainable Governance of New Commons through Formation of Integrated Local Environmental Knowledge," will be useful in discussing the effects of global climate change on local fisheries. The main reason for its usefulness is that it allows us to treat climate change as an exogenous condition for changes in fishing environments. In this sense, "Fish & Chips" contains the basic mechanism for taking global environmental issues into account.

Chapter 9, which is Kimura and Oishi's "Gaming for Arctic Sustainability," introduces the board game "The Arctic," its application, and players' responses. This game was created to deepen our understanding of the mechanisms that are driving the governance of the polar regions in the pursuit of sustainability as global warming progresses and the Arctic ice melts. Kimura, who is a specialist in international law, led the design of the mechanisms. Oishi, who is a specialist in cultural anthropology, assisted in the game design from the perspective of the indigenous societies in her field of research (the Arctic) and from the perspective of the impact of climate change on them.

Ota et al.'s "Serious Board Game Jam as an Exercise for Transdisciplinary Research" (Chap. 10) deals with the Serious Board Game Jam (SBGJ), which was held at the RIHN as a case study to examine the process of using a game jam as an exercise in transdisciplinary collaboration while providing a rubric to help organize the appeal of a serious game. Wicked problems are complex and troubling environmental and social issues that require a transdisciplinary approach. This chapter shows how providing a space for game-based learning and the co-creation of game design can contribute to social design and collaborative promotion.

In Part III, "Simulation and Gaming for Social Entrepreneurship," we discuss how to utilize S&G from the perspective of human and social design to come.

Forecasting is difficult for common people. We can address this concern using the following formula:

Present Society + Impact + Correct Response = Coming Society.

Impact is an uncontrollable and unfavorable event that considerably influences society. For instance, earthquakes are impossible to forecast and prevent. The only action that can be done is to manage the disaster in proper ways to reduce the damage.

"Impact" comes to us suddenly. The type of disaster is not defined, and preparation for such in present society seems impossible from the aspects of cost, reality, and its certainty. However, such expansion of imagination is necessary to confront new crises before the impact comes. If there is no such simulation, no one can manage the tragedy, and the situation will worsen. However, experiments at sufficiently large scales cannot be conducted. Therefore, S&G is useful and necessary for cultivating a future society. S&G is also useful for citizen drillings owing of its nature: fun to play and easy to learn.

In Part III, the editors emphasize the necessity of training S&G pillars. Simulation gaming cannot work without an adequate commander. Such personnel with leadership have sharper insights than common people; thus, they can understand the meaning of their ongoing activities. However, no black swan is present in the current world, and no one can imagine it. They might be ridiculed by common people as crying "wolf" due to their outstanding sense. The worst case is that even if simulation gaming were developed, no one would be able to operate it.

This story shows that a fundamental issue in developing simulation gaming for the future society is the parallel to grow up handler. Social entrepreneurs, i.e., those who are willing to study new games with flexible ideas for future, must be respected by common people. We must cultivate a warm environment to assist such talented people. Gaming has communication as an add-on function. Communication encouraged by gaming can bridge the gap between social entrepreneurs and common people.

In Part III, the editors included four articles meant to cultivate games and encourage their developers.

Chapter 11, which is Kunigami and Terano's "Amalgamating Agent and Gaming Simulation to Understand Social-Technical Systems," starts by discussing the basic characteristics of complex and/or complicated sociotechnical systems, which address both technical and social issues with human decision-making processes. Thereafter, the authors explain the importance of the new ways of system thinking in a human-in-the-loop manner. For this purpose, the editors propose a methodology for amalgamating agent and gaming simulation. The characteristics of the methodology are summarized as follows: (1) the systematic analyses of users' behaviors in gaming simulation, (2) machine-learning-based log analyses methods about agent simulation processes, (3) a formal description method applicable to both agent and gaming simulation models, and (4) the descriptions of practical application in sociotechnical problems.

Kaneko, Hamada, and Hiji's "Sharing Tacit Knowledge by Playing Supply Chain Collaboration Games" (Chap. 12) focuses on the invisible zone between gaming and the social system using the examples of business games. Business culture can be expressed in words, but such availability is not perfect as much tacit knowledge is hidden in a mountain of business practices. Gaming is a valuable method of enabling learners to recognize such ideas. According to the editors, one must learn the game rules first for smooth training. Thereafter, by accurately playing the game, the learner may acquire the tacit knowledge of business as an experiment. Based on a questionnaire survey of students, the editors confirmed that gaming is an effective way to learn the tacit ideas of business experientially.

Covering Oyamada, Wada, and Kitani's "Diversity of Views on Food: A Gaming Simulation to Promote Food-Related Communication," Chapter 13 is about the use of games to include relational activities among people. A citizen's behaviors are affected by others' values or beliefs. Establishing a consensus among people with varied values or beliefs is difficult but essential for keeping society safe. The authors focus on food-related communications as a symbol of difficult consensus building. They introduce a new, two-storied game to find a compromise among players. Throughout the game, role play by debates and visualization of food-related consensus in sentences.

Iwasa's "Project PAL: Development of Simulation Games for Solving Social Problems of Indigenous People" is Chap. 14. It attempts to extend simulation gaming to resolve ethnic problems. In a diverse society, the solutions of social problems are sometimes biased toward mainstream society, thereby dismissing minority groups (indigenous people). Iwasa's challenge is to find solutions that respect indigenous culture by combining diverse voices that enable consensus. To build such new opportunities for both mainstream and indigenous societies, learning and understanding the hidden knowledge and systems in society with a positive mindset is necessary by avoiding a confrontation. Therefore, she developed a simulation game called "Project PAL," which is a five-staged game including role play, case study, and problem solving by drawing pictures and making stories. The results lead to social designs for the future.

The authors of this book have backgrounds in urban planning, architecture, sociology, systems science, environmental studies, international law, ethics, physics, cultural anthropology, energy engineering, information science, mechanical engineering, and pedagogy. Their highly diverse interdisciplinary/transdisciplinary nature accords with the academic tradition of S&G.

Richard Duke discussed S&G as a mode of communication for dealing with complex problem situations in "Gestalts" in 1973. However, the editors aim to show through this book that S&G is a social design technique that deals with the circulation between theoretical knowledge and action knowledge. Therefore, this book is published in the Translational Systems Science series.

Editors Kaneda and Hamada published the post proceedings of ISAGA in 2015 and 2018 from this series. We aim to transmit some of the academic gems of our S&G research from Japan by publishing this book in the form of a monograph. We asked young researchers to write these chapters to ensure that the book covers various cutting-edge topics. Consequently, other than following the tradition of S&G research, we are conscious of the simultaneity of the complex and evolving environment of the field of digital knowledge. This form is expected to resonate with a diverse generation of readers.

The novel coronavirus has raised the issue of how knowledge should be communicated among generations. As an epidemiological characteristic of the coronavirus, a large difference is present in the risk of severe disease among age groups. Combined with a drastic change in the information environment, this characteristic highlights the importance of intergenerational communication in society. We think this is another direction in which S&G research is moving.

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Part I
Simulation and Gaming for Social Design: Theory, Methodology and Perspective

Chapter 1
Simulation and Gaming as Instrument for Social Design

Toshiyuki Kaneda

Abstract In gaming, games can be treated as instruments implicitly. However, due to the ambiguous nature of the notions of "game" and "gaming," the academic current of simulation and gaming studies, which has come out within the last 50 years, displays truly extensive and ambiguous polymorphism.

In this chapter, titled "Simulation and Gaming as Tools for Social Design," the author describes the characteristics of problem-solving oriented simulation and gaming, mainly with our social design in the twenty-first century in mind, going back to Richard Duke's arguments of the Gestalt communication. The author also explains the common process structure of gaming techniques. Moreover, also describes gaming as a scientific method, and looks at gaming simulation for social design through comparison with game theory, conflict analysis, and agent-based social simulation, which are operational models of multi-agent systems.

1.1 Introduction

Gaming means "playing a game," which implies treating the game as an implicit instrument. The ambiguous definition of the notion of a "game" is a common topic of discussion in the field of analytical philosophy. While the focus has shifted away from both gaming as a technique and its utility, it has great variety due to varying degrees of instrumentality. Possibly, for this reason, the academic current of simulation and gaming studies, which have emerged within the last 50 years, displays truly extensive and ambiguous variety. In this chapter, simulation and gaming are observed as instruments for social design.

Considering social design as we know it in the twenty-first century, the basic principles of simulation and gaming, especially those directed at problem solving, are described. Also, perceived reality and its shared communication as basic principles are reviewed. Besides, an effort is made to organize gaming techniques from the

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process structure point of view together with a thorough investigation into the peculiar structures of these techniques. Further, perspectives on gaming-simulation for social design are reviewed through studying the relationship between gaming and the traditional scientific method, along with the mutual comparison among game theory, conflict analysis, and agent-based social simulation (ABSS) in contemporary multi-agent systems theory.

The Japanese version of this chapter, titled "Shakai Dezain no Shimureishon to Gemingu (Simulation and Gaming for Social Design)" was published by Kyoritsu Shuppan in 2005. The following sections are a translation of a revised and improved version of the first chapter, which was originally titled "Simulation, Gaming and Social Design."

1.2 Gaming as Instrument

1.2.1 Gestalt Communication

Richard Duke's "Gaming: The Future's Language," published in 1974, outlines the basic principle of gaming as a problem-solving technique (Duke 1974).

Quoting the position of philosopher R. F. Rhyne (1972), Duke argues that one such principle is "to stimulate exploration of the means whereby appreciation of complex wholes may be more quickly and more reliably told to others." Rhyne's position can be summarized in today's world due to the complex interconnectedness of multiple issues, the objects of investigative action among decision makers, and those that help in decision-making can only become more vast and complicated. The methods of knowledge that are required today are those that provide an understanding of the whole, rather than minor details. This is the same for citizens, leaders of the industry, government, and researchers. Traditional empirical methods make it difficult to gain a deep understanding of issues, primarily because of time constraints. Therefore, a novel approach is necessary. Even today, many situations are observed in which the whole cannot be understood if not through aggregation work, such as city censuses.

In this regard, Duke presents a new mode of communication, so-called "multilogue," along with new means for such communication, which he calls "future's language." He includes gaming and simulation in the category of future language, along with maps, videos, 3D models, flowcharts, and operations analysis rooms.

Actual problem situations stem from composite realities. If we take the present condition of metropolitan areas as an example, we will find complex systems within complex systems, and option after option, which leads to a situation that blocks our view and goes beyond our understanding capacity. Whether or not such an environment is difficult to manage, it definitely is complex to an extent that it needs to be managed from various points of view. As a result, people gain a "perceived reality" that is different for every individual, and in order to communicate this reality they need to structure it into concepts. However, the way this structure is formed may vary from person to person. For instance, let us imagine asking a sociologist, an economist, a geographer, a policy scientist, an engineer, and an urban planning specialist for their opinions on the issues that a large city faces over time. The way each of them expresses their views, the major points will most likely vary broadly according to their specialization. The reason is although there is actually only one reality, there are multiple different ways to represent it based on nonidentical perceptions and structures.

When people participate in gaming-simulations that have been appropriately "modeled" on actual problem situations, their perceived realities are intentionally combined at the debriefing stage. Through this process, participants are able to share a closer "Gestalt" as it relates to the problem situation. Duke calls this kind of communication "gestalt communication," and presents gaming techniques as tools that stimulate the multilogue with this function. The "future's language" mentioned by him in the book's subtitle can be interpreted as the language that holds this intention.

1.2.2 Why Now Gaming in Contemporary Information Society?

What then can we demand from gaming considering problem situations in twenty-first-century society from the perspective of social design? The answer is outlined in the six points as follows:

1.2.2.1 A Technique to Understand and Share a Complex Reality as a Whole

In contemporary society, to recognize specific problems, it is essential to understand the problem situations as a whole and to communicate among concerned parties. However, actual problem situations stem from complex realities and might be impossible for people to understand or express at some times. Gaming is a promising instrument to stimulate the gestalt communication required to understand the whole, as has been mentioned by Duke. Visions of the future and "composition" can also be included among the types of realities to be pursued.

Today, the use of a wide variety of digital data such as behavior sensing data has been made available and as new aspects of reality in social systems and urban spaces grow we could probably state that a System of Systems is emerging. However, the situation in which we find ourselves—confronted with a messy reality—has not essentially changed from that of the fields within fields argued by Rhyne.

1.2.2.2 Potential of Gaming Models to Flexibly Convey Reality

By taking advantage of the diversity of "games" that gaming can handle and the flexibility of model representation, it is possible to pursue model representations of problem situations that are desired in problem solving but cannot be adequately described by conventional abstract models that are overly conscious of universality. If the "aim" is well defined, the gaming model is appropriately prepared, and the gaming is conducted in the "context" of the problem situation, then the attempt will be very effective in solving the problem. However, models that are specific to a problem situation often have a significantly narrower scope of application when compared to abstract models. Therefore, in order to use gaming techniques for problem solving, a detailed check of the "problem situation," "context," and "aim" is required. This means that gaming techniques need to be positioned from a broader perspective.

1.2.2.3 Experience-Based Participation Tools—Healthy Relationship Between Civic Values and Social Design Practices

A wealth of prior research works demonstrate that gaming techniques are powerful dialogue tools to stimulate communication through the sharing of simulated experiences. In addition, when sufficiently developed and applied, gaming may turn to be a productive tool for positive participation in public design in the fields of civil society as well. For instance, with a design game aimed at resident participation, it would be both necessary and possible to create a "barrier-free" design that treats everybody—young or old, male or female, abled or disabled—equally.

Arai (1988) calls this a healthy relationship between education and research. In recent years, progress in the practical application of gaming has been accompanied by a tendency to develop a code of practice that relies on the "morality" of group actions and the "spontaneity" of participants.

1.2.2.4 Reality Composition in Information Society Design

Nowadays, as the Internet and other such information technologies continue to progress, active members of society are confronted with an information environment that did not exist in the past. Most likely, this information environment will continue to change in the future. This has a significant influence on the way people organize reality as it relates to actual society. Having this in mind, designing an information environment can be a central issue in social design today.

It is important to point out here that model design is essential in designing the desired information environment, and for this reason, the approach of bringing in existing games as models of information environments has been used in social networking sites, for example, with the motivation of introducing user-friendly interfaces. This is even the "new normal" that continues to evolve through the explosive spread of SNS in recent years.

1.2.2.5 A Model Representation Form as Multi-Agent System

There are several known operational model forms with multi-agent system that are expected problem-solving techniques for dealing with social problem situations, and gaming technique is one of them. In general system theory, multi-agent system is a system of interaction among multiple decision-making agents. In Sect. 1.5, in addition to gaming-simulation models, game theory models, conflict analysis models, and ABSS models are discussed as model representation forms of the multi-agent system. All of these research fields have been developing in recent years and their interchange with simulation and gaming studies is growing as well. Another popular trend is constituted by rigorous attempts to combine gaming techniques with other existing techniques.

1.2.2.6 Contribution for Social Design Science

When not only gaming models but also multi-agent operational models are used for problem solving, a way of approaching social design that uses these models efficiently and effectively according to the aim and situation, in other words, the social design science becomes significant. Under this science, it is desirable that gaming techniques and other problem-solving techniques using multi-agent models be positioned appropriately.

1.2.3 Three Directions of Gaming for Enhancing Instrumentality

Since it relates to simulation and gaming for social design, in this chapter, the aims of gaming techniques are presented in the following three categories, focusing on the directionality intended by the organizers.

- Those oriented to the composition of the target problem situation and the search for solutions to the problem situation.
- Those oriented to the generation of theoretical models or the scientific testing of hypothetical models.

Those oriented toward providing learning opportunities for participants, i.e., knowledge and skill acquisition and experiences sharing.

Other directions such as mere transmission of messages or pursuit of pleasure may also exist, but they are beyond the scope of this chapter.

Hereafter, the three above-mentioned directions will be referred to as "Problem Solving Oriented," "Scientific Theory Oriented," and "Learning Opportunity Oriented," respectively. Assuming that there are "aims" that are shared by two or more of these directions, these can be represented as a three-sets Venn diagram. For example, some "aims" may be present in the Problem Solving Oriented and the Learning Opportunity Oriented, or absent from Problem Solving Oriented and Scientific Theory Oriented. Gaming is thus classified according to its "aims." This interconnection is shown in Fig. 1.1 along with specific examples of each theme. The majority of the simulation and gaming for social design that is discussed within this chapter belongs to the Problem Solving Oriented category. However, there might be cases that do not fit clearly within any single direction, and we do not have to exclude ambiguous cases from their problem awareness, as will be addressed below.

Rather, regardless of the specific "aim," what current researchers are emphasizing is the common effect of gaming on "manipulative and experiential understanding of models" and "communication of models." In understanding large, complex, and incomprehensible models, people not only look at them from various angles but also recreate or deconstruct them. In the case of gaming, one can "immerse" oneself in a game that represents the model and experience it. Such manipulations and experiences form an internalized reality for each participant, and by encouraging their interplay in discussions among participants, the understanding of the model in question can be shared among many people. It is mainly due to these effects that gaming simulations can be useful in exploring social design and problem solving.

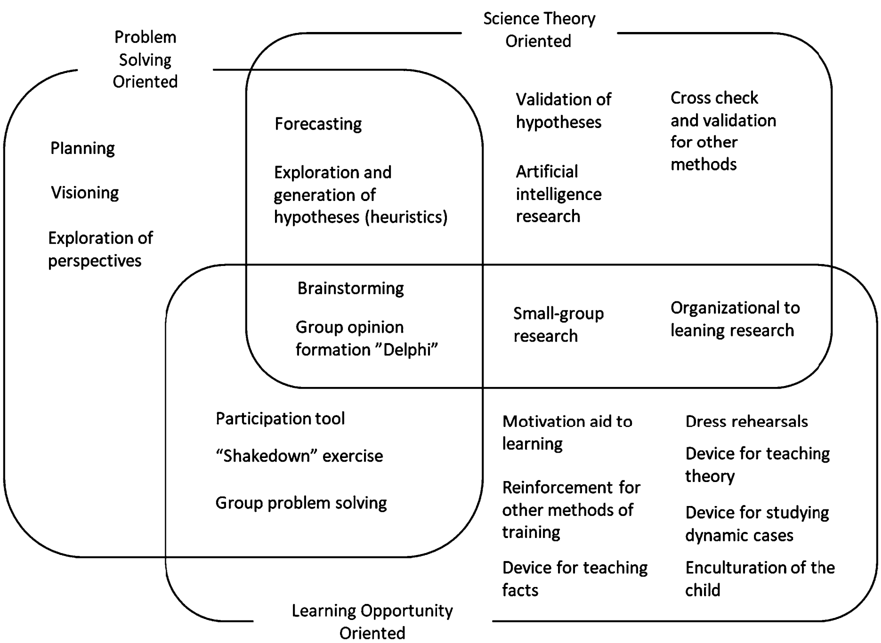

Fig. 1.1 Directions of gaming techniques

1.2.4 Competition and Role-Playing: Two Typical Society Models in Gaming

In gaming for social design, a game can be considered as models of society. The variety of games stem from a high degree of freedom in model representation. Here, an explanation will be given for two different types of society models that can be featured in gaming, concentrating on competition and role-play responding to the player's actions.

1.2.4.1 Competition Society Model

This society model takes the form of a setting in which players are explicitly given goal functions (goals) and constraints on their behaviors (rules). It is a model to which the metaphor of a competitive situation, i.e., rules in a sports competition, applies, and is the first thing many readers associate with the word "game." The zero-sum game theory model is one of the purest forms of a competition society model. This society model is characterized by the fact that each player is expected to behave competitively under the given rules of the game, independent of the "context" of the problem situation. Thus, the "thinking" of players in this society model is detached from the real problem situation that constitutes the target of the model.

1.2.4.2 Role-Playing Society Model

On the other hand, a role-playing society model is as follows. First, a role is given for each of the participants in the form of words and symbols. From the information presented, each evokes his or her internalized role norms and interprets his or her role during gaming. After that, the participant recognizes a given situation and performs the role action under it. At this time, the participant depends on the "context" for action selection, as mentioned above. It is important to note that unlike the competition society model, the existence of norms, interpretations, and cognitions characterizes the behavior of players in this society model.

In some of these society models, the role actions of each agent are periodically mutually evaluated among the others. In other words, the agents carry out their roles by referring to the evaluation information of other agents. On the other hand, each agent presents to the others the results of its evaluation of its role-playing behavior in light of the norms of the expected roles that it has formed and has internalized under the circumstances it has recognized in gaming.

This kind of mutual evaluation mechanism is one typical case of this role-playing society model. Since the mutual evaluation mechanism generates "mutual control" among agents, this mechanism acts as a coordination principle. Obata's (1992) waste treatment gaming is a positive example of this mechanism.

1.3 Common Process Structure in Gaming Techniques

1.3.1 Process Structure

Here, we will call gaming with instrumentality a gaming technique. In general, techniques and methodologies should be characterized by their process structure. Although there are a wide variety of actual gaming techniques, the author would like to explain gaming techniques formally by showing the following process structure.

Process 0: The following Processes, *1* to *5*, will be implemented to aim for beneficial effects such as exploring solutions appropriate to the problem situation or some knowledge related to social design. These processes are pre-designed to operate under a certain aim and "context."

Process 1: Before the implementation of gaming, a "game" should be prepared. This game is a representation of a "model" that in some way simulates a (social) problem situation. The model and the game may be newly created for this purpose, or they may be adapted or modified from what already exists.

Process 2: At the time of gaming, the players choose their actions while following the "rules" of the game. The state of the game progresses as an accumulation of the mutual actions of the players. However, the actions chosen by the players are influenced not only by the game rules but also by the "context" in which they find themselves.

Process 3: Through the experience of gaming, each player acquires a "reality" on the model from his/her point of view. In addition, people observing their gaming play acquire a "reality" on the model as well.

Process 4: Each participant (including players and observers) should have a reality on the problem situation from before the gaming. In the post-event "debriefing," participants compare the reality on the model described in *Process 3* with the reality they originally had about the problem situation.

Process 5: In "debriefing," participants intersect their own "realities on the model" and the "realities on the targeted problem situation" in order to explore a comprehensive reality that can be shared.

An illustrating example of this process structure is BARNGA (Thiagarajan and Thiagarajan 2011). The organizer sets the aim (*Process 0*) and designs a card game with a seed to be revealed at the end (*Process 1*). The participants engage in the game, genuinely believing that the intent of the game is the playing card competition itself (*Process 2*). However, an unexpected turn of events leads them to start thinking about the meaning of this gaming. Through gaming, the participants acquire some kind of impressions (*Process 3*). Someone begins to say that this experience is somewhat similar to a cross-cultural situation. Everyone recalls their own impressions of the experience and compares them with the impressions of the gaming experience (*Process 4*). This is indeed very similar among the participants and they may discuss as such with each other. Through this discussion, participants understand the implications of BARNGA (*Process 5*).

Further, Policy Exercise introduced by Toth in the 1980s can also be interpreted through the lens of this process structure (Toth 1988). The organizer prepares a fictional game with a system model that structurally imitates the problem situation, and invites stakeholders to participate in a "structured dialogue" between them about the problem situation through some kind of reality sharing. It should be noted that Policy Exercise also follows the process structure of *Processes 0* through *5*. However, in Policy Exercises, the model needs to be abstract and the game needs to be intentionally made unrelated to the real problem situation in order to avoid the recurrence of straightforward conflicts of interest among them during gaming.

1.3.2 Dealing with Reality

As explained above, "reality" plays a vital role in gaming techniques. Here, reality is defined as "an image of experienced and perceived reality." In a certain sense, gaming techniques are nothing other than the derivation of insights or findings by participants via comparisons among each own internal realities as well as the realities of other participants. Whether by experiment, operational understanding, or by communication of the model, in any case, these techniques appear as manners to mediate reality.

In the above explanation of the process structure, the "reality of the model" and the "reality of the problem situation" have been presented as two different types of reality. Let us explain both using the example of BARNGA. The first reality is the impression of being tricked in the card game experienced by participants. The second reality refers to the past personal experience impressions of individual participants in cross-cultural business situations. BARNGA takes on the meaning when each of the participants connects these two realities inside him or her.

Process 1 and *Process 4* are conversion processes that are essential to preserving compatibility between the "reality of the model" and the "reality of the problem situation." *Process 1* is a forward conversion by organizers and designers moving from the "reality of the problem situation" to the "reality of the model." In contrast, *Process 4* is an inverse conversion by participants, moving from the "reality of the model" to the "reality of the problem situation." These two processes correspond to the encoding and decoding that occur in communication theory.

Further, variance in gaming techniques can be considered through a reinterpretation and simplification of part of this process structure. The assisted negotiation proposed by Susskind et al. (1999a, b) and known as support techniques for environmental conflict resolution are not generally referred to as gaming techniques but can be interpreted as such. Assisted negotiation is a scheme whereby stakeholders concerned with a problem situation are made to experience "experimental new rules," in an attempt to stimulate substantial agreement among concerned parties through high-quality content of mutual actions that are thereby produced. This can be identified as an example of replacing the reality of the model with the powerful reality acquired through a social experiment (introduction of rules). In this case, it is essential for each concerned stakeholder to hold a reality and it is not necessary to combine the realities of concerned stakeholders afterward. Therefore, *Process 5* of the process structure is omitted. Besides, in relationship building workshops (e. g., Elliott 1999) it may be necessary to define the meaning of games and models more ambiguously. Still, these can certainly be seen as cases of variance in gaming techniques.

Incidentally, we should not forget that the game itself provides a special kind of reality to the life world. For example, we need to take into account the fact that the word "game" may conjure up images of the realities of sports, play, and gambling. This may be a merit or a demerit. For instance, when addressing a problem situation that requires a serious attitude, the adoption of a game that is interpreted as "playful" would clearly have an adverse effect. On the contrary, strategies with precise "aims" may be efficacious. These outcomes are closely connected to the "context" such as the time and place of gaming, the theme, the aim, and so on.

1.3.3 Is Gaming a Mapping or a Metaphor?

As for "model," some people may think of this word as a kind of formal theory that produces rigorous science. Here, the model, which is also called a "gaming model" in this chapter, relies basically on the concept of system model in system theory established in the mid-twentieth century. In such models, the description of the problem situation can be comprehended as "one system" and the writing of the model can be understood as "another system." Under such a premise, the concept of homomorphism in system theory becomes key for a set of mapping relationships between the components and internal structure of the two systems, the problem situation, and the model. Hence, the system model can be referred to as "model as a mapping." In the system model, the mapping relationships between the problem situation and model can be condensed analytically through a point-by-point examination. Through this operation, consistency between the "reality of the model" and the "reality of the problem situation" yielded through gaming is ensured by logically connecting the two.

Simulation is formed according to this explanation of system model. In simulations, the "reality from the present to the future" yielded through the simulation is superimposed on the "reality from the past to the present" of the problem situation. In other words, the reality gained as a result of the simulation is regarded as an extension of the reality of the present situation. This type of operation is called "extrapolation." Through such operations, insights and future visions supported by reality, the composition made up of various elements, or something that is missing is sought.

The credibility of the interconnection of consistency between the two realities depends on the consistency between the problem situation and the model. Hence, what simulation refinement heads for is an introduction to scientific theory.

Gaming-simulation is a technique that features the characteristics of both gaming and simulation. Gaming-simulation also attempts a “composition” of various aspects of reality by all participants through combining the realities each had yielded during gaming at the debriefing stage. Gaming wherein the theme has to do with future visions can also include operations whereby this composite reality is superimposed with the reality of the problem situation. In social design gaming featuring this kind of simulation, the introduction of system models with multi-agent is extremely significant.

Regarding that, the model can also be comprehended as a type of “metaphor” of the problem situation. Here, metaphor is defined as an expression aimed at calling attention to a hidden property of the object by using words that hint at something unanticipated. In the case of gaming techniques, a metaphor is something that calls attention to the hidden peculiarities of the problem situation via gaming experience, which presents a simple but surprising model. For instance, in BARNGA the act of playing a game of cards without speaking is used as a metaphor for business situations. In this case, the “card game” can be considered as a model for “business situations.”

Now, let us observe the changes in the mental images of participants after encountering the metaphor. As soon as an impression of the model is gained through the experience of gaming, it is rapidly connected to one of the various aspects of reality held by participants about the world of their daily lives. This might produce a hearty laugh or a feeling of surprise. “A is like B”—the speed and surprise of this connection are the sources of the metaphor’s efficacy.

In this sense, the “model as a metaphor” is considerably different from the “model as a mapping.” In this model, although a connection is comprehended to exist between the model and problem situation, there is no meaning to be found by considering each as a system and carefully examining the mapping relationships among its components. It is enough, at least, for a matching to exist between a part of the reality of the model and a part of the reality of the situation in the eyes of the participants. Homomorphism between the model and the problem situation is not necessary. Instead, the “model as a metaphor” is meant to scheme participants’ intuitive recall of realities applicable to the “context” of the field of gaming. The above-mentioned BARNGA is a gaming using metaphors, although it cannot be called a simulation per se. The “model as a metaphor” exemplified by BARNGA needs to properly apply the “aim” and “context.” This means that such a model cannot essentially be detached from its context.

Now, the question would be “Is the model a mapping or a metaphor?” Investigations into gaming models by simulation and gaming researchers have certainly been marred by this polarized way of thinking. Here, I would like to share my own views on the matter with social design concept in mind. First, as for the relationship with the real problem situation, one of the necessary conditions required by gaming models is system models. This is particularly effective in cases characterized by a large scale. However, when attempting to compose a real problem situation into a model or game, the challenge would be producing something hard for participants to understand, either in the operation process or at the stage of gaming. While modeling, reality may unintentionally be distorted. To avoid this situation, it is necessary to simultaneously apply techniques using a bold metaphor that evokes the "holistic essence" of things in the real experience.

1.3.4 Importance of Contexts

Some readers may have noticed that in the above-mentioned process structure there is a discrepancy in the meaning of the context used in *Process 0* and the context used in *Process 2*. In fact, the context in *Process 0* is the context in which the problem solver plans to gaming, or in other words, the problem situation itself, while the context in *Process 2* is the context in which the player considers his or her own behavior during the gaming.

The former discussion of context is linked to the discussion of the validity of the implementation of gaming techniques for problem situations. This is because the implementation validity of gaming should be discussed in terms of the fit among the problem situation, the aim of gaming, and its implementation. However, this is related to the content rather than the form. In gaming practices, context and background are used about the circumstances of specific fields. In a few chapters of my previous book (Kaneda 2005), I have discussed the concepts of negotiations, conflicts, disputes, social organization, community development, and environmental policy formation as well as various aspects of gaming exercises and their background, i.e., "context."

Next, the context in the *Process 2* will be discussed. This relates to whether the game is a competition or a role-play. Let us imagine a game in which players are given only role norms and behave in their roles according to these norms. In other words, players are required to role-play. In this case, when choosing how to act within the game, human beings will probably bring some implicit "context"—aside from the provided rules—into their behavior. Human players may choose how to act by calling to mind real situations that they link with the gaming situation.

Provided this example, while action choices in competitive situations are independent of context, action choices in role-play situations are characterized by their extent of dependence on the context. Further, context dependency is a desirable characteristic in gaming-simulation. This is because context dependency is an important contributing factor to gaming-simulation, which establishes the ability to address a variety of interpretations by participants as well as the manipulation of abstractness on symbols as the model elements by the organizers.

Is the game a competition or a role-play? In other words, are players called for making decisions independently or depending on the context? This hinges on the design principles of the gaming model. At this point, gaming techniques can allow for great freedom and flexibility.

1.3.5 Prototyping

How shall we design a gaming model that represents a problem situation? Below is an explanation of the method known as "prototyping."

The answer to the above question is to first create a gaming model, then implement and gradually improve the game while establishing "aims" through communication among organizers, designers, and participants, and finally grow closer to social design and problem solving as a result. The approach of realizing games with partially incomplete forms, ambiguous models, or undifferentiated "aims" is referred to here as "prototyping." A prototype is created and improved with version updates so as to be more and more effective according to the "aim" of the gaming. Throughout this process, it is vital to make incremental improvements that are sufficient to the "growing degree of depth" of the reality addressed by designers and participants.

In prototyping, the aphorism of the "Procrustean bed" is used with a nuance of self-admonishment, referring to the problem situation being forced to fit within an established model of understanding. As this form of prototyping takes root, Piaget's structuralism, which recognizes targets as undifferentiated elements and develops successive distinctions of these elements, becomes significant. Besides, in the improvement of Problem Solving Orientated gaming models, it is essential to instead plan both prototype and version updates in accordance with the depth of reality awareness reached by designers and participants.

1.4 Gaming as Scientific Method

1.4.1 Is Gaming an Empirical Science?

This section contains a brief discussion of the interconnection between gaming and the traditional scientific method in the form of questions and answers. The first question is whether the whole-system behaviors observed as a result of gaming can be considered valid as an empirical science. To answer this question, a prior explanation of gaming as a science by system theorist, Russell L. Ackoff (1962), is introduced below.

Ackoff divides this question into two parts: the validity of gaming models and gaming design, and the validity of making inferences about the problem situation based on the results of gaming.

As for the first part, according to him, "Gaming is essentially experimentation in which the behavior of decision makers is observed under controlled conditions. It differs from most psychological and social experimentation only in that the conditions under which the "play" is observed represent some situation outside the laboratory about which knowledge is sought. The experimental situation, then, is deliberately constructed as an iconic or analog model [a homomorphic or isomorphic model] of a type of situation of interest." Further, "In cases where a completely specified course of action or decision procedure cannot be derived from a model, but a partially specified action or procedure can, the effect of the action or procedure may be determined by gaming."

As for the second issue, "The fundamental weakness of current gaming is being incapable to draw strong inferences from the play of the game to decisions in the situations that the game models." This is specifically due to "the inferences that are drawn are weakened by the complexity of the game. A model, whether an equation or a game, is always a simplification of reality, and for this reason only it is useful in science. It is vital, however, to understand the nature and significance of the simplification because only then can we justify inferring from the model to reality."

However, "The more aspects of reality are represented in a game, the more difficult it becomes to analyze its structure, i.e., to represent it by a mathematical model. On the other hand, unless enough of the relevant aspects of reality are included it cannot be an adequate model of reality. The gradation between excessive simplicity and complexity can be attained only by experimenting with the game itself." Ackoff concludes that "[Gaming] has been used primarily where large complex systems are involved, systems where structures are not thoroughly understood. Under such situations, the principal use of gaming is the exploration of structural relationships. Results obtained from the game should be treated as suggestions or hypotheses which should be more rigorously tested." Further, "Gaming should not be considered as a substitute for analytic model construction. On the contrary, it should be viewed as a way of obtaining information that can be used to generate models where analysis of or experimentation on the "real" situation is impractical or impossible."

Today, gaming can be regarded as a means to gain useful "heuristics." For instance, when hypothetical models of future environments and states of emergency need to be "extrapolatively" constructed from the expertise of environmental scientists and disaster prevention scientists, or when a comprehensive investigation into social issues is not progressing sufficiently as new and complex problems arise.

In summary, the utilization of gaming as an instrument for empirical science is a means to test hypotheses based on other experiences or theories, which is both possible and practical. However, the most significant characteristic of gaming is not being a means to test simplified hypotheses, but rather to structurally investigate complex realities. When applied to large-scale complex targets, gaming is effective in allowing participants to heuristically obtain previously "unimaginable scenarios," "verifiable hypotheses to pursue," and a "narrowing of the elements eligible for composition." To a certain extent, gaming can be appropriately positioned as an instrument for social design science as is the theme of this chapter. Going forward, gaming combines the aims of not only the scientific theory oriented but also the problem-solving oriented and the learning opportunity oriented, which may lead to greatly significant practical applications.

1.4.2 Does Gaming Rely on Game Theory?

The next question is whether gaming has its foundation in game theory. The research of Harvard Negotiation Project scholars (Fisher et al. 2011) and the succeeding current of negotiation gaming can be cited as examples of models relying on game theory as their foundation. However, many other examples of gaming that by far surpass them do not rely on game theory.

In addition, gaming has historically been studied since well before game theory. Within the scope of simulation and gaming studies except for the activity of researchers such as Shubik (e.g., Shubik 1975), the connection with game theory is not particularly strong when compared to other fields of study. Given the mathematical space in which models can be described, the space of "playable" gaming models is large, including the space of game theoretic models. In the early days of game theory, there were attempts to experiment with actual human players in model situations such as the prisoner's dilemma. Some of these experiments were conducted to find solutions to social problems, while others were conducted by game theory researchers to explore theoretical developments.

In addition, among the aforementioned types of the society models, it may be possible to introduce game theory as the basis for the competition society models. On the other hand, some of the role-playing society models do not have explicit preferences or utilities as rules of the game, and it is not possible to introduce such models as found in game theory.

1.4.3 Testing the Validity of Gaming

In the field of econometrics, there are formal procedures to verify the validity of a built model. However, gaming-simulation models undergo no such procedures. Here, the question is, how shall we test the validity of gaming? This section discusses this question and possible answers by dividing it into two parts: the formal validity of gaming models, and the implementation validity of gaming.

As it relates to the formal validity of gaming models, the first condition these models must fulfill is to borrow a term from the mathematical system theory and homomorphism in relation to the target reality as discussed earlier.

Second, the author thinks that the modeling approach for large-scale systems that leads to this formal validity should be a constructive approach (model analysis by model synthesis). Constructive modeling here means to construct a model of a large and complex object by combining partial models whose properties are already clear, and then comparing the behavior of this model with that of the object. While constructing an artificial social model, we can deepen our understanding of the social system by comparing the behavior of the social model with that of the real world. This approach is the basis for the prototyping already mentioned.

In a broad sense, the constructive approach satisfies the condition of falsifiability. In other words, the appearance of the same behaviors at one time is not enough to immediately regard the model as correct. Moreover, if the constructed model behaves differently from the target system, that model is rejected. When a model is rejected, we try again by changing the partial model or, in some cases, by recombining the partial models. This process has an important meaning. One model that has not been rejected should be constructed, and if more than one model is possible, the models should be narrowed down by using various supporting evidence.

As for the implementation validity of gaming, this is an issue that involves the entire gaming application effort including the setting of gaming models and contexts. Therefore, the validity of gaming must be tested while accounting for the existence of context dependence and intersubjectivity. In addition, as emphasized in *Process 4* above, in the problem-solving-oriented gaming, a fitting relationship between the reality of the problem situation that participants have and the reality they get from the gaming experience should be emphasized. Therefore, one of the criteria for validity evaluation is how to appropriately provide the participants with materials (environment) to reconstruct the reality of the target problem situation or problem structure. In this way, unlike the concept of formal validity of a model, this validity should be judged by people who are deeply familiar with the real problem situation and problem structure, and who mix their subjectivity in the debriefing session after participating in the gaming.

1.5 Gaming Model as Multi-Agent System

Various system concepts have continued to play crucial roles in simulation and gaming studies since the 1950s. In recent years, research on a system theory of multi-agent system as a system underlying Gaming Simulation Models and Multi-Agent Social Simulation Model has made significant progress (e.g., Kaneda and Kitani 1994, 1995, 1996, 1997, 1998; Kaneda 1999, 2005, 2007, 2012). Nowadays, multi-agent system concept has attracted attention as the common form for model representation of social situations. In this section, gaming techniques are positioned as model representation forms of multi-agent systems within the problem-solving techniques, and their characteristics are compared.

Furthermore, the introduction of the concept of multi-agent system was one of the directions in the refinement of gaming model. The hybrid to the other problem-solving techniques with the multi-agent models that feature forms of models is also connected to new possibilities in gaming.

1.5.1 Multi-Agent System as Complex System

Multi-agent system is also known as "complex system that includes agents." This means that macro-phenomena of the whole system emerge via the accumulation of mutual actions by individual agents. Four characteristics of a multi-agent system as complex system are outlined below.

1.5.1.1 System of Medium Number

Medium number systems indicate the domain of numbers that are not covered by either mathematical analysis, which studies heterogeneous specimens of small numbers or statistical analysis, which studies homogeneous specimens of large numbers. The mathematical analysis used in traditional science can only study two to several agents, primarily due to limitations in the computational complexity. Statistical analysis, on the other hand, leads to the abstraction of agent individuality and the considerable simplification of interaction among agents. In medium number systems, which exist in the gap between these two domains, substantial changes, irregularities, and discrepancies with all theories often occur regularly. According to complex system scientist John Casti (1996), the domain of medium number systems should be studied as a system and simulation should be actively used to that end.

1.5.1.2 Local Information, Bounded Rationality, and Adaptation Function in Decision-Making

In contemporary society, nobody has all the information. On the contrary, each agent cannot directly know the thoughts or actions of other agents, and normally bases their decision-making on limited local information. Decision-making situations like those of drivers in a traffic jam or traders on the stock market are in fact a daily occurrence. Local information is one of the characteristics of social situations as multi-agent system. In turn, local information is one of the sources of bounded rationality in an agent's decision-making.

In addition to bounded rationality, the function of adapting to one's environment is sometimes assumed in models of decision-making agents in multi-agent systems. An example is the study of the classifier system implemented for the El Farol problem presented by economist Brian Authur. Casti called multi-agent systems that fulfill this assumption "complex adaptive systems." In regards to multi-agent systems, many theorists insist on the emergence of macro-phenomena of the whole system via agents' micro-behaviors with both bounded rationality and intellectual adaptation functions.

1.5.1.3 Contingency

Let us consider a decision-making agent who decides what action to take based on rules expressed with the situation-action pair. At this time, their decision-making will be contingent on the situation in the sense that their decisions will be made in response to the situation. This type of situation-dependence is called "contingency." For instance, if given the situation of agent X, agent Y takes action on this situation and the subsequent action of agent X will be contingent on the action of agent Y. The uncertainty that agent X faces with such a contingency is a considerably different concept than the uncertainty due to noise as explained in probability distribution including models of natural phenomena.

In addition, if the actions of agent Y were also contingent on the actions of agent X, none of the agents would be able to choose their actions spontaneously. In social systems theory, such a situation is called "double contingency" and the introduction of social roles is explained as a way to reduce this kind of uncertainty.

1.5.1.4 Micro–Macro Linkage

As discussed earlier, a necessary condition of multi-agent system is causation from micro to macro. However, multi-agent system can also be considered as established by causation from macro to micro. For example, the El Farol Bar problem fits within this pattern. In an information society, individual agents are flooded with information about the entire societal situation and are strongly influenced by such information in their decision-making. In this sense, the interconnectedness of micro and macro is a common characteristic of multi-agent system as a complex system.

1.5.2 Operational Models with Multi-Agent System for Social Design

With problem-solving techniques that deal with multi-agent systems in mind, the following four models are addressed, overviewed, and compared:

- Game Theory Model
- Conflict Analysis Model
- Agent-Based Social Simulation (ABSS) Model
- Gaming-Simulation Model

The first criterion for comparative arrangement is the difference in the implementation form of the model—mathematical formula, computer algorithm, or flesh and blood human—and the second criterion is the ability of the model form of the multi-subject system to depict the reality of the problem situation.

1.5.2.1 Game Theory Model

The category of game theory model primarily focuses on the game theory founded in the 1940s by John von Neumann and Oskar Morgenstern. A typical example of this model description of multi-agent system is the zero-sum game theory as the standard version. This theory features three main components:

(1) A game with a simple mathematical structure, featuring "player set," "strategy set," and "payoff functions."
(2) Players' decision-making principles are expressed by a formula known as the "Maximin principle."
(3) Equilibrium solutions for the whole system, derived logically by premises (1) and (2).

Here, (2) is the agents' decision-making model, and (1) is the rule that regulates their interactions. Therefore, noncooperative zero-sum games are a model of multi-agent system.

Characteristic of the game theory is the concept of (3) equilibrium solutions. A wealth of examples of this can be produced via on-paper calculations with the logical stringency that is the foundation of utility theory. Game theory provides the opportunity for valid insight for those facing complex problem situations. However, this appears to be caused by the vividness of models as metaphors encouraging the simplification of problem awareness and by the strong message of the concept of rationality itself rather than by the ability of the model to represent the reality of the problem situation.

1.5.2.2 Conflict Analysis Model

This is a general term for models of multi-agent systems developed for conflict analysis, and is a problem-solving-oriented system mathematics that starts from a game theory description. In meta-game analysis, as introduced by N. Howard in the 1970s (Howard 1970), the strategies of decision-making agents are rephrased in if-then form, i.e., as reactive strategies so as to identify and categorize new equilibrium solution concepts. First introduced by graph theory, the idea of metagames developed into one-shot games to study conflict analysis. In contrast, P.G. Bennett's hypergames (Bennett 1980), which redefine whole-system games as the "normal form game" expand the game description to express the internal model of each agent with the "normal form game" thereby analyzing subjective perceptions by decision-making agents and how they are influenced by misconceptions.

These are unique in that the problem situation is mainly represented and calculated by a model that extends the game theory notation. In addition to written calculations, computer programs are often used for calculations. Further, these models emphasize counter-intuitivity, which is another characteristic of the complex system.

1.5.2.3 Agent-Based Social Simulation Model

Multi-agent system simulations that implement decision-making agent models via computer programs have long fascinated researchers. Sample examples are projects that substitute part or all of the players with machines to offset the excessive time and cost required by the operation of a gaming-simulation involving massive numbers of human players as decision-making agents within the game. In the well-known Agent-Based Social Simulation (ABSS), agent models are implemented as computer programs with memory and learning functions. In such agent models, the assumption of bounded rationality is sometimes insisted. Progress in computer science, particularly improvements in computer performance and program productivity were essential for the realization of ABSS.

One of the precursors of ABSS is the Repeated Prisoner's Dilemma Competition by Axelrod (1984). In this competition, participants prepare computer programs or multiple agents that output strategies depend on the game situation and they also participate in a computer experiment in which the agents are asked to calculate the results of the game many times. Many of the attempts of this competition are scientific theory oriented, and attempts to explore new theoretical horizons through this competition approach have become more popular in recent years. It is often discussed together with complex systems science.

In general, ABSS is often understood as a scientific theory oriented experiment. However, several adaptations to the problem-solving oriented have been reported in prior studies in the fields such as crowd control, evacuation guidance, disaster management, stock trading, public auctions, and so on.

1.5.2.4 Gaming-Simulation Model

This refers to models for simulations in which human players play one or more agents as components of a multi-agent system. Gaming-simulation allows for a high degree of freedom and flexibility in multi-agent system model construction. However, it should be noted that gaming-simulation has constraints about "playability." Playability refers to the ease of play for human players, and is a concept that defines the scale and content of models that human players can and should participate in, such as games that were once too large and time consuming for anyone to use. Since the advent of gaming software and online games, this playability has continued to expand.

Another advantage of Gaming-Simulation Models compared to the other models is that they allow us to observe by "entering" the game, as humans participate in the actual gaming as one of the constituent agents in a multi-agent system. It is also possible to examine contextual factors in an agent's decision-making.

1.5.3 Comparisons Among Operational Multi-Agent Models

The differences between the game theory model and Gaming-Simulation Model were illustrated by the game theorist Martin Shubik in the 1970s (Shubik 1975). Over more than half a century the concepts of non-complete information, imperfect information, learning, and bounded rationality were introduced into game theory, which has caused substantial changes. However, very little has changed in the basic framework. A comparison among techniques that address multi-agent system models in addition to Conflict Analysis Model and ABSS Model is shown in Table 1.1. In a gradation of the four types of models side by side, comparisons are made for each of the following characteristics, positioning the two models of Game Theory Models and Gaming-Simulation Models at each end of the spectrum: homogeneous or heterogeneous agents, complete or incomplete information, learning, dynamic or static models, role-play, problem symbolization, fixed/unfixed payoffs and utility, and explicit or implicit rules. In summary, the major peculiarity of gaming-simulation models occurring in multi-agent system models is that they provide human players with decision-making situations that are rich in variety, individuality, and complexity. Therefore, they demand from human players the ability to interpret the problem situation.

There is also potential for new techniques to combine these four types of models, and there are known reports of scientific theory-oriented reports that attempt to complement the findings by cross-checking the results of different models on the same target. In addition, there is a problem-solving-oriented use of gaming, which is a heuristic search for possible scenarios. In this case, only the model form used in the completed model is shown as a result, and the contribution of the gaming simulation may not be apparent to the public.

1.6 Conclusion: Gaming as Primary Instrument for Social Design

In this chapter, simulation and gaming are observed as instruments for social design and their basic principles are described considering our social design as understood in the twenty-first century. The two concepts of game and gaming are both polymorphic, so to speak, with a variety of concrete examples, but gaming is characterized by its "instrumentality," its awareness of its uses.

Section 1.2 presents the writings of R. Duke, who emphasizes the role of gaming as a medium for sharing and communicating a complex reality as the basic principles of gaming. Furthermore, considering the issue of social design, the three directions of problem solving, scientific theory, and learning opportunity are outlined. However, there could still be more directions such as entertainment.

Section 1.3 begins with a step-by-step description of the process structure that characterizes gaming as an instrument. The concepts concerning reality, a model as a

Table 1.1 Comparisons among multi-agent models

	Game theory models	Conflict analysis models	Agent based-social simulation models	Gaming-simulation models	
Homogeneous agents	←	←	→	→	Heterogeneous agents
Complete information	←	→	→	→	Incomplete information
No learning	←	←→	→	→	Learning
Primarily static	←	←	→	→	Primarily dynamic
No role playing	←	←	←→	→	Role playing
Game formulation is independent of problem situation (Context-independent. No coding problem)	←	←	←	→	Game recognition depends on each player's problem situation recognition (Context-dependence. Coding problem)
Clearly given payoffs and utility functions	←	←	←→	→	Player's implicit, ambiguous, and changing payoffs and utility functions
Explicit rules of the game	←	←	←	→	Implicit rules of laws and customs of society

mapping and a model as a metaphor as well as context are put into question and a prototyping approach that constitutes the first step of multi-agent system modeling is outlined from the viewpoint of an undifferentiated part of directional consciousness.

Section 1.4 introduces the traditional discussion on the relationship between the scientific method and gaming, whereas Sect. 1.5 introduces the game theory, conflict analysis, and ABSS as different model representation forms of multi-agent system in contemporary system theory and identifies the peculiarities of gaming-simulation by comparing it to these techniques.

In my opinion, social design takes the form of a kind of trans-relational science. When defined narrowly, social design science can be characterized as a problem-solving-oriented multi-agent systems science. Elsewhere, the author had once mentioned soft systems methodology, policy science, and planning theory as examples of advanced research topics that will lead to the coming social design science (Kaneda 2005). Here, however, I have omitted details mainly due to a lack of space. As for specific examples, the author had already discussed the reports of action research and gaming exercise proposed by soft systems methodology in another article (Kaneda 2019; Kaneda et al. 2020). In our social design science, a discipline characterized by a constant back-and-forth interaction between the wisdom of theory and the wisdom of practice simulation and gaming can be expected to become a primary instrument of social design science.

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Chapter 2
A Learning Process Analysis on Hypergame for Understanding Cognitive Conflict

Toshiyuki Kaneda and Shinobu Kitani

Abstract This study aims to describe the modeling of mutual learning processes by agents, which was conducted by the authors between 1997 and 1998 under the name of the Learning Process Analysis on Hypergames (LPAH) in an effort to analyze the collaborative planning formation process in which several agents cooperated to devise a plan such as an international partnership. A mathematical notation of a hypergame is introduced in which decisions can be mutually made despite misperceptions of the game situation. Moreover, the analysis framework is established using a model of mutual learning processes in hypergames. Then, an analytical example of how businesses can attract projects via international investment will be developed and presented under the title of "Actual LPAH." Finally, the conclusions are drawn and the contemporary importance of this analytical method today will be considered.

2.1 Introduction

Herein, a collaborative planning formation process is considered in which several agents collaborate to devise a plan such as an international partnership. However, each agent involved has veto authority until the contract for the devised plan is signed. For each agent, the process of devising the plan can be interpreted as a process to correct self-recognition, acknowledge the existence of other relevant agents, as well as their choices and preferences, and to search for game situations that are closer to the truth. Because the final decision is made in accordance with the game recognition closer to the truth obtained via this process, the devised plan is not necessarily one that is agreed on by each player. Rather, it is a mutual learning

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process, and its importance can be appreciated by considering the opportunity loss caused by being forced to make decisions while the process is underway. In this chapter, such a situation is represented using a hypergame; moreover, an analysis is attempted with reference to the model of the mutual learning process. It is characteristic of hypergames to be able to concisely represent a situation in which decisions by each agent can be mutually made despite misperceptions about the game's actual situation (Bennett 1977, 1980). Hypergames have been used in applications such as military operations (Bennett and Dando 1979) or in the analysis of social events (Bennett et al. 1980) as an ex-post analysis model for explaining seemingly irrational decisions and misperceptions by agents. In hypergames, multi-agent systems are described in terms of the normal form of game theory, with the internal model (recognition model) of each agent described in terms of game theory so as to be able to enhance situational awareness and mitigate misperceptions. It is known to be a type of game with incomplete information in which an assumption of shared knowledge in the game in normal form is partially incomplete with each agent characteristically making decisions not based on Bayesian hypothesis, in contrast to the Bayesian–Nash equilibrium approach. This chapter recapitulates a study of the modeling of the mutual learning process by agents, which was conducted by the authors between 1997 and 1998 under the title of the "Learning Process Analysis on Hypergames" (LPAH, Kaneda and Kitani 1998). Here, the decision-making model of agents is understood as an extension of a decision-making problem that refers to the misperception of the internal model (Kaneda and Kitani 1995; Kaneda 2012), as well as the mutual internal model correction process of the agent; in other words, their mutual learning process is defined to examine the characteristics and changes of the hypergame's equilibrium strategy. A mathematical description is used for this purpose. A dynamic model of a hypergame is known as a hypergame analysis (Wang et al. 1988). Correspondingly, research focused on learning by agents in a hypergame is known as learning game analysis (Kijima 1991; Kijima and Kartowisastro 1992). This study characteristically introduces the hypergame space both for ex-post analysis and as a framework for controlling its processes.

Thereafter this chapter is structured as follows: In Sect. 2.2, conflicts in multi-agent systems are taxonomically classified and hypergames are positioned as one of the mathematical description models. Furthermore, an example of the learning process in hypergames is presented. Sections 2.3 and 2.4 explain, under the title of the first-level hypergame and theory of its learning process, their mathematical formalization. Section 2.5, entitled Actual LPAH, presents an analysis of how businesses attract projects via international investment. Finally, Sect. 2.6 draws conclusions regarding the contemporary importance of this analytical method.

2.2 Conflicts in Multi-Agent Systems and Their Analysis

2.2.1 Conflict and Recognition

The word "conflict" has been simply defined as a gap or opposition between contending agents. In this study, however, a taxonomical classification of conflict is attempted by making use of two classification standards: conflict of interest and cognitive discrepancy. The former of these concerns whether there are opposing interests between agents. This concept of conflict of interest can be substituted by pluralism, which is discussed in Chap. 1. According to the theory of social systems, opposition is exacerbated when the goals of oneself and others cannot be achieved in harmony in a situation in which agents are interacting with one another; this is called conflict. The latter classification standard concerns whether there is a cognitive discrepancy. The agent who is the actor selects actions based on the situation it recognizes. However, cases wherein situational awareness does not match the actual reality are conceivable. Moreover, it is possible that a discrepancy exists between what each agent anticipates in terms of the actions and roles of other agents. It is eminently possible that these circumstances will induce conflicts among agents. Cognitive discrepancy indicates such discrepancies in the situational awareness and expected roles. Next, we will establish types of conflict as per whether or not both conflict of interest and cognitive discrepancy play a role. Note that when neither of these exists, conflict does not occur. Therefore, conflicts can be classified into three types ($=2 \times 2 - 1$) (Table 2.1).

Type I is a conflict situation in which there is a conflict of interest but no cognitive discrepancy; this is called an interest conflict. In non-cooperative game theory, a game with complete information is a model that makes it easier to understand such a conflict. A typical example of this is a sports game. In the business world, this type of conflict tends to be welcomed because it indicates equal opportunity for new market entrants. Type I is a form of conflict that occurs in an "open society." Type II is a conflict situation in which there is no conflict of interest but there are cognitive discrepancies, e.g., consider that, in a situation such as a team setting, there is no difference in individual purposes among agents as they seek to achieve a common

Table 2.1 Taxonomy of conflicts

	No conflict of interest	Conflict of interest
No cognitive discrepancy	No conflict	Type I: interest conflict Conflicts of interest in competing situations. An "equal opportunity" for new entrants (open society, complete information game)
Cognitive discrepancy	Type II: cognitive discrepancy conflict Discrepancies in situational awareness, behavioral expectations, and role expectations among actors (contingency)	Type III: complex conflict Interest conflicts behind cognitive conflicts (closed society, hypergame)

goal by allocating roles. When discrepancies arise among the agents in their respective fields of situational awareness, it is possible that a discrepancy between the role one is playing and the role others are expecting of that individual is entailed. Such conflicts originating from cognitive discrepancy are called cognitive conflicts, and can occur without the presence of conflicts of interest. Moreover, cognitive conflicts among actors are often limited to mutual evaluation, and it is conceivable that uncertainty regarding the actions of other agents, i.e., contingency, is involved in the emergence of cognitive conflicts. Type III is a complex conflict in which there are both conflicts of interest and cognitive discrepancies. This is a typical type of conflict that many actors may encounter in actual society. Moreover, there are cases where conflicts of interest only become apparent during the process of resolving a cognitive conflict. Thus, this is the most troublesome type of conflict among the three. Cognitive discrepancies can originate from misperception and a lack of information, as well as from falsehoods. Hypergames are known as a mathematical model for representing Type III scenarios.

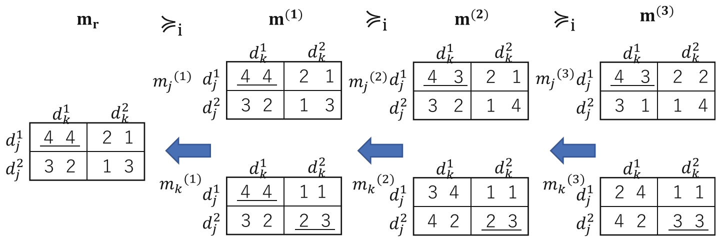
2.2.2 Hypergame—A Mathematical Model for Dealing with Cognitive Discrepancy Conflicts

Hypergames are known as a simple mathematical model for representing Type III complex conflicts in which conflicts of interest and cognitive discrepancies are intertwined. An intuitive explanation of hypergames would be a formal system that represents a situation in which players partially misperceive the rules of a game in accordance with the normal form in game theory. Thus, in a hypergame, each player possesses a game it recognizes within its internal model, separate from the true game situation. Here, a "misperceived" situation indicates misperceptions in the game structures and the choices of other players; sometimes even in their very existence. In such a situation, there is an attempt to demonstrate that a total outcome that differs from the equilibrium point of normal game theory is possible under such circumstances, based on the premise that each player will select actions that it considers to be "subjectively rational." Although a hypergame uses the standard description in non-cooperative game theory, studies on it have been more active in the field of systems theory than in economics. Hypergames concern situations in which players misperceive what is happening while feeling certainty rather than recognizing it as an uncertain situation. Furthermore, in hypergames, situations are interpreted in which no player is "misperceiving" the true game, and the internal model process of each player prompts them to approach the situation as a "mutual learning" scenario. Therefore, a hypergame can address both misperceptions, indicating that the gap caused by cognitive discrepancies and "conflict" in the true game becomes apparent when this gap is closed. Thus, a hypergame has superior qualities for dealing with conflicts that existing models do not have. In a hypergame, scenarios arise that appear to be conflict situations because of "misperceptions" among players. In such a situation, it is possible that the true game, which becomes apparent in the process of resolving misperceptions, does not arise as a conflict situation. Moreover, it is possible that the misperception is left unresolved and that players continue to take antagonistic actions in attempting to resolve the conflict, although the true game does not contain a conflict situation.

2.2.3 Learning Process Analysis

Figure 2.1 shows an example of the aforementioned situation modeled that makes use of a two-person, first-level hypergame.

The game $\mathbf{m_r}$, in which every player is performing with correct recognition (hereinafter referred to as the true game), is a 2×2 game, wherein the strategy sets of agent j and agent k are, respectively, defined as: $\{d_j^1, d_j^2\}$ and $\{d_k^1, d_k^2\}$. While the preference of each agent (preference for larger numbers) is shown in the corresponding matrix; in truth, the best result (4, 4) can be obtained when each agent selects d_j^1 and d_k^1, respectively, which they achieve when the Nash equilibrium is reached. However, in the initial stage, they mutually misperceive the preferences of each other, indicating that agent j believes this game to be $m_j^{(3)}$ whereas agent k believes it to be $m_k^{(3)}$. If they are compelled to make decisions at this stage, they adapt the Nash equilibrium strategy for games in which each agent is individually recognized. Consequently, the result (PO) deviates from that of the true game; in other words, while the pair of d_j^1 and d_k^1 can be considered as the expected result, decision-making at this stage results in the selection of d_j^1 by agent j and d_k^2 by agent



	$\mathbf{m_r}$	$\mathbf{m^{(1)}}$	$\mathbf{m^{(2)}}$	$\mathbf{m^{(3)}}$
(1) Player j's Individual Equilibrium (IE)	(d_j^1, d_k^1)	(d_j^1, d_k^1)	(d_j^1, d_k^1)	(d_j^1, d_k^1)
(2) Player k's Individual Equilibrium (IE)	(d_j^1, d_k^1)	(d_j^1, d_k^1) (d_j^2, d_k^2)	(d_j^2, d_k^2)	(d_j^2, d_k^2)
(3) Common Equilibrium of Hypergame (CE)	(d_j^1, d_k^1)	(d_j^1, d_k^1)	ϕ	ϕ
(4) Plausible Outcomes of Hypergame (PO), and the Payoff	(d_j^1, d_k^1), (4 , 4)	(d_j^1, d_k^1), (4 , 4) (d_j^1, d_k^2), (2 , 1)	(d_j^1, d_k^2), (2 , 1)	(d_j^1, d_k^2), (2 , 1)

Fig. 2.1 An example of mutual learning process of two-player hypergame (Preference Identification Order)

k, and they can only obtain (2, 1) as the result. Although the strategies selected may change in the process of correcting the recognition model of each agent through, for instance, information exchange with each other ($\mathbf{m}^{(3)}$ becomes $\mathbf{m_r}$ by first becoming $\mathbf{m}^{(2)}$ and then becoming $\mathbf{m}^{(1)}$), the result can be inferior to that of the equilibrium strategy of the true game if they make the decision in the middle of the process, when the information exchange has not been sufficiently conducted, as discussed earlier. This incomplete state of the process carries the risk of generating an unexpected result based on misperceptions. Here, the information used is, in fact, only partial information on the true game. Depending on the order in which information is obtained and when, in other words on the difference in the process route, misperceptions during the process can take diverse forms.

In this study, such a process of change in the internal model of agents is referred to as the mutual learning process. In the next section, a formalization for describing the changes in hypergames and their analysis is conducted.

2.3 First-Level Hypergame and Its Monotonic Learning Process

The main focus of this study is the situation in which each agent is unaware of others' misperceptions, which is called a first-level hypergame. It concerns situational awareness and misperception using the standard form of game theory to describe both the multi-agent system and internal (recognition) model of each agent. The notation of Wang et al. (1988) is used for hypergames.

2.3.1 n Person First-Level Hypergame

Here, the true game is postulated to be an n person game, and formalization is then conducted for the examination subject of the perceived type of misperception among first-level hypergames that deal with (A) the preference matrix, (B) the strategic set, and (C) the agent set.

Definition 2.1: *n* Person First-Level Hypergame and Its Set
The true game, m_r, is expressed as follows:

- Agent set: $\mathrm{N} = \{1, \ldots, j, \ldots, n\}$,
- Strategy set of agent j: $D_j = \left\{ d_j^h \mid h = 1 \ldots g(j) \right\}$,
- Outcome set: $\mathrm{S} = \Pi_{j \in \mathrm{N}} D_j$,
- Outcome: $\mathrm{s} = \left(d_1, \ldots, d_j, \ldots, d_n \right) (\in \mathrm{S})$,
- Preference of agent j:

  When $\prec_j$ has a strong total order relationship to S
  (when $s \prec_j s'$, j selects s' instead of s):

$$m_r = \left[\mathrm{N}, \left\{\left(D_r, \prec_j\right) \mid j \in \mathrm{N}\right\}\right].$$

Moreover, the game m_j is recognized by agent j and expressed thus:

- Agent set: $\mathrm{N}_j\ (\subseteq \mathrm{N})$,
- Strategic set of the other agent k: $D_{kj}\ (\subseteq D_k)\ (k \neq j)$,
- Outcome set: $\mathrm{S}_j = \mathrm{D}_j \times \Pi_{j\,\in\,\mathrm{N}(k\,\neq\,j)}\, D_{kj}$,
- Outcome: $\mathrm{s}_j = (d_{1j}, \ldots, d_{kj}, \ldots, d_{nj})\ (\in \mathrm{S}_j)$,
- Preference of agent k:

  When $\prec_{kj}$ has a strong total order relationship with S_j (when $\mathrm{s} \prec_j s'$, j selects s' instead of s):

$$m_j = \left[\mathrm{N}_j, \left(D_j, \prec_j\right), \left\{\left(D_{kj}, \prec_{kj}\right) \mid k \neq j\right\}\right].$$

Here, hypergame $\mathbf{m}$ is defined as the set of m_r and m_j:

$$\mathbf{m} = \left[m_r;\ m_1, \ldots, m_j, \ldots m_n\right].$$

Note that a true game in a hypergame indicates one in which $m_j = m_r$ for every agent $j(\in \mathrm{N})$, and is represented as $\mathbf{m_r}$. Moreover, the set $\mathbf{m}$ of the hypergames is referred to as the hypergame set, and is represented as $\mathbf{M}$.

2.3.2 Order Relationship between the Hypergames

Given two hypergames, three types of partial order relations are defined that compare their "closeness" to a true game, namely, the preference identification order, strategy set extension order, and agent set extension order. Note that hypergame $\mathbf{m}^{(\mathrm{a})}$ and $\mathbf{m}^{(\mathrm{b})}$ are expressed as follows:

$$\mathbf{m}^{(\mathrm{a})} = \left[m_r;\ m_1^{(\mathrm{a})}, \ldots m_j^{(\mathrm{a})}, \ldots, m_n^{(\mathrm{a})}\right],$$

$$\mathbf{m}^{(\mathrm{b})} = \left[m_r;\ m_1^{(\mathrm{b})}, \ldots m_j^{(\mathrm{b})}, \ldots, m_n^{(\mathrm{b})}\right](j \in \mathrm{N}),$$

$$\boldsymbol{m}_j^{(a)} = \left[\mathrm{N}_j^{(\mathrm{a})}, \left(D_j, \prec_j^{(\mathrm{a})}\right), \left(D_{kj}^{(\mathrm{a})}, \prec_{kj}^{(\mathrm{a})}\right) \mid k \in \mathrm{N}_j^{(\mathrm{a})}, k \neq j, \right],$$

$$\boldsymbol{m}_j^{(b)} = \left[\mathrm{N}_j^{(\mathrm{b})}, \left(D_j, \prec_j^{(\mathrm{b})}\right), \left(D_{kj}^{(\mathrm{b})}, \prec_{kj}^{(\mathrm{b})}\right) \mid k \in \mathrm{N}_j^{(\mathrm{b})}, k \neq j, \right], \left(D_{kj} \neq \phi\right).$$

First, the preference identification order is defined as the order of relationships that indicates which of the two hypergames better conforms to the preference of m_r.

Definition 2.2: Preference Identification Order $\preccurlyeq_{\mathrm{i}}$
The conformity set of hyper games $\mathbf{m^{(a)}}$ and $\mathbf{m^{(b)}}$ is $\mathrm{N}_j^{(a)} = \mathrm{N}_j^{(b)} = \mathrm{N}$, $\prec_j^{(a)} = \prec_j^{(b)} = \prec_j$, $D_j = D_{kj}^{(a)} = D_{kj}^{(b)}$ with m_r at every $k, j \in \mathrm{N}(k \neq j)$ and is defined as follows:

$$\Delta_j \equiv \Pi_{k,j \in N, k \neq j}\left\{\left(\prec_{kj} \cap \prec_k\right) \cup \left(\overline{\prec_{kj}} \cap \overline{\prec_k}\right)\right\}.$$

At this point, the relationship of $\mathbf{m^{(a)}}$ and $\mathbf{m^{(b)}}$, which is $\Delta_j^{(a)} \subseteq \Delta_j^{(b)}$, is a partial order relationship that satisfies the reflection rule, the dissymmetry rule, and the transition rule, and is expressed as $\mathbf{m^{(a)}} \preccurlyeq_{\mathrm{i}} \mathbf{m^{(b)}}$. $\preccurlyeq_{\mathrm{i}}$ is referred to as the preference identification order.

A conformity set is a set that comprises a pair where the preference of the other agents is recognized as coinciding with the true preferences of that player. When the matches are perfect, it is $\mathrm{S} \times \mathrm{S}$, whereas it is ϕ when they fully differ. If $\mathbf{m^{(a)}} \preccurlyeq_{\mathrm{i}} \mathbf{m^{(b)}}$, it indicates that $\mathbf{m^{(b)}}$ identifies with preferences other than those of $\mathbf{m^{(a)}}$.

Example 2.1
In Fig. 2.1, the preference identification order is expressed as follows:

$$\mathbf{m}^{(3)} \preccurlyeq_{\mathrm{i}} \mathbf{m}^{(2)} \preccurlyeq_{\mathrm{i}} \mathbf{m}^{(1)} \preccurlyeq_{\mathrm{i}} \mathbf{m_r}.$$

There are cases in the relationship between two hypergames in which one correctly contains the strategic set of the other within the recognition model while maintaining its order of preference in the outcome. In this study, such a relationship is referred to as the strategy set extension order and is defined as follows.

Definition 2.3: Strategy Set Extension Order $\preccurlyeq_{\mathrm{se}}$
Between two hypergames, $\mathbf{m^{(a)}}$ and $\mathbf{m^{(b)}}$, which are $\mathrm{N}_j^{(a)} = \mathrm{N}_j^{(b)} = \mathrm{N}, \prec_j^{(a)} = \prec_j^{(b)} = \prec_j$, the relationship satisfies both the following conditions:

$$\text{(A)}\ D_{kj}^{(a)} \subseteq D_{kj}^{(b)} \subseteq D_j, \quad \text{and}$$

$$\text{(B)}\ s_j^{(a)} \prec_{kj}^{(a)} s'^{(a)}_j \Rightarrow s_j^{(a)} \prec_{kj}^{(b)} s'^{(a)}_j$$

for every $k, j\,(k \neq j)$ is a partial order relationship. This is called the strategy set extension order, and is expressed as follows: $\mathbf{m^{(a)}} \preccurlyeq_{\mathrm{se}} \mathbf{m^{(b)}}$.

Example 2.2
Figure 2.2, where the strategic set of agent k in the true game $\mathbf{m_r}$ is set as d_k^1, d_k^2, d_k^3. At $\mathbf{m^{(3)}}$, j perceives the strategy of the opponent to be $\left\{d_k^2\right\}$ only, and k perceives the strategy of the opponent to be $\left\{d_j^2\right\}$ only. At $\mathbf{m^{(2)}}$, j perceives the strategy of the opponent to be $\left\{d_k^1, d_k^2\right\}$, and at $\mathbf{m^{(1)}}$, k perceives the opponent's strategy to be

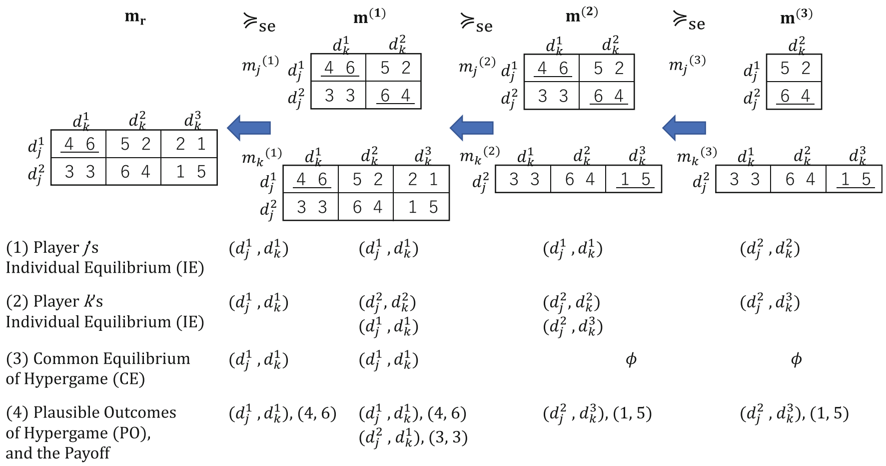


Fig. 2.2 An example of mutual learning process of two-player hypergame (Strategy Set Extension Order)

$\{d_j^1 d_j^2\}$. Lastly, at $\mathbf{m_r}$, j perceives the strategy of the opponent to be $\{d_k^1, d_k^2, d_k^3\}$. At this point, the relationship preference of the result is inferred as being maintained. At this time, the order is as follows: $\mathbf{m^{(3)}} \preccurlyeq_{se} \mathbf{m^{(2)}} \preccurlyeq_{se} \mathbf{m^{(1)}} \preccurlyeq_{se} \mathbf{m_r}$.

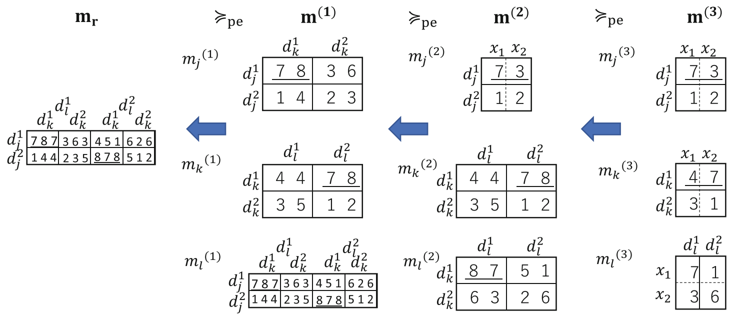
Furthermore, it is possible to consider hypergame relationship cases in which one player recognizes the existence of the other; however, this other player is unaware of the existence of the first. The true game $\mathbf{m_r}$, as is shown in Fig. 2.3, is a three-player game that adds agent l to agent j and agent k, with the real gain of each of them being prescribed by the sets of strategies that the three players selected. In hypergame $\mathbf{m^{(1)}}$, k and l recognize it to be a three-player game, whereas j is unaware of the existence of l and recognizes it to be a two-player game by j and k. This relationship can be understood as an extension (inclusion relation) of the agent set in the recognition model. The relationship between these two hypergames is known as the agent set extension order, and is defined as follows.

Definition 2.4: ***Agent Set Extension Order*** $\preccurlyeq_{pe}$
Within two hypergames $\mathbf{m^{(a)}}$ and $\mathbf{m^{(b)}}$ that satisfy the following conditions:

(A) For every $j, \mathrm{N}_j^{(a)} \subseteq \mathrm{N}_j^{(b)} \subseteq \mathrm{N}$, and
(B) For every $k \in \mathrm{N}_j^{(a)}, D_{kj}^{(a)} = D_{kj}^{(b)} = D_k \ (k \neq j)$,

$\mathrm{s}_j{}^{(b)}$ that corresponds with the outcome $\mathrm{s}_j{}^{(a)}$ j recognizes is expressed as follows:
$\mathrm{s}_j{}^{(a)} = \left(d_{1j}, \ldots, d_{kj}, \ldots, d_j, \ldots, d_{n^{(a)}j}\right)$
$\mathrm{s}_j{}^{(b)} = \left(d_{1j}, \ldots, d_{kj}, \ldots, d_j, \ldots, d_{k^+j}, \ldots, d_{n^{(b)}j}\right), \left(n^{(a)} = \#\mathrm{N}_j{}^{(a)}, n^{(b)} = \#\mathrm{N}_j{}^{(b)}\right)$
$\mathrm{s'}_j{}^{(a)}$ and $\mathrm{s'}_j{}^{(b)}$ are also expressed in the same way.

Then, if $s_j{}^{(b)}$, $s'_j{}^{(b)}$ satisfy the conditions:



	$\mathbf{m_r}$	$\mathbf{m}^{(1)}$	$\mathbf{m}^{(2)}$	$\mathbf{m}^{(3)}$
(1) Player j's Individual Equilibrium (IE)	(d_j^1, d_k^1, d_l^1) (d_j^2, d_k^1, d_l^2)	(d_j^1, d_k^1)	(d_j^1)	(d_j^1)
(2) Player k's Individual Equilibrium (IE)	(d_j^1, d_k^1, d_l^1) (d_j^2, d_k^1, d_l^2)	(d_k^1, d_l^2)	(d_k^1, d_l^2)	(d_k^1)
(3) Player l's Individual Equilibrium (IE)	(d_j^1, d_k^1, d_l^1) (d_j^2, d_k^1, d_l^2)	(d_j^1, d_k^1, d_l^1) (d_j^2, d_k^1, d_l^2)	(d_k^2, d_l^1)	ϕ
(4) Common Equilibrium of Hypergame (CE)	(d_j^1, d_k^1, d_l^1) (d_j^2, d_k^1, d_l^2)	ϕ	ϕ	ϕ
(5) Plausible Outcomes of Hypergame (PO), and the Payoff	(d_j^1, d_k^1, d_l^1) (7,8,7) (d_j^2, d_k^1, d_l^2) (8,7,8) (d_j^1, d_k^1, d_l^2) (4,5,1) (d_j^2, d_k^1, d_l^1) (1,4,4)	(d_j^1, d_k^1, d_l^1) (7,8,7) (d_j^2, d_k^1, d_l^2) (8,7,8) (d_j^1, d_k^1, d_l^2) (4,5,1) (d_j^2, d_k^1, d_l^1) (1,4,4)	(d_j^1, d_k^1, d_l^1) (7,8,7) (d_j^1, d_k^1, d_l^2) (4,5,1)	(d_j^1, d_k^1, d_l^1) (7,8,7) (d_j^1, d_k^1, d_l^2) (4,5,1)

Fig. 2.3 An example of mutual learning process of two-player hypergame (Player Set Extension Order)

(C) $s'_j{}^{(a)} \prec_j{}^{(a)} s'_j{}^{(b)} \Rightarrow s'_j{}^{(a)} \prec_j{}^{(b)} s'_j{}^{(b)}$, and
(D) $s_j{}^{(a)} \prec_{kj}{}^{(a)} s'_j{}^{(a)} \Rightarrow s_j{}^{(b)} \prec_j{}^{(b)} s'_j{}^{(b)}$,

for every $s'_j{}^{(a)}$, $s'_j{}^{(b)}$, $\mathbf{m^{(a)}}$ and $\mathbf{m^{(b)}}$ are in a partial order relationship, which is expressed as follows: $\mathbf{m^{(a)}} \preccurlyeq_{\rm pe} \mathbf{m^{(b)}}$.

When $\mathbf{m^{(a)}} \preccurlyeq_{\rm pe} \mathbf{m^{(b)}}$, $\mathbf{m^{(b)}}$ recognizes a larger number of other players than $\mathbf{m^{(a)}}$ does.

Example 2.3
In Fig. 2.3, j, k, and l are all assuming $\mathbf{m^{(3)}}$ to be a one-player game. In $\mathbf{m^{(2)}}$, k perceives it to be a two-player game between k and l, whereas l perceives it to be a two-player game between l and j. In $\mathbf{m^{(1)}}$, j newly recognized k and l newly recognized k. In m, all three players recognize it to be a three-player game. At this point, the agent set extension order is as follows: $\mathbf{m^{(3)}} \preccurlyeq_{\rm pe} \mathbf{m^{(2)}} \preccurlyeq_{\rm pe} \mathbf{m^{(1)}} \preccurlyeq_{\rm pe} \mathbf{m_r}$.

2.3.3 Hypergame Space and Mutual Learning Process

By introducing the orders preference identification order $\preccurlyeq_{\rm i}$, strategy set extension order $\preccurlyeq_{\rm se}$, and agent set extension order $\preccurlyeq_{\rm pe}$ to the (subset of) class of hypergames, diverse ordered sets can be created. This is called the hypergame space and an example of it is described below.

Definition 2.5: Hypergame Space
The ordered set ($\mathbf{M}$, $\preccurlyeq$) formed by introducing the order between the hypergames $\preccurlyeq$ to the hypergame set $\mathbf{M}$ comprising hypergames that possess the true game $\mathbf{m_r}$ is called the hypergame space.

Example 2.4: Hypergame Space Examples

(A) The ordered set ($\mathbf{M_i}$, $\preccurlyeq_{\mathrm{i}}$) ($\mathbf{M_i} = \{\mathbf{m} \mid \mathbf{m} \preccurlyeq_{\mathrm{i}} \mathbf{m_r}\}$) is called the preference identification space. At this point, the preference identification space is a Boolean lattice.

(B) The ordered set ($\mathbf{M_{se}}$, $\preccurlyeq_{\mathrm{se}}$) ($\mathbf{M_{se}} = \{\mathbf{m} \mid \mathbf{m} \preccurlyeq_{\mathrm{se}} \mathbf{m_r}\}$) is called the strategy set extension space.

(C) The ordered set ($\mathbf{M_{pe}}$, $\preccurlyeq_{\mathrm{pe}}$) ($\mathbf{M_{pe}} = \{\mathbf{m} \mid \mathbf{m} \preccurlyeq_{\mathrm{pe}} \mathbf{m_r}\}$) is called the agent set extension space. Both the strategy set extension space and agent set extension space are Boolean lattices.

As the recognition model of one agent becomes a direct addition of the six independent lattices in a two-player, 2×2 game, ($\mathbf{M_i}$, $\preccurlyeq_{\mathrm{i}}$) can be expressed as its direct product. Figure 2.4a shows a portion of the lattices related to m_j. Here, one hypergame exists, corresponding to each direct product of the lattices formed by the strategic sets and agent sets; each agent perceives the possible actions of others to exist, and the strategy set extension space and agent set extension space become Boolean lattices (set lattice) (Fig. 2.5a,b).

The process of the given hypergame $\mathbf{m}$ reaching $\mathbf{m_r}$, following the order relationships, is inferred to be the process of receiving the correct partial information of the true game (correct information) and then monotonously improving the recognition model. In this study, this is called a monotonous learning process and is defined as follows.

Definition 2.6: Mutual Learning Process in the Hypergame Space
Commonly, when $\mathbf{m_r}(\in\mathbf{M})$ is given in the hypergame space ($\mathbf{M}$, $\preccurlyeq$), the composition series from $\mathbf{m}$ to $\mathbf{m_r}$ (the partial total ordered set that covers the relationship with $\preccurlyeq$), $\{\mathbf{m^{(t)}}\}_{t \in \Lambda}$ (Λ is a partial set of integers larger than 0, with a learning target model of $\mathbf{m^{(0)}} = \mathbf{m_r}$) is referred to as the mutual learning process.

Therefore, another $\mathbf{m} \in \mathbf{M}$ satisfies $\mathbf{m^{(t+1)}} \preccurlyeq \mathbf{m^{(t)}}$ if $t \leq t'$. The reverse is true, and $\mathbf{m^{(t+1)}} \preccurlyeq \mathbf{m} \preccurlyeq \mathbf{m^{(t)}}$ is satisfied for every $\mathbf{m^{(t+1)}}$, $\mathbf{m^{(t)}} \in \mathbf{M}$ that does not exist.

Moreover, when the partial order set ($\mathbf{M'}$, $\preccurlyeq$) at the union $\mathbf{M'}$ ($\subseteq \mathbf{M}$) of every composition series that contains $\mathbf{m}$ and $\mathbf{m_r}$ becomes a partial lattice, this is specifically classified as the learning space (Fig. 2.6).

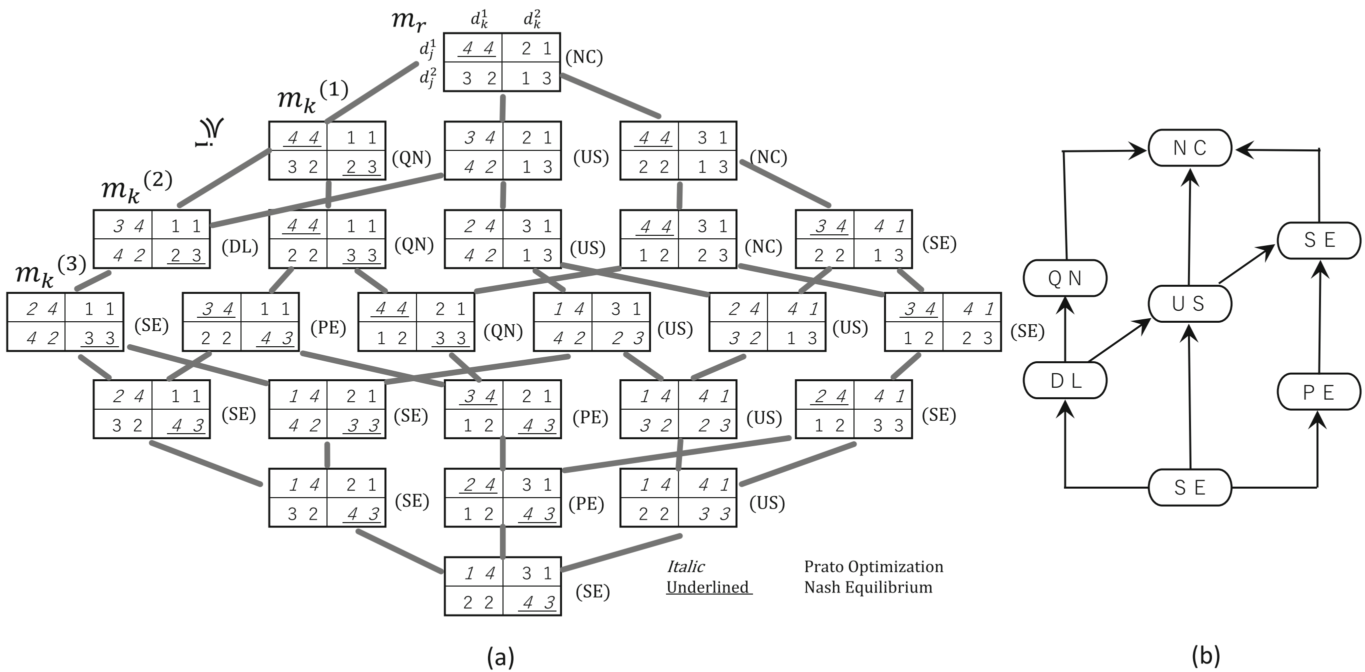


Fig. 2.4 An example of preference identification space. (**a**) A part of preference identification space (lattice formed by k's perceived games). (**b**) A transition diagram of game-type on (**a**)

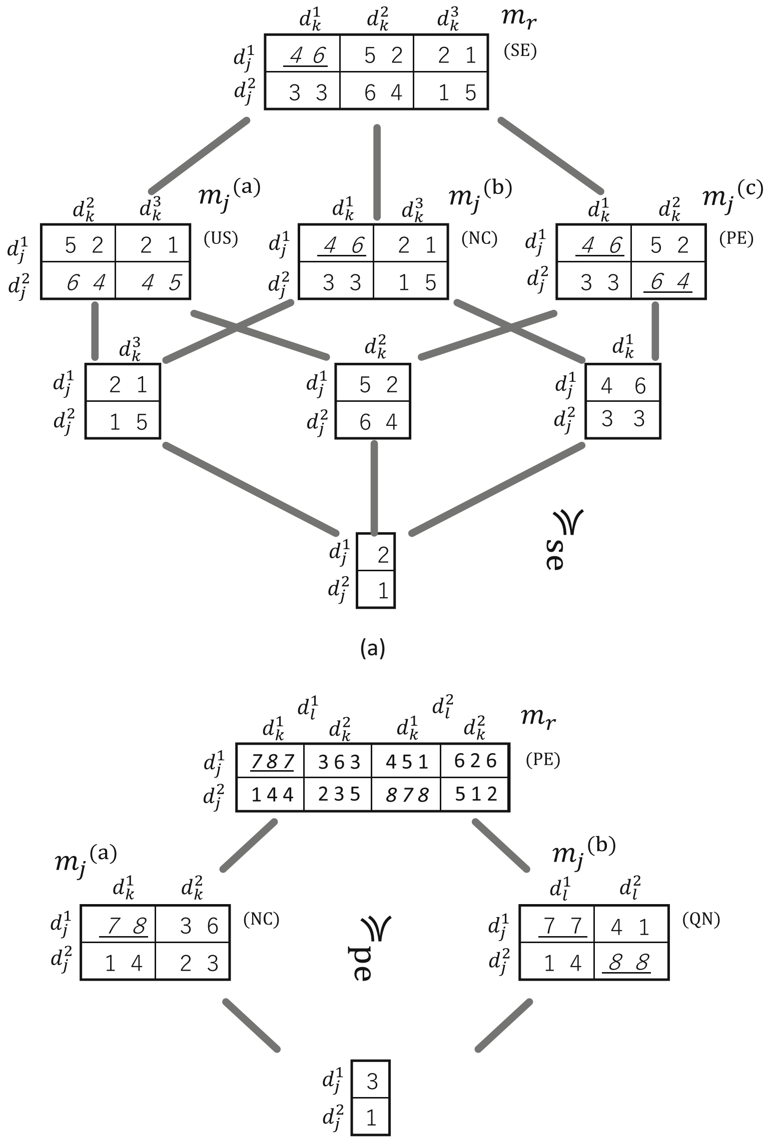


Fig. 2.5 Examples of Strategy Set Extension Space and Player Set Extension Space. (**a**) A part of Strategy Set Space (lattice formed by *j*'s perceived games). (**b**) A part of player set space (lattice formed by *j*'s perceived games)

As is shown below, when a hypergame space is developed, the following individual names are given as the mutual learning process to the composition series above.

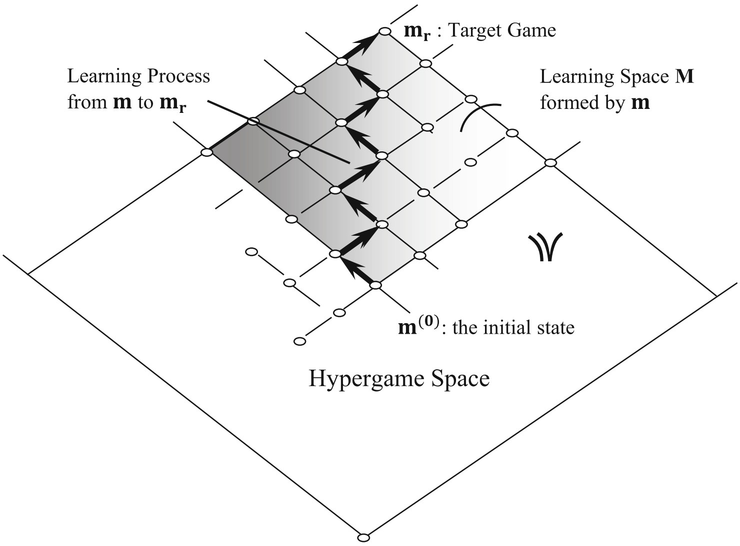


Fig. 2.6 Learning space and learning process

Hypergame space	Mutual learning process	Learning target
$(\mathbf{M_i}, \preccurlyeq_i)$	Preference identification process	$\mathbf{m_r}$
$(\mathbf{M_{se}}, \preccurlyeq_{se})$	Strategy set extension process	$\mathbf{m_r}$
$(\mathbf{M_{pe}}, \preccurlyeq_{pe})$	Agent set extension process	$\mathbf{m_r}$

Learning process is the chain that is the partial sequence of the composition series. Thus, the sequences in Figs. 2.1, 2.2, and 2.3 are mutual learning processes because they are chains, although they do not constitute a composition series. Note that this formalization of the learning process entails a type of monotony.

2.4 Learning Process Analysis in First-Level Hypergame Space

2.4.1 Framework of the Learning Process Analysis

In hypergame analysis, the equilibrium strategy that each agent devises for the game that appears in its internal model, i.e., the individual equilibrium (IE) and the common equilibrium (CE), which is the common set of individual IEs, are distinguished as different equilibrium concepts (Wang et al. 1988). Here, these are defined by extending the Nash equilibrium strategy, which is the most well-known starting point for establishing learning process analyses.

Definition 2.7: Individual Equilibrium, Total Equilibrium, and Plausible Outcomes
At game m_j, agent j perceives, the IE of $s_j = \left(d^*_{1j}, \ldots, d^*_{kj} \ldots d^*_j, \ldots, d^*_{nj}\right)$, thus indicating the following two conditions are satisfied.

(A) For every $d_j\left(\neq d^*_j\right) \in D_j, s^*_j \succ_j \left(d^*_{1j}, \ldots d^*_{kj}, \ldots d_j, \ldots d^*_{nj}\right)$,
(B) For every $d_{kj} \in D_{kj}(k \neq j), s^*_{kj} \succ_{kj} \left(d_{1j}, \ldots, d_{kj}, \ldots, d^*_j, \ldots, d_{nj}\right)$.

Furthermore, the CE of s^* indicates that $s_j{}^*$, which is an IE, matches s^* for every j. $CES(\mathbf{m}) = \{s_j{}^* | s_j{}^* \text{ is CE}\}$; in particular, it is called the common equilibrium (CE).

In this case, the outcomes that can potentially occur because of the selections of the individual IE of each agent are examined as the plausible outcomes (POs).

The PO is also the number of possible outcomes. If the IE of every agent is one, the number of POs, which are the possible results, is 1. However, if one agent has several IEs, the number of POs is the product of the number of strategies for each relevant agent because the possibility of that agent selecting any of these IEs cannot be denied. Furthermore, if there are agents with no IE strategy, the PO number is the product of the number of strategies for each relevant agent to determine the non-dominant strategies of these agents.

Example 2.5
In the preference identification of Fig. 2.1, the IE conceived by j is $\left(d^1_j, d^1_k\right)$ and that conceived by k is $\left(d^2_j, d^2_k\right)$ in $\mathbf{m}^{(3)}$ in relation to the Nash equilibrium strategy $\left(d^1_j, d^1_k\right)$, which is the outcome of $\mathbf{m_r}$. Therefore, the CE does not exist and the PO becomes $\left(d^1_j, d^2_k\right)$. Here, the PO is the only result that can potentially occur and the gain of both players is (2, 1), which is clearly inferior to the true game's outcome, which is (4, 4).

While the IE of j does not change when transiting to $m_j{}^{(2)}$ and $m_j{}^{(1)}$, the IE of k at $m_k{}^{(1)}$ increases to two, namely, $\left(d^1_j, d^1_k\right)$ and $\left(d^2_j, d^2_k\right)$. At this point, $\left(d^1_j, d^1_k\right)$ appears in CE, and the PO becomes $\left(d^1_j, d^1_k\right)$ and $\left(d^1_j, d^2_k\right)$; two outcomes, namely, (2, 1) and (4, 4), could therefore occur.

Example 2.6
In Fig. 2.2, the outcome of $\mathbf{m_r}$ is $\left(d^1_j, d^1_k\right)$, and its gain is (4, 3). The IE of j is $\left(d^2_j, d^2_k\right)$ and that of k is $\left(d^2_j, d^3_k\right)$ at $\mathbf{m}^{(3)}$. CE does not exist, PO is $\left(d^2_j, d^3_k\right)$ and the possible gain is (1, 5). When the strategy set extension process continues, the IEs of j at $m_j{}^{(2)}$ become $\left(d^1_j, d^1_k\right)\left(d^2_j, d^2_k\right)$. The IE of k at $m_j{}^{(1)}$で is changed to $\left(d^1_j, d^1_k\right)$ and at this point, the CE $\left(d^1_j, d^1_k\right)$ is generated for the first time. However, as there are two IEs from j, the PO has two outcomes, namely, (4, 6) and (3, 3).

Example 2.7
At the agent set extension process shown in Fig. 2.3, the IEs of $m_j{}^{(3)}$, $m_k{}^{(3)}$, and $m_l{}^{(3)}$ in relation to CEs of m_r, which are $\left(d^1_j, d^1_k, d^1_l\right)$ and $\left(d^2_j, d^1_k, d^2_l\right)$ (thus, there are four POs),

are $(d_j^1), (d_k^1)$, and ϕ, respectively. Therefore, there are two POs, namely, (d_j^1, d_k^1, d_l^1) and (d_j^1, d_k^1, d_l^2). Whereas IE at $m_k^{(2)}$ becomes (d_k^1, d_l^2), CE and PO do not change. As the IE at $m_j^{(1)}$ is (d_j^1, d_k^1), and those at $m_l^{(1)}$are (d_j^1, d_k^1, d_l^1) and (d_j^2, d_k^1, d_l^2), (d_j^2, d_k^1, d_l^1) and (d_j^2, d_k^1, d_l^2) are added to the set of potential outcomes.

2.4.2 The Stability of Common Strategies During the Mutual Learning Process

With respect to the common strategy CE, it known to feature characteristics that promote stability during the mutual learning process. In this section, two propositions about the common strategy of hypergame $\mathbf{m}$ that matches the equilibrium strategy of the true game are presented. First, two types of learning stability, namely, process and learning stability, are defined.

Definition 2.8: Learning Stability of Equilibrium Strategy
With $s^* \in CES(\mathbf{m})$ in hypergame $\mathbf{m}$:

(A) s^* is stable in the learning process $\{\mathbf{m^{(t)}}\}$: $\Leftrightarrow$ $s^* \in CES(\mathbf{m})$ and is satisfied in every $\mathbf{m^{(t)}}$.
(B) s^* is stable in the learning space $(\mathbf{M}, \preccurlyeq)$: $\Leftrightarrow$ $s^* \in CES(\mathbf{m})$ and is satisfied in every $\mathbf{m^{(t)}} \in \mathbf{M}$.

It is clear from the definition that, while it is stable in the learning process, if it is stable in the learning space, the reverse is untrue.

Proposition 2.1: Stability of common strategy in the learning space during the preference identification process
In the learning space $(\mathbf{M}, \preccurlyeq_{\mathrm{i}})$, the spread with the given m_r is as follows:

If $s^* \in CES(\mathbf{m})$ and $s^* \in CES(\mathbf{m_r})$ at every $\mathbf{m^{(t)}} \in \mathbf{M}$, $s^* \in CES(\mathbf{m^{(t)}})$ (Proof at the end).

Proposition 2.2: Stability of the common strategy in the learning space during the strategy set extension process
In the learning space $(\mathbf{M}, \preccurlyeq_{\mathrm{se}})$, the spread with the given m_r is as follows:

If $s^* \in CES(\mathbf{m})$ and $s^* \in CES(\mathbf{m_r})$ at every $\mathbf{m^{(t)}} \in \mathbf{M}$, $s^* \in CES(\mathbf{m^{(t)}})$ (Proof at the end).

We will now discuss the meaning of the two propositions that have been outlined.

Once every agent has obtained the same Common Equilibrium (CE) as that at m_r, the equilibrium strategy is maintained regardless of which learning process is taken from that point forward. In other words, there are islands of hypergames near m_r where the equilibrium strategy is stable within these hypergame spaces. When a hypergame enters this area, the equilibrium strategy will not be lost regardless of which agent obtains new learning information. The research interests of the authors lie in the stability of equilibrium strategies in communication between agents. The formalization of the hypergame space was performed using lattices to enable the handling of the smallest partial information in the internal models, and because the learning information could be analyzed as the results of communication between agents rather than the results of decisions made in the early section. The presented propositions assert the stability of the framework, which was extended to the communication.

2.4.3 Changes in Game Type Recognized by Agents During the Learning Process

In this section, the changes in the game type recognized by the agents during the learning process are analyzed to highlight the bottleneck where misperceptions by each agent cannot be resolved when learning is stopped; in other words, it is a dangerous route. First, the classical classification of 2 × 2 games by Rappaport (Rapoport and Guyer 1966) is simplified, and games that are 2 × 2 or larger are classified into six types, from the relationship between the Nash solution and the Pareto solution (Table 2.2).

The following are explanations of the six game types:

1. NC (No conflict): If both the Nash solution and Pareto solution are 1 and they match, there is no conflict.
2. SE (Simple equilibrium): A case such that there are several Pareto solutions but the only Nash solution is a Pareto solution. The individual rationality does not deviate from the total group rationality; this is most common in 2 × 2 games.
3. DL (Dilemma): The case where although one or more Nash solutions exist, they do not match the Pareto solutions. The individual rationality and total group rationality cannot be reconciled with each other, e.g., the famous "prisoner's dilemma," belongs to this category.

Table 2.2 Taxonomy of game type by relationship of the Nash equilibrium (N) and Pareto optimum (P)

Category name	Num. of Nash equilibrium	Relation between N and P	Num. of 2 × 2 Game2 (Rapoport and Guyer 1966)
NC: No conflict	1	$N = P$	15
SE: Single equilibrium	1	$N \subset P$	38
DL: Dilemmas	$\geqq 1$	$\#(N \cap P) = 0$	4
QN: Quasi no conflict	$\geqq 2$	$\#(N \cap P) = 1$	6
PE: Plural equilibria	$\geqq 2$	$\#(N \cap P) \geqq 2$	6
US: Unstable	0		9

4. QN (Quasi-no conflict): The case where there are several Nash solutions, but only one of them is a Pareto solution. Conflict does not emerge in practice though because this Pareto solution is superior to all of the other Nash solutions for every agent.
5. PE (multiple equilibria): The case where there are several solutions that are both Nash and Pareto solutions. The "chicken game" and the "battle of the sexes" belong to this category.
6. US (Unstable): The case where no Nash solution exists in terms of pure strategy.

Example 2.8
Changes in the game type of the recognition model in the preference identification space are discussed. In Fig. 2.4a, the first recognition model $m_k^{(5)}$ of agent k is simple equilibrium (SE) in relation to the true game, m_r. When $m_k^{(4)}$ and $m_k^{(3)}$, there is no conflict (NC); when $m_k^{(2)}$, it is quasi-no conflict (QN); when $m_k^{(1)}$, it is a dilemma (DL); and it is SE when m_r. A transition pattern type of game is shown in Fig. 2.4b and is obtained when equivalence classes are formed as per the classification standards of Table 2.2. Thus, as the game type of each agent dramatically changes during the learning process, they are exposed to the possibilities of conflicts and dilemmas, and it demonstrates that their appearances completely differ depending on the learning route taken.

Example 2.9
The changes in the game type of the recognition model in the strategy set extension space are discussed here. It is possible to apply the game type to the Boolean lattices in Fig. 2.5a, which are 2×2 or more. In this example, QN when $m_j^{(a)}$, multiple equilibria (PE) when $m_j^{(b)}$, and DL when $m_j^{(c)}$, when the true game m_r is QN. Similar to the case in the previous example, this demonstrates that the "appearance" of the game type completely differs depending on the difference in the learning process. Similarly, Fig. 2.5b shows the transition of the game type in the agent set extension space.

In summary, the hypergame space is the state space of a multi-agent system that includes the perception state of individual agents in the learning process analysis by the authors, whereas the learning process above it indicates a monotonous asymptote to the target model. Note that this does not directly consider the learning algorithm.

2.5 The Actual Case of LPAH: The Process of Attracting Business Projects Through International Investment

In this section, a hypothetical example of "business project attraction through international investment" is discussed to explain the hypergame. This project was proposed through a meeting between foreign investment firm A and local government B on which the decision was made to proceed as per the planning process.

(I) Project Formation Phase
Foreign investment firm A and local government B jointly prepare a business plan.
(II) Location Selection Phase
Based on the result, local government B selects the candidates for the business base.
(III) Project Implementation Phase
Local government B prepares the location for businesses to move in collaboration with the local community C. Subsequently, foreign investment firm A invests in this location to establish a business base.

However, public opinion on the selection of the business location became heated in the location selection stage. Ultimately, foreign investment firm A decided to withdraw from the investment, although area y had been selected, and the project was not brought to fruition.

First, the stakeholders were set to be A: foreign investment firm, B: the local government, and C: the local community. Table 2.3 shows the option set of each of these agents. The options of agent A are decisions on whether to invest and withdraw from the project; the options of agent B are the selection of the potential business locations and cancelation of the project; and the options of agent C are whether to support the plan.

2.5.1 *Prior to Project Formation Phase*

Initially, foreign investment firm C considered the project as a vague vision of developing a tourist resort. Thus, it was only thinking of area x, which is suitable for this idea (and highly attractive for investment) for the base business plan. The game that appears in the internal model of agent C is a two-player one with a simple structure pertaining to whether or not local government A and foreign investment firm C both join the project (See Fig. 2.7I-1). In this game, the gain of agent A is the sum of successful investment 2 and project cancelation -1, which indicates that it is

Table 2.3 Stakeholders in project process and their option sets

Agent ID	Names	Options	Contents
A	Local governments	x	Selecting a location in the x are (high investment attractiveness)
		y	Selecting a location in the y area (low investment attractiveness)
		z	Cancel the project
B	Local communities	a	Support for the proposed site
		b	Opposition to the proposed site
C	Foreign investment firm	1	Investment execution
		0	Withdrawal of the investment

Agent ID	Names	Options	Contents
A	Local Governments	*x*	Selecting a location in the *x* area (high investment attractiveness)
		y	Selecting a location in the *y* area (low investment attractiveness)
		z	Cancel the project
B	Local Communities	*a*	Support for the proposed site
		b	Opposition to the proposed site
C	Foreign Investment Firm	1	Investment execution
		0	Withdrawal of the investment

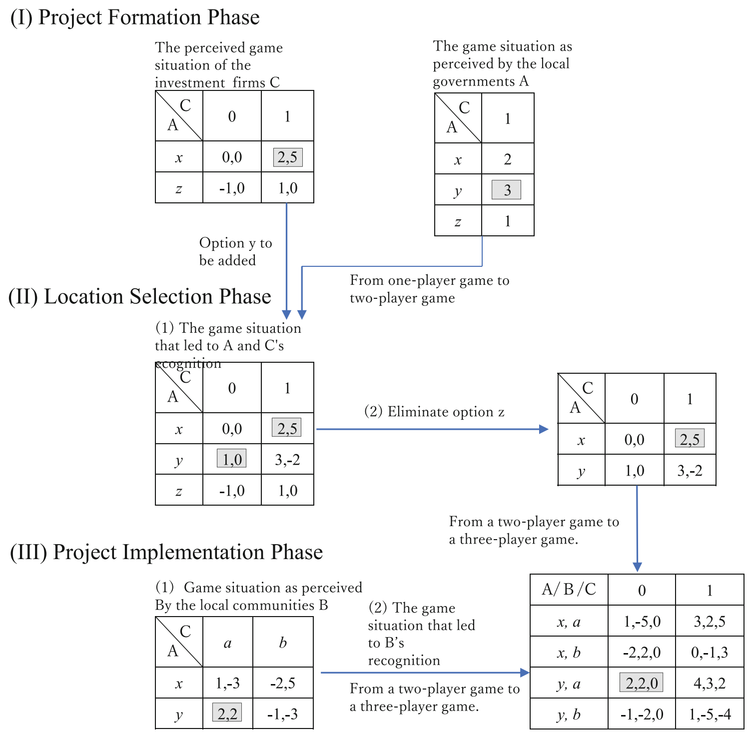


Fig. 2.7 Hypergame descriptions in mutual learning process on international investment project on industrial location

2 when (x, 1), -1 when ((x, 0), $2 - 1 = 1$ when (y, 1), and -1 when (y, 0). However, the gain of agent C is 5 when (x, 1), which indicates the investment is executed as per the plan, and 0 in all other situations. At this point, agent C takes the equilibrium point of the game to be (x, 1) without any doubt.

Furthermore, local government A understood the project to be a policy issue for promoting national industry and a solution for regional inequality. Thus, its vision for the project was vaguer than that of foreign investment firm A. Here, the internal model of agent A was formalized as a one-player game in practice ((I) (B)), where agent C possessed a singleton action set (a set with only one element) for which the only option was action 1: "investment execution." From the perspective of solving regional inequality, the highest preference (gain point: 3) of agent A was area y, which was therefore less attractive for investment than area x. Its second preference (gain point 2) was area x, and its third preference (gain point 1) was the project's cancelation. At this point in the process, agent A and agent C had completely different game states in mind.

2.5.2 Project Formation Phase

Local government A and foreign investment firm C attained an accurate understanding of the options and preferences of each other through the joint preparation of the business plan. At this point, the game that the two agents perceived was the same two-player game with 2×3 options ((II) (1)). This game had a "social dilemma" structure, where (y, 0), which was the only Nash equilibrium and was not Pareto optimal. During this phase, agent A removed project cancelation option z and the game state moved to ((II) (2)). However, the game state remained a "social dilemma." It is conceivable that at this point, the two agents were exploring the negotiation possibilities behind the scenes to move from the Nash equilibrium (y, 0) to the Pareto optimum (x, 1). Note that (II) (1) was formed when shifting from the (I) phase to the (II) phase, and was the result of adding option y to game (I) (1) that C was originally recognizing and can be considered as a synthesis of game (I) (1) and game (I) (2), which each agent, respectively, recognized. Moreover, note that agent C considered investment in area y to be unprofitable and assigned a gain point of -2 to it. Note the fact that, in the game, agent A was extended from a one-player game to a two-player game.

2.5.3 Location Selection Phase

At this point, reporting on this plan excited the local community, and a national discussion ensued. Although the community of area x perceived this project as being an excessive and undue encroachment by foreign capital, the community in area y considered a positive and proactive attitude toward it. The model does not distinguish between individual communities and treats them as one agent B, and is termed the "local community" for the sake of simplification. Local community B implicitly assumed the investment execution by agent C and perceived the situation as being a simple two-player game between agent A and agent B ((III) (1)). Here, the gain of A was 0 when x, and when y, it was given as 1 when the other player agrees, and as -2 when it disagrees with 1 being the base value. The gain of C was given as 2 when supporting the attraction of business, as 1 when opposing it, and as -3 in other instances. The resolution of the game conceived by agent B was achieved (y, a) without conflict. Agent A was supposed to select area y and agent B was supposed to accept it. However, because of the appearance of local community B, local government A started to perceive this game as being a three-player one ((III) (2)). Thus, the gain of A was the correction of (III) (1) with successful attraction as 2. Similarly, the gain of B was the collection of (III) (1) with successful support as 1 and its failure as -2; the gain of C was the correction of (II) (2) with investment execution despite the opposition from the local community. The equilibrium point (y, a, 0) of the game recognized by agent A was the only Nash equilibrium and it was Pareto optimal. In the end, A selected area y. Moreover, the foreign investment firm C, which did not notice the existence of the third player, i.e., the existence of agent B, until the last minute was surprised by this selection and secretly chose to withdraw its investment, i.e., option 0, in response to y being given. Furthermore, local community B, i.e., the community of area y, expected investment from foreign investment firm C and started to take action to attract business. However, no company willing to invest in that location appeared and the project failed. If the game state that emerged in Fig. 2.7III-2 was the true game, it can be argued that the recognition models of investor group C and local group A were consistently asymptotic to the true game from the initial (I) phase to the (II) and (III) phases. Such an asymptotic process of recognition models is known as a monotonous learning process. As is demonstrated by this example, even if the recognition model of each agent follows a certain monotonous learning process, it does not guarantee an improvement in the solution for every agent. Although this is only one example, an analysis of the change process in a hypergame offers meaningful knowledge for an exploration of the resolution strategy for complex conflicts. To date, a hypothetical project has been used to explain the interpretation of the model of the process. This project was prepared based on a study of a real international urban development project explored between Japan and Australia in the late 1980s called the Multi-Function Polis (Kaneda and Tawaraya 1998). The study by the authors comprised an intensive content analysis using news reports as the data source; it does not clarify how the real stakeholders perceived the situation within their respective "internal models." Moreover, while the premise of a rational actor is looser in a hypergame, it still does not deviate from the category of the first model proposed by Allison. One must be aware of the fact that a significant degree of abstraction was applied to the model. Nevertheless, the model discussed here demonstrates that it is possible to build a coherent explanation system by employing system concepts such as the hypergame and mutual learning and connecting partial factual data.

2.6 Conclusion

In this work, various concepts for establishing the analysis of the learning process in an n-player first-level hypergame were mathematically formalized and their characteristics organized. Hypergame space is central to the formalized concepts, characterized by three types of model orders, namely, the preference identification order, the strategy set extension order, and the agent set extension order. The clarified characteristics include the fact that when the equilibrium strategy of the hypergame matches that of the true game in the first two learning processes, they remain stable in the learning space. Moreover, a project to attract businesses via international capital investment was explained in terms of a collaborative planning process, which it exemplified. The learning process analysis presented here was inferred to offer insight that would be useful for devising strategies and predicting and responding to potential conflicts in actual problems, in addition to its utility for ex-post analyses. The hypergame described in this chapter deals with a situation in which mutual actions were considered while each player was not aware of the "misperception" of its own internal model, as well as those of others; it is called a first-level hypergame. The game situation where certain players are "aware" of the misperception of other players is called a second-level hypergame. The stage of the hypergame is raised further if some players in turn perceive recognition by these players who believe that they recognize this second-stage situation to be a misperception. In the 2010s, research on the abstract formalization of hypergames advanced (e.g., Sasaki and Kijima 2016). Moreover, there have been new attempts at theoretical advancements (e.g., Kovach et al. 2015). Furthermore, the hypergame is a model that describes cognitive gaps by exploring them down to their fundamental mechanisms; it has proximity to cultural exchange games (Fowler and Pusch 2010) such as BAFABAFA (Shirts 1975, 1997) and BARNGA (Thiagarajan 1984; Thiagarajan and Thiagarajan 2011). The authors are also of the view that it has potential as a tool for transrelational systems research.

Note that this study is the result of the editing, recomposition, and English translation of the following three studies: A Theoretical Study of the Performance of Model-Referenced Decisions on the Model Learning Process (Kaneda and Kitani 1995); Learning Process Analysis on Hypergames (LPAH)—For Risk Management on Potential Conflict in Collaborative Planning (Kaneda and Kitani 1997); Gaming Models for Urban Society Conflict in "Simulation and Gaming for Societal System Design (Kaneda 2005)."

Proof of "Proposition 2.1"
First, the following lemma is proven. "For A_j, A_j', that is, $A_i \cap A_j = \phi$ $(i \neq j)$, it is $A_j \subset A_j'$ for every j if $\cup_j A_j \subset \cup_j A_j'$" [Proof of the lemma]. For every a $\in A_j$, a i that is a $\in A_j'$ or a $\in A_i'$ exists. Therefore, $A_j \subset A_j'$ can be proven by demonstrating that a does not belong to A_i' for every i. If a $\in A_i'$ and $A_i \cap A_j' = \phi$ for a given i, a does not belong to A_j. This contradicts a $\in A_j$. Thus, no i, that is, a $\in A_i'$, does not exist [Lemma q.e.d].

Here, this lemma is applied to matching set Δ_j shown in Definition 2.2. The focus is on the preference identification process of agent j, shown below. For instance, when:

$$\Delta_j \equiv \Pi_{k,\ j\in\mathrm{N},\ k\neq j}\left\{\left(\prec_{kj}\cap\prec_k\right)\cup\left(\overline{\prec_{kj}}\cap\overline{\prec_k}\right)\right\}$$

$$\Delta'_j \equiv \Pi_{k,\ j\in\mathrm{N},\ k\neq j}\left\{\left(\prec_{kj}{}'\cap\prec_k\right)\cup\left(\overline{\prec_{kj}{}'}\cap\overline{\prec_k}\right)\right\}$$

It is $\Delta_j \subset \Delta'_j$ for agent j if $\mathbf{m} \prec_{\mathrm{i}} \mathbf{m}'$, and it is $\prec_{kj} \subset \prec'_{kj}$ from the earlier lemma. Therefore, the following is true:

S $\prec_{kj}$ s′ if s $\prec'_{kj}$ s′⋯⋯⋯⋯(*)

Returning to the main proposition, when an arbitrary model m is given, it is $s^* \in CES(\mathbf{m})$ for the Nash equilibrium $s^* = (d_1{}^*, \ldots, d_i^*, \ldots, d_j^*, \ldots, d_n{}^*) \in CES(\mathbf{m_r})$. At this point, the following inequality is obtained from the definition of the Nash equilibrium:

For every k and j that are $d_{kj} \neq d_{kj}{}^*$, it is

$$\left(d_{1j}{}^*, \ldots, d_{kj}{}^*, \ldots, d_j{}^*, \ldots, d_{nj}{}^*\right) \succ_{kj}\left(d_{1j}{}^*, \ldots, d_{kj}, \ldots, d_j{}^*, \ldots, d_{nj}{}^*\right).$$

At this point, regarding $\mathbf{m} \preccurlyeq_{\mathrm{i}} \mathbf{m}'$, from (*), it is

$$\left(d_{1j}{}^*, \ldots, d_{kj}{}^{*\prime}, \ldots, d_j{}^*, \ldots, d_{nj}{}^*\right) \succ'_{kj}\left(d_1{}^*, \ldots, d_{kj}{}', \ldots, d_j{}^*, \ldots, d_{nj}{}^*\right),$$

for every k and j that are $d_{kj} \neq d_{kj}{}^*$.

This indicates $s^* \in CES(\mathbf{m}')$. [q.e.d.]

Proof of "Proposition 2.2"

Here, the strategy set extension process of agent j is understood as follows. It is $s^* \in CES(\mathbf{m})$ for the Nash equilibrium $s^* = \left(d_1{}^*, \ldots, d_i^*, \ldots, d_j^*, \ldots, d_n{}^*\right) \in CES(\mathbf{m_r})$. At this point, the following inequality is obtained from Definition 2.7.

For every k and j that are $d_{kj} \neq d_{kj}{}^*$, it is

$$\left(d_{1j}{}^*, \ldots, d_{kj}{}^*, \ldots, d_j{}^*, \ldots, d_{nj}{}^*\right) \succ_{kj}\left(d_{1j}{}^*, \ldots, d_{kj}, \ldots, d_j{}^*, \ldots, d_{nj}{}^*\right).$$

For every k that is $d_k \neq d_k{}^*$, it is

$$\left(d_1{}^*, \ldots, d_k{}^*, \ldots, d_j{}^*, \ldots, d_n{}^*\right) \succ_k\left(d_1{}^*, \ldots, d_k, \ldots, d_j{}^*, \ldots, d_n{}^*\right).$$

Let us think of $\mathbf{m}'$, that is, $\mathbf{m} \preccurlyeq_{\mathrm{se}} \mathbf{m}$. The preference $\succ'_{kj}$ inside $\mathbf{m}'$ matches $\succ_k$ inside $\mathbf{m_r}$, considering the fact that $\mathbf{m_r}$ is the limit of the strategy set of $\mathbf{m}'$ during the strategy set extension process. Moreover, if $s^* \in CES(\mathbf{m})$, s^* is one of the results in $\mathbf{m}'$ from the definition of the strategy set extension order $\preccurlyeq_{\mathrm{se}}$. Therefore, at this time, for every k and j that are $d_{kj} \neq d_{kj}{}^*$, it is

$$\left(d_{1j}{}^{*}, \ldots, d_{kj}{}^{*\prime}, \ldots, d_{j}{}^{*}, \ldots, d_{nj}{}^{*}\right) \succ'_{kj} \left(d_{1j}{}^{*}, \ldots, d_{kj}{}', \ldots, d_{j}{}^{*}, \ldots, d_{nj}{}^{*}\right).$$

Thus, $s^{*} \in CES(\mathbf{m}')$ is true [q.e.d.].

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Chapter 3
Designing a Right-Conversion Game for Affordable Housing in Addis Ababa

Biya Girma Hirpo and Toshiyuki Kaneda

Abstract Right-conversion is an urban redevelopment approach which involves transferring of rights on land and building to the equivalent floor of newly constructed buildings in the project area. This chapter details the design of a right-conversion game and its application to a slum redevelopment project that aims to provide affordable housing in Addis Ababa. In this study, the basis of an Addis Ababa version right-conversion is first identified. Then, the game is developed, and a playtest is performed on a case study slum area in Woreda 01 in Lideta Sub-City. The result of the conducted playtests revealed that the approach is an effective way to deliver affordable housing and furthermore, it contributes to improving the participation of residents in the decision-making process, utilizing land efficiently, and creating a design responsive to the local lifestyle.

3.1 Introduction

Addis Ababa, the capital and largest city of Ethiopia, is home to over 3.5 million people (CSA 2013). According to the United Nations Human Settlements Program (UN-Habitat), slum areas comprise 80% of Addis Ababa, of which 60% are filled with Kebele houses (UN-Habitat 2010). Kebele houses are government-owned, low-cost rental houses, most of which are located in the inner city. These low-cost rental houses are characterized by poor housing conditions, a low level of infrastructural services, narrow roads in the neighborhood, and substandard building materials, such as traditional wood and muds (Elias and Laura 2018). Further, private home ownership levels are low in Addis Ababa's slum areas; only 30% of houses are

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owner-occupied (Haregewoin 2007). However, the condition of the privately owned houses is better than that of Kebele houses.

The Government of Ethiopia established a policy to redevelop slum areas and deliver affordable housing to the citizens in 2008 under the Integrated Housing Development Program (IHDP) (UN-Habitat 2010). Affordable housing refers to housing units that are affordable by that section of society whose income is below the median household income (Bhatta 2010).

The IHDP is financed by the government and aims to provide condominiums for low- and middle-income citizens, who typically live in precarious housing situations. Condominium recipients pay for the full construction cost of their condominiums over time. Although these condominiums offer improved physical environment and infrastructures, they have not had their desired impact, for three main reasons.

In many cases, the monthly mortgage payments were too high, making them unaffordable for the residents; as a result, up to 70% of homeowners have moved to new locations and now rent out their condominium (UN-Habitat 2010). Additionally, many of the IHDP-provided condominiums are located in the city outskirts, where access to jobs is low, making them inaccessible to would-be residents. Many residents originally living in slum areas that relocated to the city outskirts find their social support network and livelihood disrupted, as they can no longer participate in their formal or informal business activities (Elias and Laura 2018). Finally, there has been a lack of community participation (Gezahegn and Jan 2015). As noted by Yap Kioe Sheng, “whenever low-income housing projects fail to produce the desired result, the failure is attributed to a lack of community participation” (Sheng 1990). People know best what they need, want, and can afford; genuine community participation can result in projects that satisfy both the community and the authorities (Paul 1987). Further, having residents participate in the planning, designing, and building process leads to an environment that is more responsive to the local lifestyle (UN-Habitat 2010).

The objective of this chapter is to show the potential of a right-conversion type urban redevelopment system to deliver affordable housing for low-income residents currently living in slum areas. In order to reveal this potential, we developed a right-conversion game, a tool that is used as the main research methodology. The game aims not only to provide affordable housing but also to increase resident participation in the decision-making process, increase the development of public facilities, and provide designs adapted to the local lifestyle. A playtest is then performed on a case study slum area in Woreda 01 in Lideta Sub-City to validate the process.

3.2 Right-Conversion Type Urban Redevelopment

Right-conversion is an approach that originated under the 1969 Urban Redevelopment Act in Japan. After World War II, Japanese urban areas saw an increase in the population and industrial development. These increases led to a number of problems, including housing shortages, congestion (traffic jams), insufficient urban facilities, and deteriorating living environments, thus revealing the necessity of urban redevelopment projects. Two urban redevelopment methods have been employed:

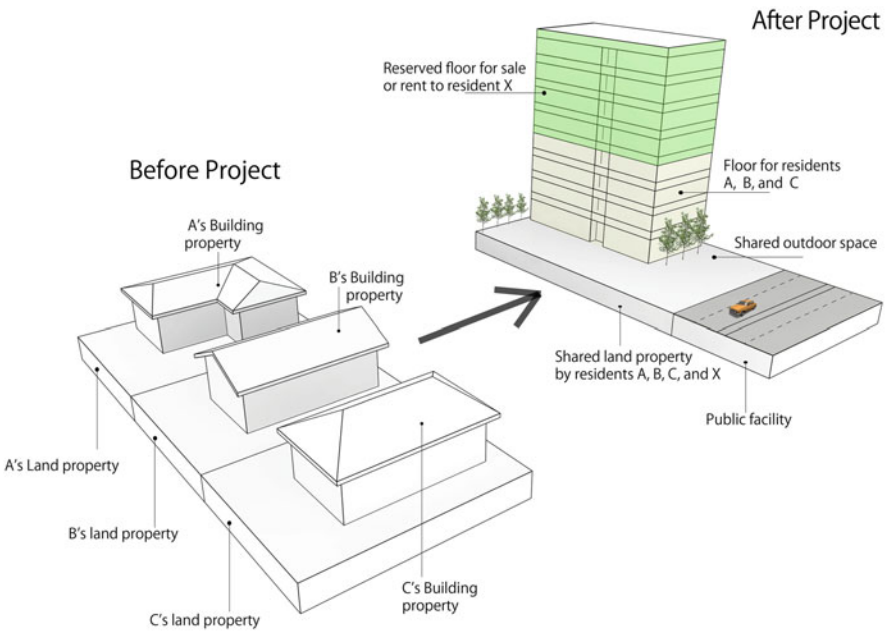


Fig. 3.1 Representative example of right-conversion type urban redevelopment

Category I, based on right-conversion, and Category II, based on land purchase (JICA 1987).

Right-conversion involves the transference of land and building rights to an equivalent space in a newly constructed building, as shown in Fig. 3.1. After the area is identified to be redeveloped, the executor proposes the right-conversion plan by classifying the original rightful persons in to two categories, namely persons who desire to remain on the area or move out. It is carried out by valuating the rights of former rights holders and acquiring a right floor for the valuation in a new building. Accordingly, former rights holders can continue without relocating their residence or business. Those who do not wish to use the floor of a new building can receive monetary compensation in accordance with the amount of previous assets (Ibid.). This method does require appropriate legislative systems to be developed for social system support, modernized city planning systems, and the official valuation of assets (Kaneda et al. 2020).

Right-conversion projects contribute to the development of public facilities, create favorable urban environments, increase housing supply in urban centers, and reorganize and modernize urban structures. It consists of the cooperation of three parties: landowners (owners of land and buildings), those who acquire reserve floor space (developers, etc.) and the national or local governments. The projects can be executed by individual owners, urban redevelopment cooperatives, or local public entities (JICA 1987). The costs of the projects are to be covered from the sale of reserved floors and governmental subsidy. The subsidy mainly consists of subsidy for street construction works and subsidy for survey and site preparation. However, the project cost is to be born temporarily by the executor (Ibid.).

3.2.1 *Basis of an Addis Ababa Version of a Right-Conversion Type Urban Redevelopment*

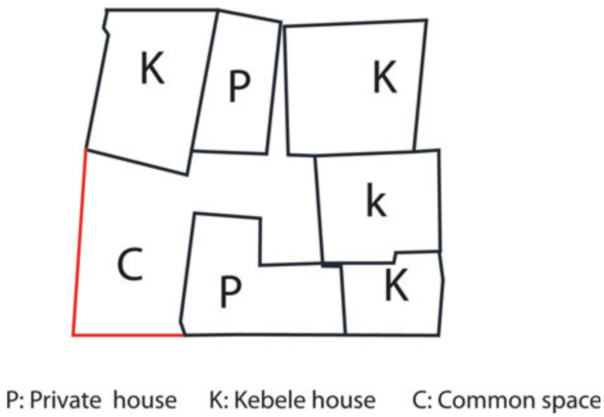
In the slum areas that are the focus of this study, there are Kebele houses and Private houses as shown in Fig. 3.2. Kebele houses account for the majority of properties, although there are also significant number of privately owned houses. Regarding the legal rights of the residents, the two households have different legal rights. Kebele houses are owned by government therefore residents have only rental (tenancy) rights to use the house while private house residents have ownership (property) rights.

In both cases, the ownership of land is vested in the Government of Ethiopia (Atakilte 2003). However, private house owners have land possession right while Kebele residents have only use right on the land. To explore other rights, the lifestyle, source of income, and advantages of living in slum areas were studied. The following points were gathered:

- In slum areas, houses function both as a living space and a working space where income is generated.
- The houses have spaces that are flexible, multifunctional, serve daily and nightly functions, are continuously changing, and are dynamic (Felix and Bisrat 2016).
- Residents have a complex social support system, have high levels of social interaction, and live interdependently (Gossaye 2000).
- The houses are in the city center and in close proximity to the resident's place of employment.
- The neighborhood has shared common spaces that are multifunctional.

As the majority of the houses in slum areas are Kebele houses and the residents are low-income groups, it is assumed that right-conversion would be executed by local public entities. Therefore, in the right-conversion Addis Ababa version, the city administration is assumed the main executor of the redevelopment activity.

Fig. 3.2 Representative example of composition of Kebele and private houses in slum areas



Since the government is the main executor, the usual administrative procedure for executing urban redevelopment projects according to the IHDP is followed at the initial stage. During IHDP projects, first, residents are informed of the redevelopment idea and shown the prepared redevelopment plan. The residents can then opt-in to stay on-site after the completion of the redevelopment project, in which case they receive an apartment unit (condominium) with a rent-to-own option (Abebe 2018). The government covers the construction cost; residents who own the new condominiums then repay the cost of their units gradually. In this case, Kebele house residents' "rental right" is converted to "ownership right" of the new houses. Nevertheless, the initial down payment, usually 20%, and the monthly mortgage payments were too high which makes owning the new houses unaffordable. Therefore, in the right-conversion model, in addition to changing "rental rights" to "ownership right," Kebele house residents' "rental rights" will also be transferred to the new houses. In addition, private house residents "ownership right" is transferred to the floor of newly constructed buildings in the project area as shown in Fig. 3.3.

From our study of advantages of slum areas, the need to maintain an adequate income, not housing conditions, is often the primary concern of low-income residents. Without increasing income, it is difficult to create affordable housing. Therefore, this work also considers that a person's right to work and generate income in their house must also be transferred to the newly constructed houses.

3.3 Right-Conversion Game

A game is set of activities performed by groups of players who have goals, limitations, and payoffs as result of their decisions (Greenblat and Duke 1981). In the field of urban planning, games have been used to collect data from citizens, foster citizen engagement, foster communication among stakeholders, and further professional education. Game design is what regulates gameplay (Greenblat 1988). The Addis Ababa rights-conversion game is developed by using the 'Rights-Conversion-Type Urban Redevelopment Game Considering Financial Risk Management' as a game frame (Kaneda et al. 2019). *Our* gaming exercise is a role-play game, in which each player assumes the role of a character based on the provided information.

3.3.1 Outline of Right-Conversion Game

The gaming procedure for the developed right-conversion game used for the simulation of collective slum redevelopment projects in Addis Ababa involves the following five steps:

Step 1. Gaming Assignment: First, the pre-project information about the resident and proposed redevelopment plan are presented to the players. This information includes house ownership type (Kebele or private), surface area of the house,

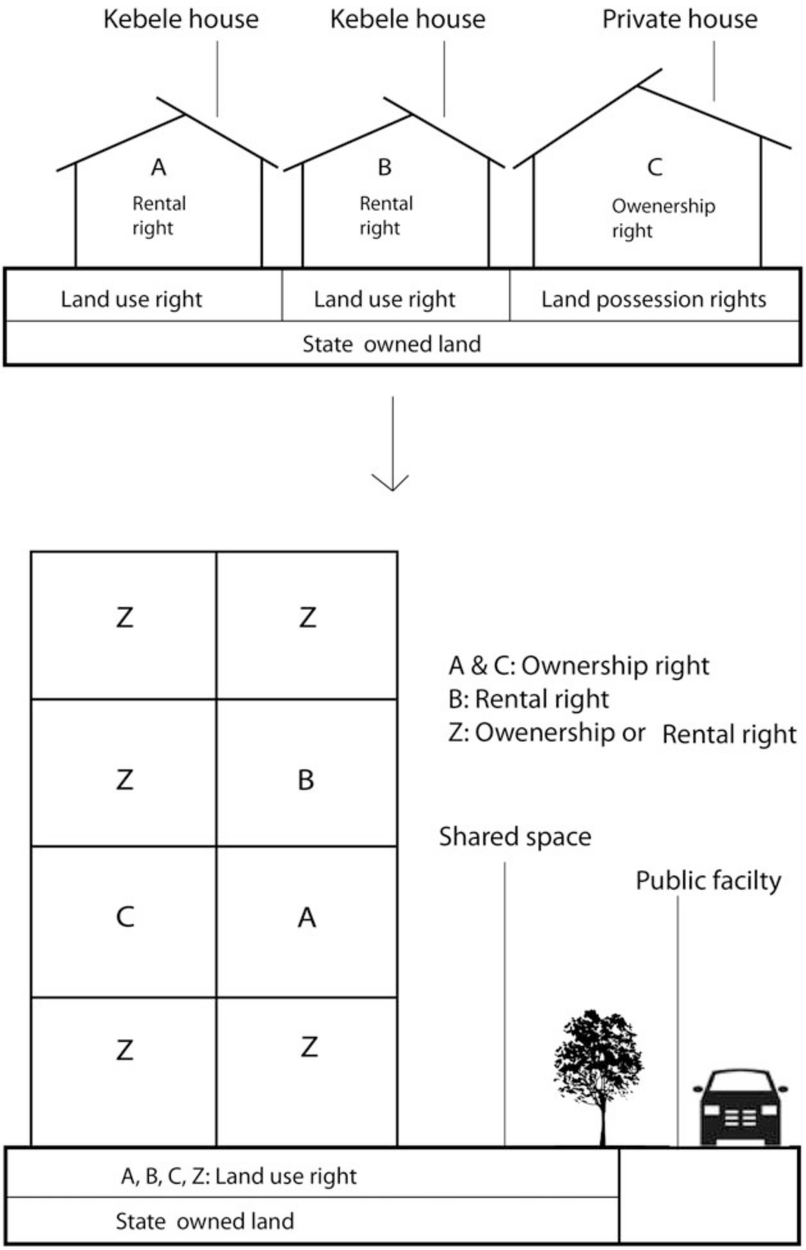


Fig. 3.3 Right-conversion model Addis Ababa version

house floor plan, house functionality, family size, source of income, and monthly income. This information allows the role-player to assume the condition and interest of the residents.

Step 2: Creation of an Individual Plan: The players then focus on imagining the future development of the entire area while considering the size and type of their individual unit. Individual plan formation boards are prepared for each resident. In Fig. 3.4, sample individual plan formation board is shown for the resident living on plot number one. To assist players in the planning process, request cards for the total development and special request cards for the individual house unit are prepared; the list of request cards are shown in Fig. 3.5.

Step 3: Creation of an Agreed Plan: The players then discuss and decide what type of redevelopment best meets the needs and profits all players. After a consensus is reached, they draw up an agreed group plan for a redevelopment.

Step 4: Occurrence of Risk Events: The facilitator randomly selects one risk card and informs the players of the change, such as an increased construction cost or a delay in construction. The effect of these cards on the decision to complete the project is detailed in Step 5.

Step 5: Affordability Check: Finally, the players must decide whether to proceed with the project, based on whether it is affordable. The following mathematical formula was thus developed, representing the total costs minus the total income, for which a negative result indicates that the project is affordable.

$$\begin{aligned}&(\text{Floor area} \times \text{Construction cost} + \text{R})\\&\quad - (\text{Monthly saving} \times 20\,\text{years} + \text{Compensation award})\end{aligned} \tag{3.1}$$

Here, the floor area depends upon players' interest and choice. As shown in Fig. 3.4, for example, a player who choose one-bed-room type apartment will receive floor area of 50 m^2. Additional floor area can also be requested by using the request card dedicated for that. R represents the added costs due to the risk card. The monthly saving represents 30% of their monthly income, which accounts for their previous monthly income and a randomly selected expected income increase of 0%, 100%, or 200%. We expected there will be an income increase as they are going to live and work in a better environment. However, we also considered 0% increase because of occurrence of risks which might avoid an income increase. The compensation award is the amount of money awarded to private house owners in recognition of the demolished house for redevelopment.

3.3.2 Devices for the Gaming Exercise

During gameplay, all "requests" to be included and "risks" to which the project is exposed are represented by cards; list of cards is shown in Fig. 3.5 and sample request cards and risk card are shown in Fig 3.6. Each request card shows the additional item a player wants to incorporate into the project plan. For example, the resident may choose a request card for quite environment if he/she wants the site to have calm atmosphere. The special request cards are incorporated to increase

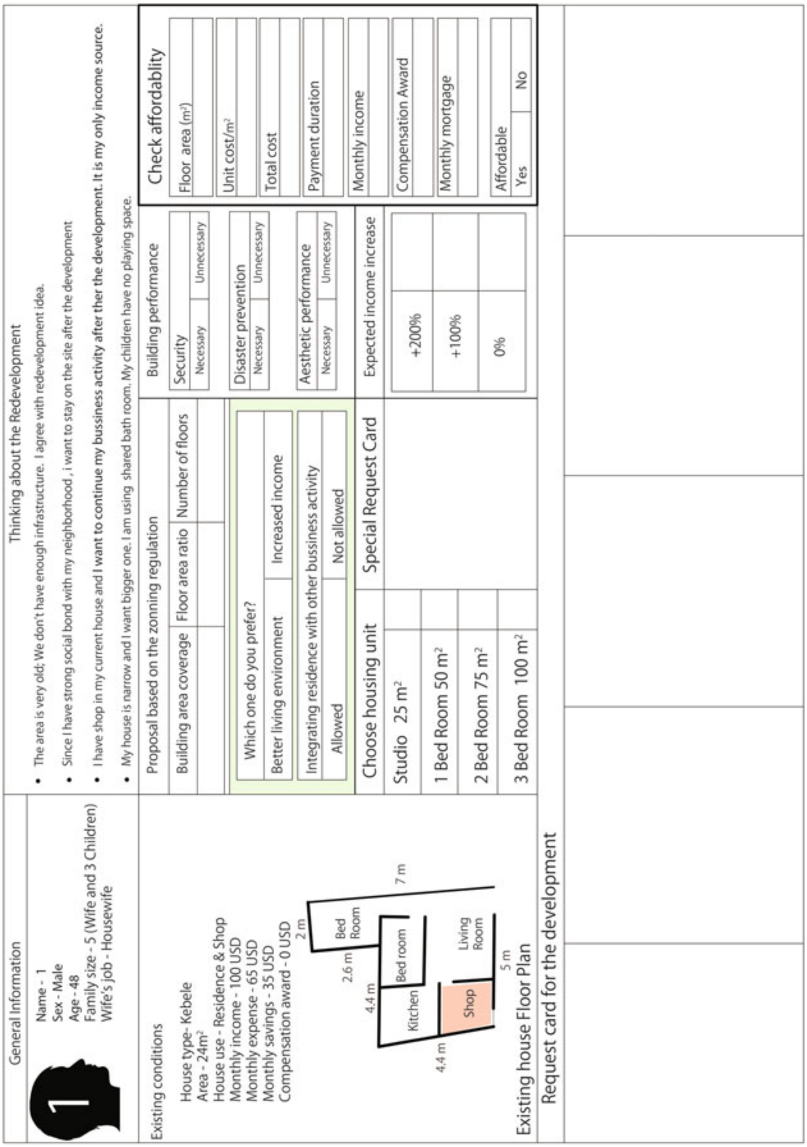


Fig. 3.4 Sample individual plan formation board, plot number one

Request Cards (For the total development)

Development suited to cityscape	Children playground	Reduce financial burden
Generate footfall	Small scale development	Improve security
Use local building materials	Large scale development	Make affordable
Easy management after redevelopment	Green building	Aesthetics
Make durable	Quite environment	Common space
Green environment	Improve disaster prevention	Shorter development period

Special Request Cards (For the individual house unit)

Lower floor	Movable partition wall	Shared house
Upper floor	Additional floor area	No partition wall
Commercial unit	No finishing work	

Fig. 3.5 List of request cards

player's income or decrease the construction cost of the house. Additionally, Legos were used to create three-dimensional model of the agreed design at the end of the gaming exercise.

3.4 Case Study

3.4.1 Case Study Details

Lideta is approximately 2 km from the central business district, as shown in Fig. 3.7; it is one of the highest-valued areas in Addis Ababa and has a high potential for redevelopment. The selected site, shown in Figs. 3.8 and 3.9, is in Woreda 01 in Lideta Sub-City, commonly referred to as the Darmar area. Covering 1590 m^2, the site contains 18 households, of which 12 are Kebele houses and the remaining 6 are private homes. Most of the houses were constructed 50 years ago with mud and straw and do not have indoor plumbing. Poor housing conditions, fragmented plot sizes, and narrow roads characterize the neighborhood. Of the 18 current households, 10 were assumed to opt-in to redevelopment. These residents' information and house condition are shown in Table 3.1.

In accordance with the city's land-use regulations, the studied area is planned for high-density mixed residential. The floor area ratio (FAR) should be between 4.5 and 5.5, and at least 40% of the building (excluding parking space) should be residential. The maximum building area coverage (BAC) is 75% and the maximum height of the building is 35 m. One tree (approximately 4 m^2) should be planted every 100 m^2 (Addis Ababa city planning project office 2017). The construction cost varies depending upon the height and use of the building as shown in Table 3.2.

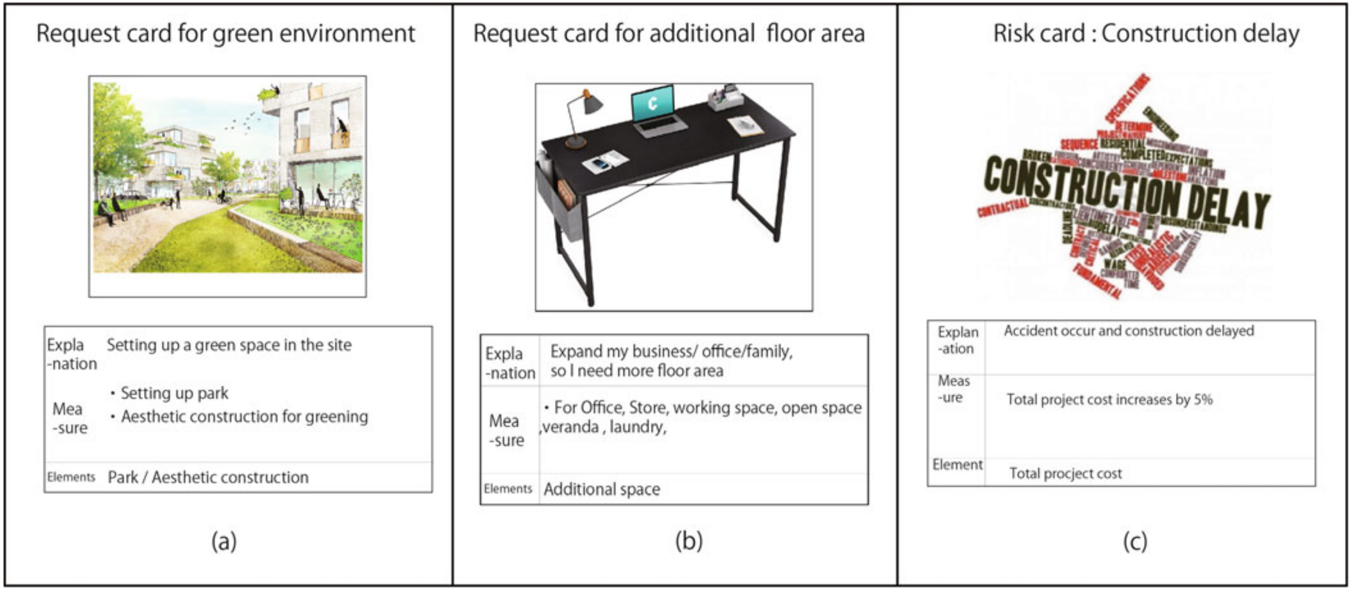


Fig. 3.6 Sample (**a**) Request card for the total development, (**b**) Special request card, (**c**) Risk card

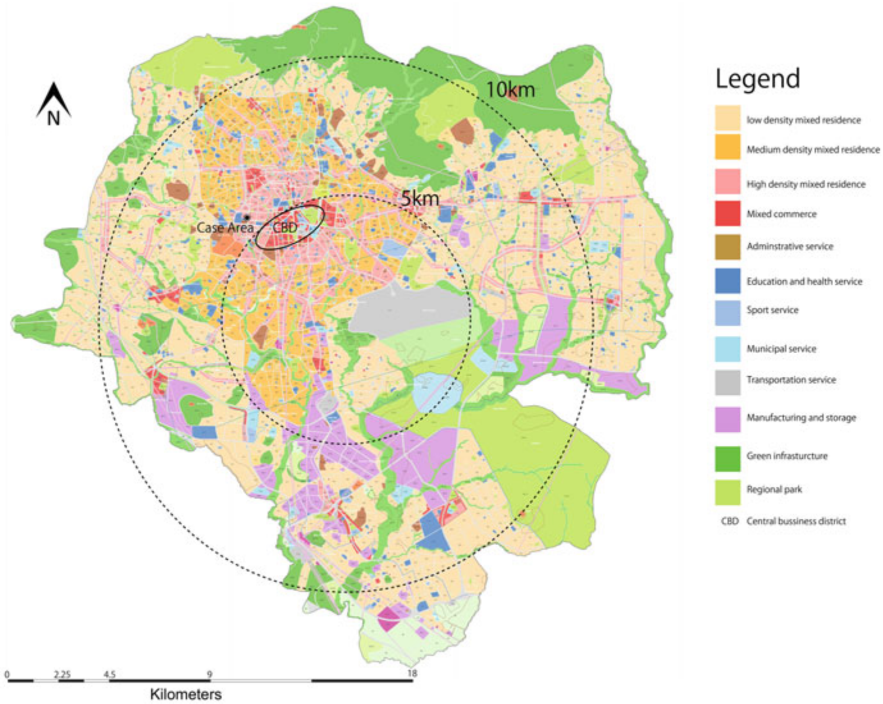


Fig. 3.7 Addis Ababa land use (Addis Ababa City Planning Project Office 2017)

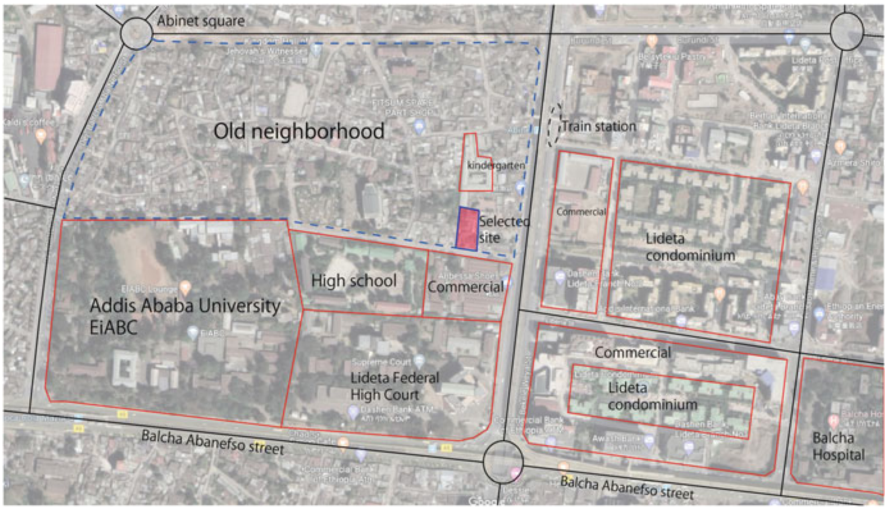


Fig. 3.8 Case study area, outlined in blue line (Adapted from Google Maps 2020)

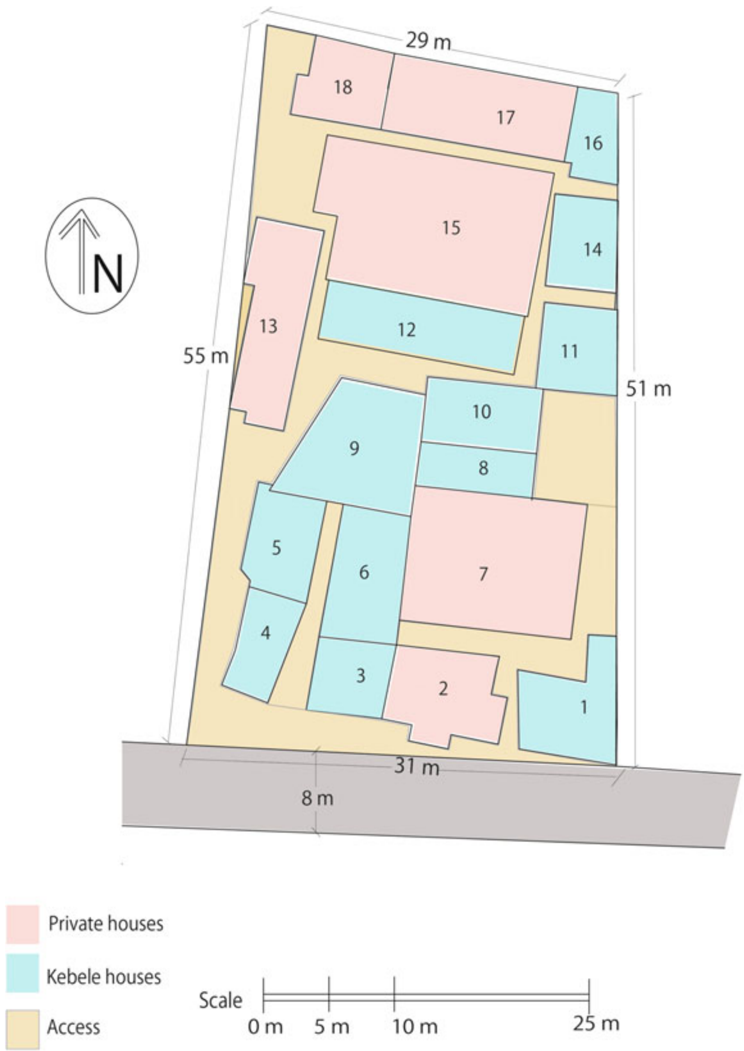


Fig. 3.9 Map of existing neighborhood used for case study

3.4.2 Proposed Plan

The city administration first proposes the redevelopment plan to the residents, who can agree with the plan, modify it, or propose their own plan. In this case study, a proposal is made based on the zoning regulations, IHDP experiences, and other legal frames. In the proposed plan, shown in Fig. 3.10, FAR = 4.5, BAC = 65%, and the original site were readjusted and decreased by 20% for the construction of infrastructures. Two apartment blocks and one commercial block, each containing seven

Table 3.1 Pre-project condition of the owner and the house

Plot No.	House type	Area	Main use of the house	Additional use	Family size	Monthly Income
1	Kebele	24 m^2	Residence	Shop	5	100 USD
2	Private	29 m^2	Restaurant	–	6	260 USD
5	Kebele	21 m^2	Residence	–	3	100 USD
6	Kebele	28 m^2	Residence	Furniture workshop	7	260 USD
7	Private	74 m^2	Residence	Hair salon	5	100 USD
9	Kebele	43 m^2	Residence	Bakery	6	160 USD
10	Kebele	22 m^2	Residence	Laundry	4	130 USD
11	Kebele	19 m^2	Residence	Local bar	4	130 USD
12	Kebele	35 m^2	Residence	Barber shop	5	130 USD
15	Private	103 m^2	Residence	–	4	330 USD

Table 3.2 Estimated construction cost for the new building

Building height	Residential building	Commercial or Office building
G + 0–G + 1	130 USD/m^2	100 USD/m^2
G + 2–G + 4	200 USD/m^2	150 USD/m^2
G + 5–G + 7	260 USD/m^2	200 USD/m^2
G + 8–G + 12	330 USD/m^2	260 USD/m^2

floors, were proposed. The area dedicated for the commercial block is to be leased for private developers to cover the cost of infrastructure. The area dedicated for open space can be used for green area, a children's playground, or parking space.

3.4.3 Playtest

The playtest was conducted at the Nagoya Institute of Technology with five international students, pictured in Fig. 3.11. Each player represented two households and the exercise took three hours. First, the pre-project site conditions and the proposed plan were presented.

The players then formed their individual plans; this included selecting their preferred housing unit and any other special request cards. The most commonly selected special request cards used were the additional floor area and request for commercial units. The most selected total development request cards are a children's playground, a green environment, affordable construction, reduced financial burden, and the use of local building materials. The following cards were not used: development suited to cityscape, large-scale development, aesthetic building, and disaster prevention improvements.

After discussion, the players agreed upon the following cards: shorter construction period, green environment, common space, reduced financial burden, and use of

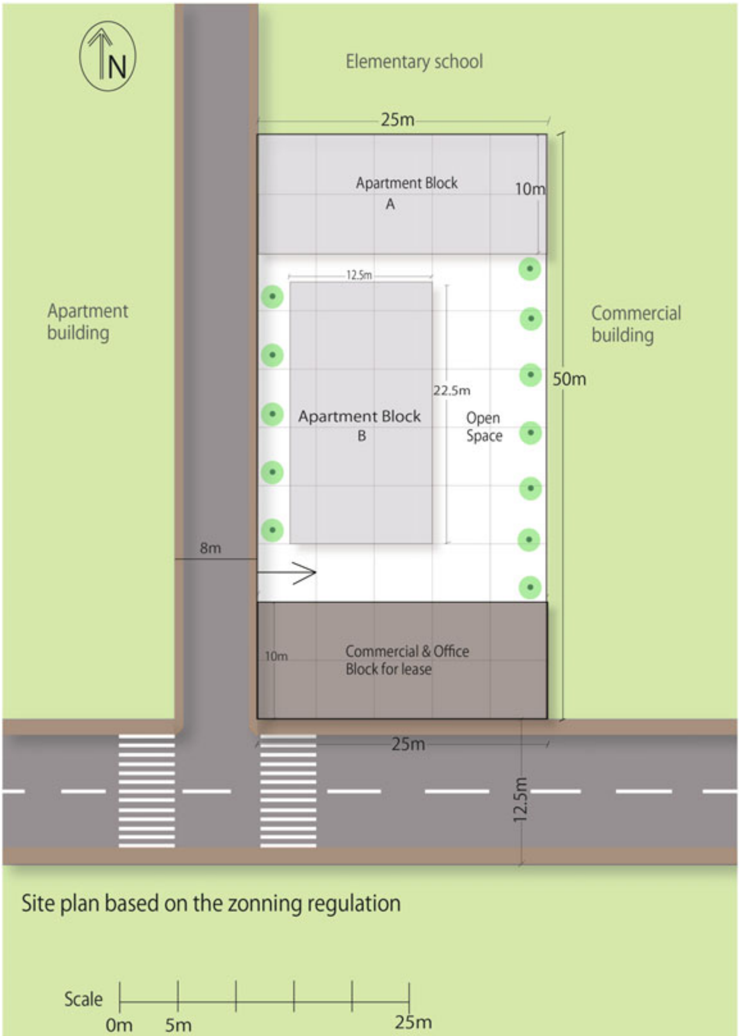


Fig. 3.10 Proposed redevelopment plan for the case study

local building materials. All players chose an increased income over a better living condition. They also preferred to integrate business into their residence; incorporating home-based business activities helped make the housing unit affordable.

Based on the discussion and the agreed cards, players proposed their own plan in response to the originally proposed plan. They proposed two apartment blocks which have commercial unit on the ground and first floors. Their proposal has

Fig. 3.11 Individual plan formation during the playtest

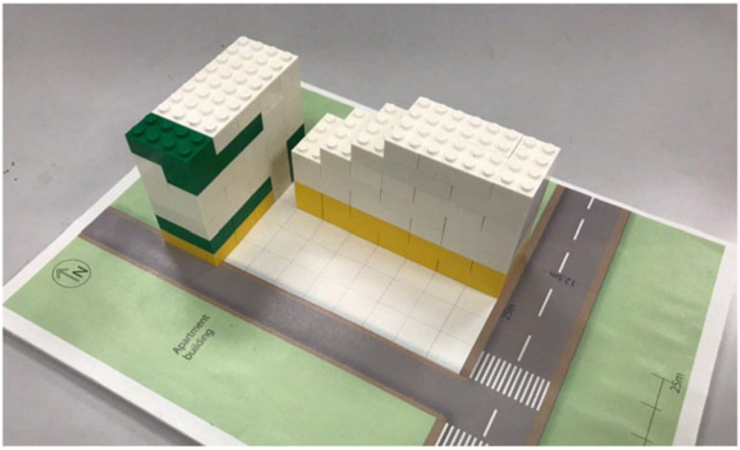


Fig. 3.12 Lego blocks model built by players

wider open space than the first proposal. They also prepared a Lego block model, shown in Fig. 3.12. Here, the yellow, white, and green blocks represent the commercial unit, apartment units, and the specific location of each players house, respectively.

3.4.4 Right-Conversion Game Evaluation and Findings

In the fourth stage, the randomly selected risk card caused a 2% increase in construction cost. The expected income increase was 100%. The affordability of the houses was then checked as shown in Fig. 3.13. Of the ten studied residents, plot 5 and 7 cannot finish the payment in 20 years. Then, the resident on plot 7 decided to decrease her floor area so that she can finish in 20 years. However, the resident on plot 5 could not afford even though he decreased his floor area. Then, he decided to use his rental right to receive the new house by rent without any option to buy. The playtest was then concluded with a ten-minute feedback session. The following feedback points were raised to improve the design of the right-conversion game:

- As the game is mainly designed for local residents to use, the rules and procedure should be made as simple as possible. For example, it may be difficult to calculate the FAR.
- It may be beneficial to include the roles of other stakeholders, as well, such as the contractor in the game play.
- The drastic difference between expected income increases of 0% and 200% has a major impact on the game and may be unrealistic; players recommended expected income increases from 0% to 100% in six ranges: 0%, 20%, 40%, 60%, 80%, and 100%.

3.5 Recommendation

- Without increasing resident's income, affordable housing is difficult to achieve. Therefore, in slum redevelopment projects, job creation mechanism must also be considered in parallel with the physical improvement of the area. Therefore, a person's right to work and generate income in their house must also be transferred to the newly constructed houses by incorporating home-based business into the design of residential units.
- Existing residents who want to continue their business must get priority to receive the commercial units by only paying the reserve price without getting into an auction. This helps former rights holders to continue living in the city center without relocating their residence or business.
- Kebele house residents who could not afford to buy the condominium units must get an option to transfer their rental rights to the new houses.
- The land ownership right has to be transferred from the government to the individuals. Currently, illegal selling of land is rampant as the land-holders afraid the government will take the land anytime. This has created urban sprawl and slum expansion in the city. Therefore, legalizing land sales, controlling the process, and preparing proper land-use plans will help to eliminate the problem from the root. Furthermore, transferring land ownership to individuals will ease the application of right-conversion in Ethiopia. Private developers will negotiate

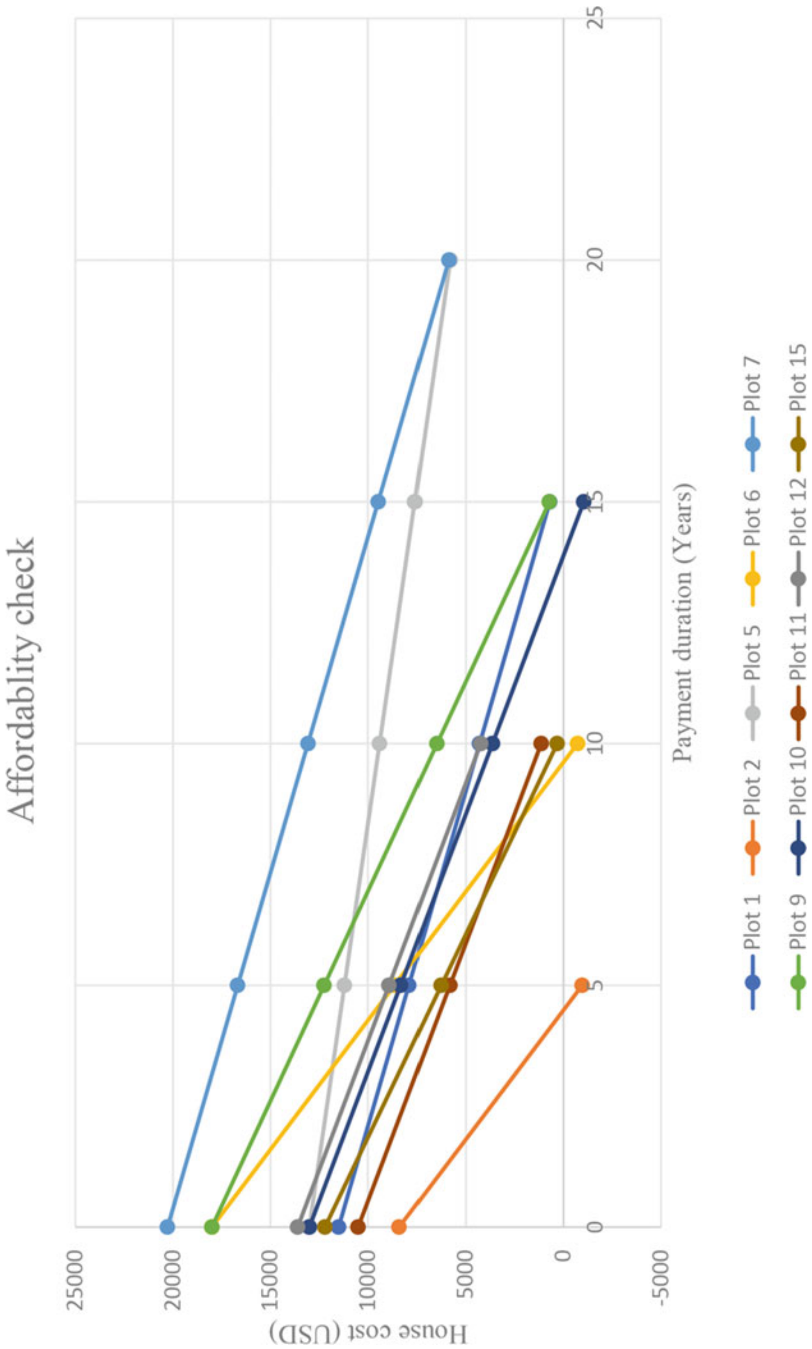


Fig. 3.13 Playtest result

with land-holders, whereas government controls land-use and other legal issues. It will have little reliance on public authorities and minimize monetary transactions which make it a useful approach for urban development projects in developing countries.

3.6 Conclusion

The main goals of this study were to explore the potential of right-conversion type urban redevelopment to deliver affordable housing for low-income households. The players were able to understand the idea behind the right-conversion project and the objective, procedures, and rules of the game. Each player's aim was to increase their income and decrease the cost of their house by using the request cards. The game also presents an effective way to increase participation, as it allows players to cooperate, share ideas, and make decision. Furthermore, this collaboration led to an unanticipated result, i.e., the players felt a high degree of ownership. Furthermore, the gaming exercise helped to developing public facilities, and creating a design responsive to the local lifestyle. Overall, applying the right-conversion game to explore the slum redevelopment project was interesting and effective for all players. However, further study on the development of right-conversion system for Addis Ababa is necessary. Here, the government was considered as the main executor of the redevelopment project; if executed by private developers, right-conversion will have little reliance on public authorities and will minimize monetary transactions, making this a useful approach for urban development projects in developing countries.

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Chapter 4
Games to Change Perceptions of Social Norms: What Constitutes Serious Games?

Michitaka Ohtani

Abstract This study determines the constituent requirements of serious games. From the viewpoint of discourse analysis, this study examines the issues around the typical definition of serious games and extracts the requirements that bear the meaning of "serious." This chapter clarifies that within a serious game, the functions and characteristics peculiar to the game as well as the "real advantage" obtained from the game are constantly adjusting. And, the effects of the gameplay are recursive. In this chapter, these two aspects are presented as the constituent requirements of serious games. Finally, taking a game with the theme of gender and sexuality as an example, this study points out that, from the constituent requirements of serious games clarified in this study, serious games are a practice that makes people realize that social norms have been collapsed.

4.1 Introduction

Various norms are inherent in society, and there are situations in which normative values become important when considering solutions to some social issues (Hechter and Opp 2001). In designing some kind of society (e.g., a sustainable society), normative values can influence that design.

In designing a particular kind of society, it would be attractive to use and produce games based on the normative values of society (Lafontaine et al. 2020). When designing a game, by reflecting social norms in the game, it is possible to express a multifaceted aspect of society, which shows the way to define an appropriate society. In addition, playing a game that deals with some kind of social issue allows the players to experience and recognize social norms related to the social phenomena

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handled in the game, and gives the players a perspective that cuts out various aspects of the real world.

Serious games are digital games that are generally developed and used for the purpose of "solving problems in various areas of society" and "for more than just mere entertainment"; they are attracting interest in various research fields, such as psychology, cultural research, sociology, and pedagogy (Connolly et al. 2012; Fedwa et al. 2014; Boyle et al. 2016).

Such serious games are used not only in the areas of medicine and education, but also in thinking about climate variability response, city planning, natural and scientific energy management, and governance of natural resources (Rodela et al. 2019). In this way, since the theme of these serious games is to solve a social issue, it is conceivable that games are produced or used on the premise of some social norms. Therefore, as a stepping stone to the discussion of this chapter, I start by considering the basic points of serious games.

This study considers that creating and using games that include social norms provides important knowledge in designing a particular kind of society. Therefore, this study considers "serious games."

If serious games are developed or utilized to solve problems in a particular social domain (e.g., education, business, politics, or healthcare), then their purpose differs from that of games intended for ordinary entertainment. In other words, what makes a game "serious" lies in solving problems in different areas of society for more than mere entertainment. Therefore, something denotes the meaning of "serious" to differentiate the two types of games.

However, it is difficult to clarify what "serious" means from a simple difference to an entertainment game. This is because a game has a variety of specifications, uses, genres, and ways of playing, and its substance changes depending on the location of the reference axis.

In the past, there has been much discussion on the definition of serious games. Although serious content has been clarified, the content changes according to the person arguing a point; some people point out that there are as many definitions as there are people involved in serious games (Susi et al. 2007).

With such a wide mix of definitions of "serious," it is extremely difficult to newly identify the contents and meaning of what a serious game is. This chapter does not directly discuss the contents of what makes a game "serious," but instead clarifies the meaning of "serious" the various assumptions that support its contents. Then, this is presented as a constituent of serious games.

There are two reasons for doing so, as follows. First, there are various debates on the definition and classification of serious games, which have refined and subdivided the items related to the requirements of serious games, and clarified the variety of serious games. However, as various types of serious game definitions (requirements) have been established, the items and requirements related to each definition have become duplicated, and the relationship between items and requirements has become multi-layered and complicated. In other words, it is difficult to understand serious games. In this context, this study attempts to identify common configuration requirements for serious games by considering the requirements of the definition through elevating the level of abstraction.

Second, the fact that this study considers definitions based on this one-step abstraction can be attributed to the interest in how serious games are developed and used. Since the subject of this study is not a definition with classification and evaluation of serious games, there is no consistency between the different requirements for serious games. This study clarifies only the formal requirements that construct a serious game.

For these two reasons, this study discusses the prerequisites for a game to be "serious" by using the viewpoint of discourse analysis, focusing on issues concerning the wider definition and general presentation of serious games.

4.2 Serious Games Overview

4.2.1 Serious Games Overview

The term "serious game" is said to have first appeared in the book *Serious Games* by Clark C. Abt (Abt 1970). Abt (1970) defined serious games as those that "have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (p9). At the time, games were meant for simulation, and were not video games as we know them today. Instead, Abt (1970) referred to the effectiveness of using games for education and communication.

The term "serious game" came into the spotlight only after the 2000s. Serious games began to spread in the USA in 2000, with the release of Virtual U, a university management simulation game, and the release in 2002 of America's Army, an advertising tool of the US Army. In this way, interest in the social use of digital games increased outside the gaming industry, and communities related to serious games were established, including the launch of research projects and promotional activities, including The Serious Games Initiative, Games for Health, and Games for Change (Loh et al. 2015).

In addition, movements were established in Japan, such as Serious Game Japan in 2004, the hit Brain Age series in 2005, a game industry strategy study group established by the Ministry of Economy, Trade and Industry in 2006, and the hit Wii Fit in 2007. Interest in games targeting fields other than entertainment has increased; these fields include education/learning and medical/welfare, centering on the game industry (Fujimoto 2010).

Serious games are still widely used around the world in various fields of society, for example, the military, governments, education, companies, and medical care, and market research in recent years shows that they are expected to grow. In the academic field, many scholars in various fields, such as psychology, cultural research, computer science, sociology, and pedagogy, are interested in serious games (Breuer and Bente 2010; Yu 2019).

4.2.2 Definition of Serious Games

This section defines a serious game of which there are currently many. Susi et al. (2007) point out that there are as many definitions as there are people associated with serious games. In addition, many similar concepts, such as edutainment, e-learning, and digital game-based learning, are incorporated in serious games. Thus, the definition of serious games is complicated.

For example, serious games are defined according to social domain (e.g., education, healthcare, and advertising) or whether the game is targeted at the scope of its functional meaning, the inclusion/exclusion of "fun," and the intent of its development (Zyda 2005; Michael and Chen 2006; Susi et al. 2007; Loh et al. 2015).

First, there is a philosophical position that a game does not have a clear boundary with daily activities, and the boundaries are ambiguous even in various games. Thus, it is impossible to define a serious game in a single way. Wittgenstein (1953) argues that the notion of a game has no clear boundaries and allows similar things to be perceived "like a game."

Wittgenstein (1953) notes as follows:

> How should we explain to someone what a game is? I imagine that we should describe games to him, and we might add: This and similar things are called 'games'. And do we know any more about it ourselves? Is it only other people whom we cannot tell exactly what a game is? However, this is not ignorance. We do not know the boundaries because none have been drawn. To repeat, we can draw a boundary for a special purpose. Does it take that to make the concept usable? Not at all! (Except for that special purpose) (p. 33).

Duke (1974), who discusses simulation and gaming, mentions that a game is recognized as a "game" even though each one is different:

> A careful review of the variety of products currently available as serious games turned up the startling disclosure that they seem to share no single characteristic: neither subject matter nor technique, nor duration, nor client, nor audience configuration, nor paraphernalia, nor style. [. . .] Curiously, professionals have no difficulty alluding to all of these as games. Or addressing the phenomenon they use as "gaming" even though the particulars are so varied and diffuse (pp. xv–xvi).

In this way, the game itself has no boundaries and is a collection of similar objects. Although not as abstract as the concept of this game, the concept of a serious game is a collection of similar objects.

For example, similar games with social functions, such as an advergame, an applied game, games for health, and game-based learning, are positioned as serious games. Some games are considered functionally useful in some kind of social context, and it is by the current state of the serious game (what is supposed to be) that similar objects are accumulated inconsistently while their boundaries are ambiguous.

According to Fujimoto (Japan Machinery Federation et al. 2008), "There has been constant debate over what serious games mean, what is a serious game, and what is not a serious game. Some consider other established genres, such as advergames and virtual worlds, as different from serious games, while others consider them as serious games, and the problem of the unclearness of such a definition and the discomfort of naming as a serious game continue to be discussed from the beginning of the movement of the serious game today" (p. 99). This highlights that the definition of "serious game" is in a complicated state.

4.3 Reasons for Adopting Two Definitions

4.3.1 Characteristics of the Two Definitions

Given the intricate background, this study deals with the following two general definitions of serious games: games that are used for more than just mere entertainment (Susi et al. 2007; Breuer and Bente 2010) and games that are used to solve problems in various areas of society, including education (Fujimoto 2007). This section discusses issues related to these two typical definitions.

This study addresses these definitions because they have the following characteristics: first, serious games are not defined as a genre of games, but by bringing together a community of people interested in the social uses of the game, such as edutainment, Games for Health, and advergames (Japan Machinery Federation et al. 2008). Therefore, the definition includes such actors as developers, game players, and game users.

Whether the game is commercially available and made for entertainment is relevant, because these two definitions are defined according to the purpose of digital games, which can still be positioned as serious games if they are used for social purposes or for purposes other than entertainment (Charsky and Mims 2008; Shute et al. 2009; Squire and Jenkins 2003; Van Eck 2006).

In addition, because of the definition based on usage rather than content, the open-ended nature of digital games these days (content modified by updates and MOD), and the variability of the game industry, serious games correspond to fluid movements (e.g., the current situation in which specifications of game content have diversified owing to changes in platforms), and the digital game area can broadly be framed as "serious."

These features explain the reasons for the definitions that are generally used, but the features also function to incorporate various games as serious games. These definitions do not comply with the functions and contents of the game, but depend on the context surrounding the game and external factors. Therefore, the definition does not work for the precision of the features of the serious game, its fixation, and the precise classification. However, this definition has strong practical value, namely, bringing together the community surrounding the game.

4.3.2 Reasons for Adopting the Two Definitions

The reason that this study adopts such a context-sensitive definition is that it extends the definition of serious games to as many games as possible. In line with these definitions, this study considers developers, players, and game users to be the three actors within the definition. Serious games are thought to be defined in the context of game usage.

When considering the requirements for seriousness from the functions and contents that belong to serious games, it is difficult to consider them in a way that is consistent with the requirements presented in the conventional definition theory and similar concepts. This is because there are diverse requirements and concepts in conventional definition theory, and the relationships between those requirements and concepts are unclear (Susi et al. 2007; Japan Machinery Federation et al. 2008; Loh et al. 2015).

For example, in games (use) for learning, there are similar concepts, such as game-based learning, e-learning, and edutainment. Although these games are regarded as serious games or as a subset of serious games (Susi et al. 2007; Ratan and Ritterfeld 2009), the scope of their subjects and the practice of education differ between these concepts. For example, e-learning simply implies distance learning via the Internet, and it is not always necessary for use of games and entertainment of games to be a requirement (Koubek and Macleod 2004). In edutainment, simple games are often used as educational tools, mainly for preschoolers. However, there are no age restrictions on serious games, and they can include both simple games that can be used by children and complex games that adults can enjoy (Michael and Chen 2006).

In game-based learning, in addition to using games in the educational domain, educational methods that adapt game-like elements to reality are incorporated in practice. In addition, game-based learning requires games to possess an entertaining nature and considers the relationship between game entertainment and learning (Prensky 2007).

Given the differences between these concepts, it is extremely difficult to identify the requirements for serious games while matching the differences in the target scope and educational practice.

In addition to these learning areas, there are conceptualized areas, such as advergames with an advertising function and Games for Health for the medical domain, but these are limited to targeted areas. The game is positioned and discussed independently, without reference to its relationship with other areas (e.g., learning areas).

In the field of simulation, the entertaining nature of the game will not always be required for the construction of the model building. Whether to consider such a model simulation as a serious game depends on its application and the viewpoint of the actor.

Therefore, it becomes difficult to argue the requirement for serious games while being consistent with the requirements of other similar concepts.

However, in the case of these two definitions dealt with in this chapter, it is not strictly determined whether the game is serious, based on specific requirements regarding genre and content, for example, belonging to the game and specific usage purposes and methods, such as education and treatment. That is why a wide range of games can be regarded as “serious.” It is for this reason too that this study considers the concept of serious games.

The requirements of the two definitions adopted, namely, games used to solve problems in various areas of society and games that used for more than mere entertainment, are very simple requirements. In the case of such a definition, the meaning of “serious” is tentatively assigned to a place that is not a function or content belonging to the game, and the requirement can be considered as a serious game. In fact, these two requirements incorporate many games as serious games, because their contents are vague and never strict. Therefore, it is possible to explore the premise (requirement) of defining many games as serious games by considering these two definitions.

This study does not deal with the definition (requirement) itself, but rather the issues concerning the definition (requirement). The reason that the definitions themselves are not considered is that the requirements of these definitions depend on the external factors surrounding the serious game, so that the reality of the requirements will changes depending on the situation. Thus, this study clarifies some assumptions for serious games and presents them as requirements. By exploring these vague but deep-definition issues, this paper investigates what makes a wide variety of games “serious.”

4.3.3 Discourse Analysis on Serious Games

In a situation in which there are intricate requirements of serious games, there is also a debate on the characteristics of serious games from the external perspective, without reference to the functions and contents belonging to the game. For example, Mayer et al. (2016) analyze the discourse of serious games from the perspective of Goffman’s framing analysis, and organize the usefulness of serious games.

Mayer et al. (2016) classify the types of serious games into four frames: I: tool, therapy and drug; II: creative innovation; III: persuasion; and IV: self-organization. The frame “tool, therapy, and drug” is used to improve, for example, learning, therapy, and rehabilitation of games. The frame “creative innovation” is used to improve competitiveness and policy. It is intended to be used in accordance with future social designs, such as planning and organizational concepts. The frame “persuasion” is a kind of game that deals with thoughts and beliefs, and conforms to the communication elements of the game, which consider the nature of the message and the persuasiveness of the content. The frame “self-organization” considers the fusion of games and society, and includes games using augmented reality technology and rudification, in which the elements of the game intervene in the daily lives of real people. Then, the four items of truth claim, evaluation criteria, research orientation, and rebuttal are provided for each frame, and the features of the discourse related to each frame are presented.

These four frames are not static, but can disappear, be born anew, be connected in between frames, or be competitive. This viewpoint of serious games is understood from discourse analysis.

This is some difference here from the point in which we discuss the game itself, such as what serious games are; in other words, the discussion helps to grasp the situation of serious games from a viewpoint that considers the context and situation surrounding the serious game.

This study has a similar stance to that of Mayer et al. (2016) in that it considers the issues involved in defining serious games rather than the game itself. This study also deals with discourse analysis, such as how serious games are discussed, and in that sense, is at the same level of abstraction as Mayer et al. (2016).

Incidentally, from the viewpoint of Mayer et al. (2016), for the same single game as well as recognition of serious games, the frame may differ depending on the instructor or theorist, and the difference in recognition of each standing position and serious game can be clarified. However, Mayer et al. (2016) extract features of the discourse of serious games over four frames, and rely on differences in discourse based on the frame; at this stage, this approach does not extract uniform similarity.

The main difference between this study and Mayer et al. (2016) is that while they focus on the difference between serious games, we focus on the similarities between them. While Mayer et al. (2016) present a framework for organizing various aspects of serious games according to their usefulness, this study presents a single commonality of serious games.

To reiterate the purpose, this study clarifies the meaning of "serious" and the various assumptions that support its contents, and presents as a constituent of serious games. In the next section, we discuss issues related to the definition of two general serious games that this study deals with.

4.4 Discussion

4.4.1 Issue 1: Relationship Between Game Characteristics and Actual Advantage

In this section, serious games are those used for purposes other than entertainment, in which the relationship between real advantage and entertainment becomes an issue (Susi et al. 2007; Breuer and Bente 2010). For example, it is sometimes pointed out that a game originally has a serious aspect. Games are not without serious content, and players may play a game seriously; furthermore, the game may, in some cases, have serious and positive effects. From this viewpoint, it can be seen that something can be learned or learned from all games, and positioning a game as a serious thing is itself a tautology. Thus, the meaning of adding the word "serious" to "game" is questioned.

On the contrary, it is sometimes argued that seriousness and games conflict with each other, that is, real advantage and entertainment are contradictory or eliminated. Easy-to-understand examples include harmful theory and the adverse theory of games. For example, in digital games, there are theories that the entertainment characteristics of the game may lead to a decline in the cognitive function of the brain, and that playing a violent game may increase aggression (Lai et al. 2019). By contrast, Van Eck (2006), among others, points out the affinity between learning and play, demonstrating the usefulness of digital games.

In this way, it is argued that the entertainment characteristics of the game give some benefit or disadvantage to the player; that is, the relationship between entertainment and actual benefit is considered compatible or exclusive. In this discussion, the subject centers on how the entertainment characteristics (i.e., fun) of digital games are positioned in serious games. In other words, the issue is that entertainment and actual advantage are related.

The proper relationship between entertainment and actual advantage is constructed, and the effect of game play is evaluated and measured in serious game research. Many papers discuss the development and effectiveness of serious games. To create an environment that motivates players, it is necessary to formulate the optimal relationship between entertainment characteristics and effectiveness by increasing or decreasing the entertainment characteristics.

Such a discussion is relevant in the learning domain. To motivate players as learners, it is necessary to find the optimal balance between entertainment and learning, and formulate the game accordingly (Squire and Jenkins 2003). Ritterfeld and Weber (2006) point out three relationships between entertainment and learning:

1. Linear positive (facilitator hypothesis): more entertainment means more effective learning.
2. Linear negative (distraction hypothesis): entertainment distracts from learning, that is, more entertainment leads to a decrease in learning performance.
3. Inverse U-shaped (moderate entertainment hypotheses): entertainment is beneficial for learning, but only up to a certain point. If this amount is exceeded, the added entertainment value is detrimental to the learning outcome.

Among these three relationships, the relationship between entertainment and actual advantage is positioned as a trade-off (Breuer and Bente 2010). This trade-off relationship needs to be adjusted according to the purpose, and the effect of game play needs to be measured as an index.

Thus, a serious game may be adjusted based on the acquisition of actual advantage. Although this description occurs in the area of learning, in the case of simulation games without entertainment and games for rehabilitation and treatment, it is necessary to adjust the game system according to actual benefits, such as models, therapy, and rehabilitation. This adjustment of a game based on actual advantage is unique to serious games. It can be said that the meaning of "serious" is to make various elements of a game and actual advantage mutually related based on actual advantage.

4.4.2 Issue 2: Games to Solve Problems in Various Areas of Society

This section addresses games used to solve problems in various areas of society. The requirement of this definition is that the game is used to solve a problem in various areas of society.

Social problems of serious games refer to problems in various social fields, such as education, health care, military, and governance.

For example, in the field of education, games are used to improve learning effects, such as e-learning in the field of school education, edutainment, game-based learning, and digital game-based learning.

In the field of healthcare, games include games those for health management, such as Wii Fit, treatment of diseases at hospitals and rehabilitation facilities (Griffiths 2003), and improvement of rehabilitation (Matsuguma et al. 2012). In the military field, the America's Army, which was developed by the US Army, is aimed at advertising for recruitment and grasping the contents of military training. There are, of course, other games, including actual military training in the field of digital games.

Problems are set in various social areas, and digital games are used to solve them. In other words, games can help to solve specific problems and problems in the real world. In such cases, the requirement of being used to solve problems in various social fields, including education, means that the game has a positive effect on problems in the real social field.

However, some games that claim some principle have radical expressions, and provide antisocial information to players (or could indoctrinate them). These are also positioned as serious games, depending on their use, but in this case, the normative evaluation of educational contents strongly depends on who uses them and in what context the games are used. The subject and ideological acceptability issues cannot be dealt with by the definition of serious games. This means that the term "serious games" is not equivalent to a socially desirable effect on the player (Breuer and Bente 2010).

Such game use, for which it is not possible to determine its social desirability, is not compatible with the definition of games used for solving problems in various areas of society, including education. This is not limited to games with antisocial content (utilization), because there are games that ask what should be considered a social problem. In the next section, I will give a concrete example and explain it.

4.4.2.1 Games that Ask Questions about a Social Issue

The Coming Out Simulator (https://ncase.me/cos/) produced by Case (2014) is a simple text-type web game that is about the coming out experience of a homosexual (multi-sexual) youth. This game was created to convey the conflict of everyday experiences over a certain truth, and each character in the game claims his or her correctness. Thus, it becomes a game in which there is no specific right answer.

This game begins with a text conversation with a person who developed the game. From there, the player relives the developer's past in becoming a multi-sexual young man and chooses conversational options in the context of dialogue with same-sex partners and parents. Essentially, the conversation with characters is a style that automatically advances, and the flow of the conversation is stopped only when selecting an option. The player automatically selects the option and the conversation automatically proceeds again. This production automatically advances the conversation; the dialogue with characters is thrilling, and the feelings of characters (parents, partners, and developers) who appear in the game to the youth of the hero impresses the player (Fig. 4.1).

In this game, the flow of conversation progresses automatically, and the "normal and natural world" (hetero-sexism, hegemonic masculinity, homophobia, etc.) hunts down people. It allows players to experience sexuality and family conflicts behind the conversation options. By promoting dialogue with characters, it is possible to realize that the values of society that are considered "normal and natural" not only protect but also suppress people. It shows the player that the event is a "social problem."

A game with a theme that makes the "everyday" itself appear unnatural is not only intended for entertainment, but also asks the subject itself to consider a social

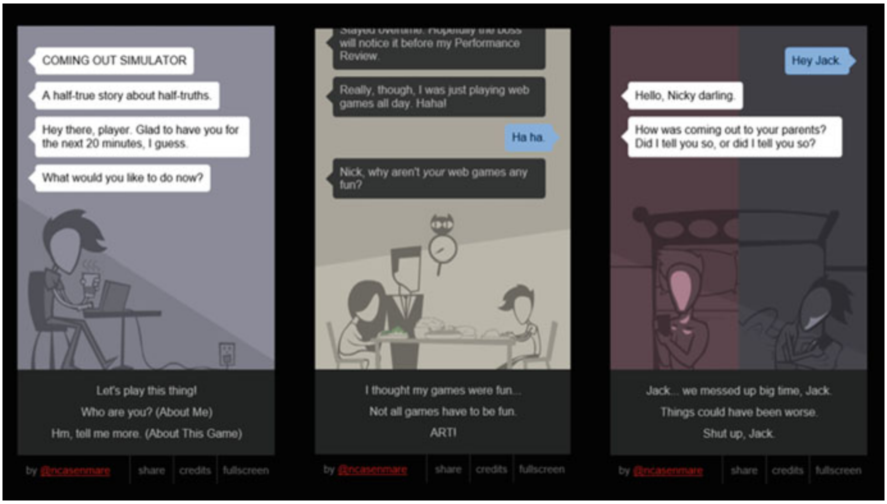

Fig. 4.1 Coming out simulator. (Reproduced from Case 2014)

issue. It is unclear whether the effectiveness of the play also contributes to solving the social problem, because it depends on the context. In this way, at present, there are games that do not know whether they contribute to solving social problems, but have a range to question whether they are social problems; such games are omitted from the definition that serious games be used to solve problems in education and other areas of society.

However, what can be pointed out based on these issues is that the influenced relationship between the person (real world) and the game is clarified in a serious game. In games (utilization) intended for learning, therapy, rehabilitation, training, and advertising, the presence or absence of effectiveness and the degree of effectiveness through gameplay are conscious and specified. Even if the effect is not clarified, the "social event" (i.e., advertisements and subjects of the actual social organization expressed in the images and components of the game screen) is also recursively perceived and sensed by the player through the settings and rules of the game.

In this way, it becomes clear that the feedback of the experience and information obtained in the game to reality is the premise of the subject, regardless of whether the effect of the game play is socially desirable. In other words, the premise of this issue is the influence of the relationship between people (or the real world) and games are recursively shown in various aspects of reality. This can be regarded as the meaning of "serious," in that it is not a subject of games for amusement. In the realm of serious games, the experiences and sensations gained by players and observers are intended to be returned to the real world, whether before, during, or after development and play, or by developers, players, or instructors.

4.4.2.2 Elements Reflecting Experience and Feelings Gained in the Game in the Real World

Players and observers have experiences and sensations in a game reflected in the real world, which is clear from the fact that the educational use of serious games is based on the dominant theme of constructivism (Rooney 2012). For example, the main theme of constructivist learning is that it is important to create an "authentic" learning environment in the sense that it recreates what the learner would face in real-life situations. In this view, many games (e.g., RPGs and multiplayer games) allow players to experience difficult situations in the real world and to take on various roles. By facilitating these in-game experiences, the game provides an environment for developing critical skills, such as problem solving, decision making, and collaborative/social skills (Oblinger 2004; Van Eck 2006; De Freitas and Griffiths 2007; Klopfer et al. 2009).

Furthermore, for the design of a serious game, it is considered that perceptual immersion is enhanced by high fidelity of the visual representation of various aspects of reality. The rationale for being true to reality in serious games stems from the dual game and educational goals of engaging and immersing players, and providing an effective learning experience (Rooney 2012). From an educational perspective, researchers argue that fidelity of reality enhances the transfer of knowledge from the virtual world to reality (Chalmers and Debattista 2009; Dalgarno and Lee 2009).

Furthermore, from the perspective of experiential learning, high fidelity to reality is said to be an important factor for enhancing the credibility of the experience gained in the game and evoking the experience of the real world. Real fidelity, especially physical fidelity, is a common goal for game designers in terms of player engagement with games and learning, and many people consider that the more realistic the physical environment, the more reliable and psychologically immersive the experience (Wages et al. 2004).

Controversy over the reproducibility of reality also arises in the debate over the educational framework of serious games. As has long been discussed with regard to the fidelity of model design in simulations (Hatzipanagos 2009), the requirement for high fidelity at both physical and functional levels is generally derived from the idea that such fidelity is required to evoke real-world experiences and thereby maximize the transmission of learning (Dalgarno and Lee 2009).

Other factors and opportunities to return the results of the game to reality, besides fidelity, include both elements belonging to the game, such as stories, rules, and operability of the game as settings, and external elements of the game play, such as the instructor’s explanation before the game play, and post-play debriefing or review (Charsky and Mims 2008).

This discussion shows that the actual benefits, knowledge, and experience obtained in the game are intended to be returned to various aspects of reality in many situations, such as before and after the development of a serious game and before and after the game play.

Thus, this section, by considering the issue of problems used to solve various areas of society, including education, clarified that the influenced relationship between a person (or the real world) and a game is recursively shown or intended in various realities, as a requirement for the seriousness of serious games.

In summary, the requirements of “serious” derived from these two points are as follows. From the first point, it became clear that in serious games, various characteristics of the game (entertainment and game system) and actual advantage are in a relationship of adjustment, regardless of the influence of the game. From the second point, it was clarified that the influence of the game play is explicitly stated in serious games.

4.5 Conclusion

Considering the serious game from the requirements stemming from the issues discussed in this chapter, it can be seen that the composition of the serious game and its use even includes the player returning the actual advantage obtained in the game to the real world (regardless of whether or not the player indeed obtains the desired benefits).

The significance of these common requirements is summarized as follows. This constituent element is related to factors belonging to the game, such as the real fidelity of the game and story setting, and external factors surrounding the game, such as the intervention of instructors using the game and debriefing by players. These have long been considered in the field of serious game research as a function or mechanism to turn the experience and knowledge obtained in the game into reality.

The chapter clarified the abovementioned constituent requirements of "serious" in serious games. As described in the previous section, this requirement is related to factors that are intrinsic to the game, such as its real fidelity and story setting, as well as external factors surrounding the game, such as instructor intervention and player debriefing. There has long been debate on the design and educational use of serious games. How does real fidelity in games (play) affect the effectiveness of games? To maximize the effect of the game, the balance between the entertainment and learning of the game has been considered as a function or mechanism for returning the experience and knowledge acquired in the game to various aspects of reality.

In other words, the fact that the experience and knowledge gained in the game are returned to the real world is a direct component of the "effect" of serious games. Whether or not this constituent feature is functional is visualized by "effect." Measuring the effect of the game is an effort to clarify the mechanism of this unfolding. The adjustment of the relationship between the characteristics of the game and the actual advantage revealed in issue 1 is also the adjustment of the element of reflection that has been clarified and the measurement of the game's effect.

Considering a serious game based on these conclusions, "effect measurement" can be said to be an activity that supports these "serious" constituent requirements. Whether or not serious games function as "serious" is measured by its effect, such that the activity supports the meaning of "serious."

However, this requirement is not limited to "effect." If a serious game is defined by the actual advantage obtained by playing the game that is returned to various aspects of reality, then this itself constitutes the interest and possibility of a serious game.

For example, the Coming Out Simulator discussed in the previous section did not affect the measurement function of the game, and above all, its content questioned whether coming out was a social issue, and whether it would be beneficial depended on the context of the gameplay. In this regard, the Coming Out Simulator is intended to recurse the benefits of gameplay in the real world differently from other serious games that aim for benefits measured by the effects of education, training, or therapy.

Then, what would happen if we used the Coming Out Simulator to depict the recursive aspects of reality in the relationship between the influence of people (or the real world) and the game? First, the Coming Out Simulator focuses on the coming out experiences of homosexuals or Polysexual, but also on the heterosexuality, hegemonic masculinity, and homophobia behind those themes. The feature of this game is that items invisible in daily life are gradually visualized as troublesome "problem groups" through conversations and choices with characters around the event of coming out. In this way, the simulator allows players to experience through gameplay how "normal" values are gradually visualized as violent "problems" that oppress people. In addition, the life of sexual minorities evokes a sense of incongruity that becomes a social issue. This is because people have different lives, and although each life is equivalent, those of sexual minorities are regarded as a social issue or problem, which itself questions the power of "normal." This falls within the range of the subject of this game.

In games that question these traditional social norms, the value standard of the majority, which is said to be the "daily routine" of "normal," is collapsed in the process from before to after the gameplay.

This is because the value norms that are believed to be normal and provide commonplace happiness in many aspects of reality are collapsed by the gameplay and the game production is regarded as problematic and troublesome.

Therefore, in serious games, aspects of changing social norms are indicated or intended by the entire recursive flow, including before and after the player's play. This finding indicates that the structural requirements of serious games presented in this chapter support the meaning of "serious."

Knowledge of the constituent requirements of such serious games provides important information for designing social systems and societies. It provides a perspective for rethinking existing social systems and fundamentals in considering sustainable social systems and designs.

In designing a sustainable society, serious games would contribute to reflection about the invisible aspects of existing social norms of values. Serious games also broaden the framework of design in a sustainable society. In this respect, there are greater possibilities for fun in serious games.

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Chapter 5
An Agent-Based Framework for E-Government Service System Design

Shuang Chang and Hiroshi Deguchi

Abstract E-government is a rapidly emerging research field in recent decades. Benefits of deploying E-government service are obvious in the sense that flexible services are provided to satisfy citizens' divergent needs and the service quality is improved through integrated services. However, the adoption rate of E-government is still relatively low, especially for transactional services and co-created services. Extant works on E-government have examined this phenomenon from various perspectives by using both qualitative and quantitative research methods. However, there is a lack of studies that investigate this phenomenon from a service system perspective by identifying and connecting the involved stakeholders as a holistic and dynamic system. In this work, we first briefly review the methodological and theoretical aspects of the E-government phenomenon. We then argue that a new perspective together with new approaches, which can capture the divergent characteristics of involved heterogeneous stakeholders, and their adaptive behaviours against the environment, are needed to investigate the embedded system complexity. We then propose a corresponding conceptual agent-based framework to identify and abstract the system components and their interactions as a holistic system. It will serve as the first step towards designing E-government services by adopting a service system perspective and micro-level simulation approaches complementing traditional approaches.

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5.1 Introduction

It is hard to define clearly what E-government system is, although its enabled services have been immersed in people's lives for years. In general, E-government is defined as "utilizing the Internet and the world-wide-web for delivering government information and services to citizens" by UN and American Society for Public Administration (ASPA) (UN and ASPA 2002). It indicates that the essence of this system is to promote and deliver transparent, convenient, and effective public services to citizens by applying advanced web technologies.

In literature, researchers studied E-government phenomenon from three major perspectives: what is E-government, what is the evolvement of E-government service, and what do citizens expect from E-government (Gil-Garcia and Martinez-Moyano 2007). Some researchers regard E-government as the application of web technologies to promote government services efficiently and effectively (Brown and Brudney 2001), and the government is virtually organized through agencies who are structured and enabled by web technologies (J. E. Fountain 2001). Additional technology deployed apart from web technologies may include database, multimedia, and so on (Jaeger 2003). On the other hand, some researchers regard E-government as electronic means that enable interactions between the government and receivers of public services, such as citizens, private sectors, and other public administrations (Means and Schneider 2000). Researchers are prone to capture this phenomenon from different aspects and define it accordingly, thus no well-recognized definition is commonly agreed yet (Halchin 2004; Yildiz 2007).

Several reasons are accounted for this difficulty in defining E-government systems, especially from the perspective of citizens who are the primary service receivers. According to Yildiz (Yildiz 2007), first, unlike the objectives of E-government, which are relatively easy to define, there is a lack of works describing the involved stakeholders' activities and the specific technology deployed in such systems. Therefore, the meaning of E-government that stems from its deployed social context, such as primary social groups and implemented strategies, is blurred and overlooked (Yildiz 2007). Second, for citizens with diverse characteristics and background, E-government may have different meanings and most of the citizens may not grasp its overall image clearly (Torres et al. 2005; Grant and Derek 2005). Third, it is not the advancing technology defining what E-government is, rather it is the service delivery process and key players' behaviours making us understand the "evolving nature of the E-government concept better (Yildiz 2007, pp.10) (Jonas 2000; Hwang et al. 1999). Since the ultimate purpose of E-government systems is to deliver better services to citizens, understanding such systems with an emphasis on" heterogeneous citizens' background, preference, and expectation towards public services is important and key to improve the service provision process and service quality.

5.1.1 E-Government Service Evolvement

There are also different ways to categorize E-government services. From the interactivity perspective, the online services can be divided into static information provision, one-way (government to customer) interaction, mutual interaction, and transactional service (Arduini et al. 2010). The services could be further summarized into two categories: information provision service and transactional service (Venkatesh et al. 2012). Compared with sheer information provision services, transactional services which involve online electronic transactions are more sophisticated and require additional procedures to complete. Co-created public service between citizens and public sectors are also emerging rapidly, such as citizen sourcing and do-it-yourself-government (Linders 2012).

On the other hand, according to Layne and Lee (Layne and Lee 2001), the services can be divided into following stages from an evolutionary perspective. In the initial stage, governmental website containing certain government information is classified and open to the public, thus only one-way communication is guaranteed. The second stage evolves to a two-way communication in which online transactions are provided. The third stage is the vertical integration of central and local public sectors by sharing information resources via database. Normally, modification and improvement on the service delivery process is required. The final stage is the horizontal integration in which different functional areas are integrated horizontally and delivered via one single portal (Gil-Garcia and Martinez-Moyano 2007).

Gil-Garcia et al. (Gil-Garcia and Martinez-Moyano 2007) also argued that there is a trend of E-government movement from national level to local sectors along with the system evolution, and the stages vary across administration levels. It is very possible that the E-government service is already well designed at national level, whilst still at an initial stage amongst the local administrative sectors (Gupta and Jana 2003). Furthermore, the target citizens, administrative processes, and technological sophistication will be different at each evolvement stage (Holden et al. 2003). The divergent demand and pressure from end-users, i.e. citizens and private sectors, may also influence the features of initiatives (Gil-Garcia and Martinez-Moyano 2007).

In reality, poor design of E-government systems that only aligns with common practices and ignores the needs of citizens often fail to entice citizens (Meuter et al. 2000; Rai and Sambamurthy 2006). Comprehending and designing use-centric public service are thus remained complicated and challenging along with the continuous service provision to citizens. Without identifying the involved stakeholders and exploring the process through which the services are delivered to end-users, as well as the social context and environment, one could not profoundly and thoroughly understand the E-government phenomenon. Hence, adopting new methodologies to investigate this phenomenon from a new perspective is critical for designing and providing the services with new insights.

In this work, we will review the theoretical foundations and methodologies deployed in E-government research in past decades, from which we could posit and justify a service system perspective and an agent-based simulation approach. We then propose a corresponding conceptual agent-based framework to identify and abstract the system components and their interactions as a holistic system. It will serve as the first step towards designing E-government services by adopting a service system perspective and micro-level simulation approaches complementing those traditional ones.

5.2 Theoretical Aspect

E-government is a relatively new research field closely relating to other research realms, such as information systems and public administration (Heeks and Bailur 2007). Most of the extant works examined different aspects of this phenomenon, for instance, E-government service adoption and diffusion process, and governance issues from either end-user sectors or public governor perspectives (Gil-Garcia and Martinez-Moyano 2007; Cordella and Iannacci 2010; Luna-Reyes and Gil-Garcia 2011; van Velsen et al. 2009; Venkatesh et al. 2012). There are few systematic studies investigating E-government system from a holistic view (Fields et al. 2007; Arduini et al. 2010) and especially from a citizen-centred service system perspective.

According to Heeks and Bailur's study (Heeks and Bailur 2007), although they expected that various theories from other disciplines had been applied in E-government research, surprisingly that most of the theoretical frameworks used were stage model-based and category-based focusing on E-government's evolvement stages and features. Theoretical frameworks from the governance literature, and models and schemas from the information system literature contribute most to the E-government research (Heeks and Bailur 2007). Theories built only from and for E-government studies are therefore expected. Within the "theories" applied, the dominant ones are from two major fields: information systems adoption/diffusion and information systems in organizations, which will be discussed respectively in the following.

5.2.1 Innovation Adoption

With respect to information systems deployed in E-government services, besides the technical development considering security issues (Kaliontzoglou et al. 2005), adoption and diffusion processes of E-government services have attracted most of the attention. There is a stream of work focusing on the innovation adoption and assimilation involved in E-government phenomena. Various factors are analysed to examine their influence on citizens' intention to adopt the services, such as trust, governmental leadership, and different measurements of services provided (Bélanger and Carter 2008; Luk 2009; Lean et al. 2009). However, the information technology itself does not define what E-government system is (Yildiz 2007), though it may shape the way of how public services are delivered to the public and how involved stakeholders communicate with each other. In the following, we will review some classic innovation diffusion models applied in those studies.

5.2.1.1 Macro-Level Diffusion Model

By 1970s, several main innovation diffusion models have been proposed and established, and their variants were widely applied in different contexts afterwards (Meade and Islam 2006). Macro-level diffusion models, such as Bass's diffusion model (M Bass 1969), were proposed to forecast the first-time adoption and to evaluate the market penetration with a focus on collective adoption behaviours. For instance, Bass's model (M Bass 1969) captures both homogeneous population's desire to innovate and to imitate others that drive the collective adoption behaviours. A large body of mathematical models have reflected a general "Bell shape" curve for period-by-period adoption and a "S-shape" curve for cumulated adopters (Teng et al. 2002).

On the other side, heterogeneous individuals are considered in Roger's innovation diffusion model (Rogers 2003). Individuals are categorized as innovators, early adopters, early majorities, late majorities, and laggards of which the percentage is a normal distribution, thus creating the S-shape adoption curve (Meade and Islam 2006). Those who are better educated and of a higher social-economic status tend to have a lower adoption threshold, thus a higher adoption rate of innovations.

This strand of macro-level models is particular useful when the market penetration or market share of innovations is of primary interest (Schramm et al. 2010). However, public services are different from innovations in the sense that service adoption is an evolving process along with the influences from end-users directly or indirectly, who learn from their past experience or the environment whilst utilizing the services.

5.2.1.2 Micro-Level consumer's Behaviour Model

Regarding micro-level behaviour models, there is a strand of well-defined social-psychological theories based on micro-level consumer's adoption models, amongst which Technology Acceptance Model (TAM) (Davis 1989), Theory of Planned Behaviour (TPB) (Fishbein and Ajzen 1975), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003) are influential. This strand of psychological-social models treats intention as the predicator of behaviours (Zhang and Nuttall 2011), and has been empirically validated in E-government research (Schaupp et al. 2010; Lean et al. 2009; Gunasekaran and Ngai 2008; Bélanger and Carter 2008). TRA-based theories which study the intention and behaviour of users taking into account not only the service itself but also the social contexts are believed to be more suitable for E-government studies (Arduini et al. 2010). However, Shareef et al. (M. A. Shareef et al. 2011) argued that those classic

Table 5.1 Comparison of innovation diffusion models

	Subjects of model		Result analysis		
	Heterogeneous agents	Agent's learning ability	Policy evaluation	Macro level	Micro level
Bass (M Bass 1969)				0	
DOI (Rogers 2003)	0			0	
TAM(Davis 1989), TPB (Fishbein and Ajzen 1975), UTAUT (Venkatesh et al. 2003), etc.	0				0
ABM	0	0	0	0	0

Note. ABM: this work

innovation adoption models were not capable to reflect complex citizens' adoption behaviours, and critical influential factors should be defined separately since they may differ along with the development of service levels. Also, this set of theory focused only on the causal relationship underlying the phenomenon and left the dynamic service delivery process unexplored. The rich and meaningful interactions among stakeholders were therefore either simplified or ignored.

Besides, there is also a strand of explanatory models such as consumer diffusion paradigm proposed (Gatignon and Robertson 1985). According to those works, the adoption of innovations depends on three major aspects: individual's characteristics, perceived innovation properties, and social influences posed on individuals (Schramm et al. 2010). Regarding E-government studies, Tung and Rieck (Tung and Rieck 2005) proposed a theoretical framework based on the diffusion of innovation theory, network externalities, adoption barriers, and influence from social aspects to analyse the E-government adoption among business organizations in Singapore. Extensive frameworks based on adoption theories and models have been proposed (M. Shareef et al. 2010; Klievink and Janssen 2009; van Dijk et al. 2008; Schedler and Summermatter 2007) and we will not review each of them here. However, different from innovations, E-government services will be improved in terms of efficiency and quality continuously, and new services will gradually emerge and be delivered during the assimilation period (Arduini et al. 2010).

In summary, there is a missing co-evolved process between the adoption behaviours and the E-government service diffusion process in above models. We should bridge the citizen's adaptive behaviours to the macro-level adoption patterns emerged from different social groups, and based on which evaluate supporting strategies to prompt the service usage. The comparison of above models is summarized in Table 5.1.

5.2.2 *Governance*

Another stream of frameworks adopted in E-government studies is from the governance literature, such as public administration and political science. They advanced the understanding of E-government phenomena from a government structure perspective and explored the relations between government, information technology, and institutions. However, it ignored the characteristics of heterogeneous primary users and their valuable feedback to the services, which is critical to the success of E-government systems, even from a governance perspective.

Governance should not be defined as a physical entity, i.e. government and governing individual citizens. Rather it is a process about authorities and citizens interacting with each other and guiding themselves (Holliday and Kwok 2004). Information and communication technologies are becoming very critical in changing the administration work of government to some extent. E-government as an emerging application of information technology can facilitate the governing process and invite a broader range of citizens participating in public affairs. With respect to E-government research, there have been extensive works devoted to study how the E-government system is inter-weaved with governance processes and how it can influence the inter-organizational management and external relationship with citizens (Holliday and Kwok 2004; Dias and Rafael 2007; Hossain et al. 2011). Theories such as institutional theory (Richard 1995) and enacted technology framework (J. Fountain 2007) were applied, although the impact still remains controversial.

Researchers also borrow concepts from organizational information technology and e-Business fields (Lee and Rao 2009). There is also a group of works focusing on the design issues of E-government services under either governmental settings or user contexts by different approaches, such as content analysis, process modelling, and output evaluation (Buchanan and McMenemy 2011; Dias and Rafael 2007; Vassilakis et al. 2007). But E-government is different from either of those fields due to the monopolistic nature of government (Srivastava and Teo 2010; Hossain et al. 2011), and the services are voluntary to use since traditional front desk services are still available as an alternative. In this sense, E-government deserves its own theories and methodologies.

5.2.3 Service System Perspective

E-government system is not only about the information technology deployed in public sectors to facilitate public administration, rather, it is a service provision process that involves both citizens as service receivers and public sectors as service providers. Undoubtedly, citizens with divergent background and different views of E-government play a key role in making E-government systems meaningful and successful (Akman et al. 2005). On one hand, citizens with divergent background will influence the services in both direct and indirect ways (Farrell and Saloner 1986). Pressures from citizens to improve the efficiency and usability of services have a direct impact on the service provided, whilst interactions between citizens and the government, together with its resulted adoption rate have an indirect impact in the sense that even the innovation provided by public sectors is affected by what is expected from the receiver side (Arduini et al. 2010). In other words, service receivers may transfer their unique experiences whilst dealing with the services to the service provider, and eventually enhance the service design at certain degree (Barras 1986).

On the other hand, regarding organizational concerns, innovation-relevant decisions reflect the vision and strategy of public sectors, and limited resources are subject to relocation among different social groups. The system should satisfy individual's needs, rather than the opposite case. Therefore, besides the basic user-friendly requirements of E-government systems, there should be more considerations on citizens' diverse behaviours of using different types of services, which will have substantial impacts on the service design. Furthermore, government should help different groups of citizens conquer the usage barriers, and policy design on supporting strategies should take citizen's needs into account as well, which makes the E-government services more complicated and challenging to understand and design (Arduini et al. 2010).

Therefore, in order to understand E-government systems as holistic ones, a service system perspective, from which individual elements of the system can be defined, integrated, and analysed (Anthopoulos et al. 2007; Demirkan et al. 2008), such as citizens, organizational resources, social-cultural context, strategy, and initiatives (Wimmer 2002), is a suitable tool to investigate this phenomenon. Services are defined as "the application of competence and knowledge to create value between providers and receivers" (Goldstein et al. 2002; Spohrer et al. 2007). From this definition, a service system involves not only technology, people, and organization, but also the shared knowledge and social context; the dynamic process is more important than static entities (Checkland 1999; Vargo and Lusch 2004; Demirkan et al. 2008); and citizens participate in and influence the delivery process directly or indirectly. In this sense, services can also be viewed as "a series of interactions between service provider and clients that result in an observable output" (Spohrer et al. 2007).

5.3 Methodological Aspect

With respect to the E-government research field, Heeks and Bailur (Heeks and Bailur 2007) concluded that although most of the works do not have an explicit epistemological stance beneath the stated methodology, the prevailing but not explicitly stated epistemology stances are positivism, and somewhere in-between to social constructionist. Accordingly, both qualitative and quantitative methods have been applied in this field. In the following, we will briefly review the methodologies applied in E-government research with the associated underlying epistemological stance.

5.3.1 Quantitative Studies

Regarding E-government research, a positivism stance implies an objective or realism ontology. This stance presumes that pivotal factors do exist in influencing the E-government development, and are controlled by the underlying causal laws (Heeks and Bailur 2007). Orlikowski and Baroudi (Orlikowski and Baroudi 1991) identified features of positivism studies as “evidence of formal propositions, quantifiable measures of variables, hypotheses tested, and the drawing of inferences about a phenomenon from the sample to a stated population”. The researchers holding this stance seek to find measurable pivotal variables including technological, social, and psychological issues which might influence the system outcomes, and to figure out the corresponding causal relationships. Accordingly, an empiricist epistemology will be placed by which the data gathered during the research are considered independent from the researchers who are observing and experimenting to acquire knowledge of such underlying causal relations (Heeks and Bailur 2007). Under such epistemological stances, quantitative research methods, such as large-scale questionnaire and survey, are primarily adopted.

Some works from this stream focus on technical issues that might influence users’ (both citizens and business sectors) adoption behaviour of different E-government services, whilst some others focus on social and psychological factors. In Venkatesh et al.’s work (Venkatesh et al. 2012), they conducted a web-based survey and identified four key factors that affect citizen’s intention of using transactional E-government services, which are usability, computer resource requirement, technical support provision, and secure provision. Schaupp et al. (Schaupp et al. 2010) evaluated the influence of factors such as performance expectancy, effort expectancy, trust, risk, social influence, and supporting facilities on U.S. taxpayers’ intention of using E-file. Lean et al. (Lean et al. 2009) conducted an exploratory study examining the Malaysian’ intention of using E-government and concluded that trust, perceived usefulness, perceived advantage and image have positive effect whilst perceived intention has a negative effect. With respect to business sectors-oriented services, some other works investigate the influence of E-government services assimilation on business value creation processes in organizations (Hossain et al. 2011).

By holding this deterministic view and conducting quantitative studies, researchers can observe and identify key factors which influence the system outcome, and explore the underlying causal laws in different cases. However, this stream of empirical study ignores the dynamic process and interactions among stakeholders which also play a key role. In addition, the particular social context is ignored which is critical for E-government research.

5.3.2 Qualitative Studies

In contrast, a social constructivism stance implies a subjective ontology by which the meaning of objects (even physical objects) assigned by different stakeholders matters the most. Under this stance, the focus of E-government research is to understand the meaning of this phenomenon constructed by each individual when using E-government services. It is assumed that the subjective understanding and interests of researchers cannot be detached from the meaning construction process neither (Heeks and Bailur 2007). Qualitative research methods such as unstructured interview and documentation analysis are applied.

Kamal et al. (Kamal et al. 2011) deployed a qualitative multiple case study approach to examine the role of different stakeholders, their perception of technology integration solutions in UK local governments, and their involvement in the adoption process. The reason of why those aspects are vital to such technology integration projects was emphasized and discussed. Cordella and Iannacci (Cordella and Iannacci 2010) proposed an e-Government enactment framework to analyse the intricacies involved in the deployed technology which is viewed as the carrier for achieving e-Government objectives. The complex relations among technologies and the political logic were also examined to investigate how they shaped the e-Government initiatives.

Most of the qualitative studies have tried to elucidate the recursive relationship among information technology, organizational structure, and social context and how the information technology was designed and deployed to achieve long-term interests inscribed in E-government initiatives by conducting theory-based case studies (Luna-Reyes and Gil-Garcia 2011). However, the qualitative studies that rely on verbal interpretation are too flexible to provide more rigorous quantifiable results due to its inherited characteristics, and new approaches are necessary to complement the theoretical discussions in order to acquire a better understanding of the relationships, consequences, and dynamic processes.

5.3.3 Agent-Based Simulation

To bridge the research gap left by extant studies with traditional methodologies, a new approach which can follow a holistic perspective is necessary and an agent-based modelling (ABM) approach (Gilbert 2008) is a promising candidate. “Simulation is a third way of doing science”, claimed by Axelrod (Axelrod 1997, pp. 5). He argued that deduction aims to derive logical consequences from a set of premises, whilst induction explores empirical data searching for any pattern. Different from these two traditional ways of doing science, simulation explores the data that are generated by simulation models embedding a set of pre-defined rules with a set of premises. By modelling a system and inputting specific data, researchers could

Table 5.2 Position of this work in E-government literature: Methodology

	Research objective				Result analysis		
	Service adoption	IT in Gov.	Resource allocation	Policy design	Policy evaluation	Macro level	Micro level
Quan.	0					0	
Qual.		0		0		0	
ABM	0		0	0	0	0	0

Notes. Quan.:Quantitative study; Qual.: Qualitative study; ABM: this work

observe the resulted emergent and unexpected output data even with simple embedded rules.

Across broad applicable areas, Axelrod (Axelrod 1997, pp. 3–4) summarized the purposes of simulation as "prediction, performance, training, entertainment, education, proof and discovery". Different from rational individuals which are usually assumed in deduction, adaptive behaviours are modelled and simulated, through which the contingent consequences raised from non-linear rules could be analysed (Axelrod 1997). Agent-based simulation (modelling) is one of the major simulation paradigms. It is characterized as a "bottom-up" simulation approach which can capture micro-level individuals' decision making and interactions among individuals and against the environment to analyse the resulted macro-level phenomena. This bottom-up approach is particularly useful to elucidate the underlying dynamic processes (Axelrod 1997).

ABM has been used extensively in both organizational innovation studies and innovation diffusion studies, respectively (Garcia 2005), but not in the service diffusion and adoption process studies yet. It can explore the interactions among involved stakeholders, and investigate how the interactions lead to collective behaviours. Besides, it can also be used to evaluate various supporting policies based on microscopic dynamics, and open new ways of collaboration among stakeholders. It is therefore a justified and promising approach to study the E-government phenomenon and to evaluate supporting strategies along with the service diffusion process since the whole process is dynamic and heterogeneous stakeholders are involved. The position of this research in terms of methodology is thus illustrated in Table 5.2. Entry "Macro-level" and "Micro-level" in the result analysis column refers to the result analyses from macro-level and micro-level perspective, respectively.

In summary, we aim to scrutinize the E-government phenomenon from a service system perspective by applying an agent-based approach. The micro-level characteristics of involved stakeholders, individuals' adaptive behaviours, interactions among stakeholders, as well as the resulted macro-level phenomenon are under investigation. Advancing understanding and insight on the dynamic behaviours of this service system at both micro-level and macro-level are expected to inspire better designed systems and strategies. Next, we will present a conceptual model of the service system, through which involved stakeholders are identified, explained, and integrated, and individual's abstract adaptive behaviours and interactions among stakeholders are articulated in order to examine and understand the system more profoundly and thoroughly.

5.4 Conceptual Framework

We introduce the conceptual agent-based framework to study E-government from a holistic perspective in this section. We first identify key stakeholders directly involved in the system, and define their interactive behaviours subsequently.

Although public sectors could gain benefits through promoting and developing E-government systems, citizens will gain much more from the services and influence the services directly and indirectly. E-government systems therefore should be viewed and examined as a series of interactions between public sectors and citizens, whilst the divergent services provided act as the intermediate point (Akman et al. 2005).

The common stakeholders of E-government systems are end-users, such as citizens and private sectors (or business organizations), service providers, and employees of the service provider (Gouscos et al. 2007). For the public sector, we will treat it as one single stakeholder without distinguishing among different departments engaged in E-government services, although the departmental coordination (or one-stop E-government) is also an important research direction of E-government systems (Wimmer 2002; Gouscos et al. 2002; Dias and Rafael 2007). Employees of the service provider (i.e. staff working for government) are not considered as well, since citizens are the most important parts and to certain extent the benefit gained by employees are similar to that gained by citizens (Gouscos et al. 2007). In the following, we will go into the details of each stakeholder, respectively.

5.4.1 Public Services

According to Gronroos's work (Gronroos 1988, 2001), the public service provided (transactional service and informational service) could be divided into three kinds: core services, facilitating services, and supporting services. Core services are the major functional services provided by individual departments, such as online transactional service. Facilitating services are aided services that help citizens complete the core services, such as computer resources and personal e-certificate that are necessary to do online transactions. Supporting services are value-added services that are often optional, such as technical support (Venkatesh et al. 2012). Services are evaluated against different criteria. For instance, usability is defined for core services, but not for the supporting services (Venkatesh et al. 2012).

Different services including transactional services and information provision services will be provided on two service channels, traditional office counter, and E-government websites. No significant differences are defined for the service provision between these two channels, but the consumed time and effort on each channel differ. For instance, online tax filing requires more efforts but less time compared to tax filing at traditional counters. Services provided through different channels will be evaluated against three major criteria, including easier, faster, and better services (Gouscos et al. 2007). Easier services and faster services are those require little effort and time to carry out, and better services are those with supporting services during the process.

5.4.2 Citizen-Side Learning and Channel Selection

The ultimate purpose of E-government is to provide services to citizens, and further to encourage them to engage in public affairs (Gouscos et al. 2007). There are no universally applicable services and thus the corresponding target users vary (Venkatesh et al. 2012). There is also a trade-off among service properties. For instance, citizens expect a higher level of security and privacy measures for online transactions, but may give up due to the complexity and poor usability involved in routine procedures (Venkatesh et al. 2012); but for other services, citizens just expect a convenient and easy-to-operate process without any security concerns.

There still exist discrepancies in the usage amongst target citizens, who have different preferences towards provided services associated with their education level, gender, and economic status (Gouscos et al. 2007). The preferences have impact on how citizens from different social groups evaluate multiple service channels and further influence the E-government usage behaviours. Different from innovation or product adoption, which is most of the time a one-time behaviour, the ability of taking up service will evolve along with the service improvements during the service diffusion processes. Citizens will learn adaptively how to use E-government systems either from their past experience or from the external environment including other citizens and the public sector.

Therefore, we will not design citizens as traditional rational agents who pursue to maximize their utilities, rather they are rule-based heterogeneous agents who will learn and behave adaptively against the environment. We categorize citizens into groups by their gender, educational level, and economic status (workers, students, and house makers). Each group values time and effort differently, therefore their selection of a service channel to take up the services will vary. Additionally, we allow citizens to improve their ability of using E-government systems through learning within their local community. Here the community composed of different kinds of citizens is treated as the “environment” of the model (Gilbert 2008). Deguchi’s social learning dynamics analytical model (Deguchi 2004) will be revised for modelling the adaptive learning behaviours.

5.4.3 Government-Side Resource Allocation

Public sectors hold two major objectives. One objective is to provide different kinds of services through multiple service channels, and technical support for using E-government, such as FAQ, email, and hotline services. In order to minimize the digital gap accounting to attributes such as educational level, the resource allocation in terms of user support should be improved continuously to satisfy the divergent requirements from all groups. The other objective is to propose and enact strategies promoting E-government services and facilitating citizens in using the services, such as public propaganda and educational workshops.

The promotion of E-government is considered as a way to increase citizen's awareness of E-government services and to spread correct information/knowledge of E-government; and organizing educational programmes aims to prompt citizens' ability of using technologies, such as organizing regular IT workshops within local communities and setting E-government self-help machines next to traditional service counters. Since education is a key factor of improving the uptake of E-government services (Gouscos et al. 2007), such educational programmes are expected to help citizens conquer barriers of using E-government services. Yet, the effectiveness of supporting strategies varies across social groups, thus optimized allocation of limited resources to address the needs fairly is critical.

We assume that the public sector will apply simple heuristics to allocate educational resources in an optimized way, such that the demands raised from different social groups can be satisfied simultaneously. We only consider E-government services in the general sense in this framework, and do not further distinguish particular services, adopted IT strategies and implemented initiatives in each local context.

5.4.4 A Holistic View

The interactions among stakeholders are realized through citizens' usage of public services provided through different channels along with the improved public support, and illustrated in Fig. 5.1. Basically, different public services are provided on both channels: traditional counter and E-government enabled by the government. The government will implement supporting strategies to entice more citizens to utilize E-government, such as learning programmes helping citizens mitigate the effort of using E-government, and public propaganda increasing citizens' awareness. Citizens will influence the public sector through the channel selection behaviour. More specifically, citizens will evaluate the channels by taking into account the service attributes, their corresponding preferences and received support from the public sector, and then choose a particular channel to take up services. Citizens will also learn from their off-line community to improve their abilities of using technologies, which may reduce the barriers of using online services. The resulted adoption rate will influence the allocation of supporting resources among different citizen groups, which will further influence the citizens' channel selection through supporting services, as a dynamic process.

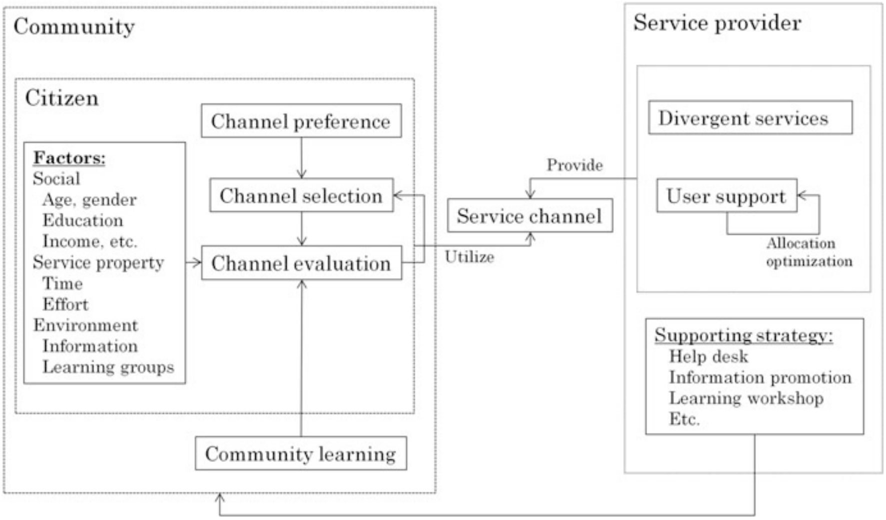

Fig. 5.1 Conceptual Framework

5.4.5 Gaming and Simulation

For an agent-based simulation approach, the validation process is one of the critical components. There are several ways to validate the models, in terms of guaranteeing consistency, against empirical data collected from the real world or stylized facts (Fagiolo et al. 2007). This stream of methods is very useful in reproducing specific social phenomena, yet our objective is to examine the link between underlying mechanisms and the resulted adoption behaviours. Ohori and Takahashi (Ohori and Takahashi 2012) introduced an analytical method for the validation of agent-based simulation, named "scenario analysis". This analytical method differs from previous methods by which average results of simulation runs are presented. Rather it describes the result of each run without modification. This method has the advantage of taking divergent situations, design policies, and possible changes into account when interpreting the simulation results, which can facilitate the decision-making process.

Gaming is another useful tool to triangulate the simulation results when conducting scenario analyses. When designing agent-based models to examine the impact of learning mechanisms on citizens' collective behaviours, we can unfold existing gaming protocols to integrate the learning mechanism. Public goods game has been widely applied in studying the social dilemma between individual interests and collective benefits, and especially suited to investigate such behaviours within groups (Camerer and Fehr 2004). In accordance with simulation models, we can design a game with a set of scenarios to be played by human players, and triangulate the results with those from simulation runs. We can also design the learning mechanism as a passive-learning process in the sense that it is embedded in the gaming session and calculated automatically whilst the players are informed by the learning results only. Alternatively, we can also allow the players to learn from their past experience or from the environment by limiting available information to the players. Based on the results and knowledge derived from gaming sessions as empirical evidence, we can further improve the agent-based model design. We can also introduce the participation of machinery agents to the games, which may induce unexpected behaviours of human players, and leverage the "wisdom of crowds" to explore collaboration mechanisms.

5.5 Concluding Remarks

In this work, we first reviewed the theoretical and methodological aspects of E-government phenomena. Based on the discussion, we argued that this phenomenon can be studied as an integrated service system considering the heterogeneous stakeholders and their interactive mechanisms from a bottom-up perspective, and thus new approaches should be adopted. This work serves as the first step towards understanding and designing E-government services by adopting a service system perspective.

We subsequently proposed an agent-based framework of E-government to identify the characteristics of heterogeneous stakeholders, their adaptive behaviours, and the interaction mechanisms among them from a service system perspective. Such integration provides a holistic view of the system which captures the dynamic service provision process and the macro-level phenomenon emerged from the micro-level interactions. It will complement studies carried by traditional approaches and advance the understanding of such systems from a bottom-up perspective. Future simulation works can be conducted based on this conceptual framework, through which the underlying dynamic process can be examined and analysed, and E-government supporting strategies can be proposed and evaluated.

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Part II
Simulation and Gaming for Sustainability

Chapter 6
Towards Explicating Gamification Types for Motivating Sustainability Action

Terukazu Kumazawa

Abstract This chapter provides you with an overview allowing you to characterize the subsequent chapters in Part II in the context of sustainability science. Reflecting that perspective, the author focuses on the types of ways in which the various kinds of research approaches incorporating a playful mindset are discussed in the literatures dealing with sustainability issues. Specifically, the author in this chapter shows the research trends of gamification in the fields of sustainability and classifies original articles and review articles from the perspective of the Sustainable Development Goals. In addition, the author tackles the categorization of types of ways in which the gamification approach is discussed through the case studies of the 21 extracted papers dealing with gamification.

6.1 Introduction

Five years have passed since the Sustainable Development Goals (SDGs) were adopted in 2015 (SDGs website). In this time, Future Earth—a framework for international collaborative research on the global environment—has been pursuing concrete approaches to guide people "from knowledge to action" (Miller et al. 2014; van Kerkhoff and Lebel 2006), for example, by promoting international collaborative research frameworks known as Knowledge-Action Networks (KANS) (KANS' website).

It has been asserted that trends in sustainability science have shifted beyond interdisciplinary survey and research frameworks to mechanisms driven by active intervention (Miller 2013). This is conceptualized as action-oriented knowledge for sustainability (Fazey et al. 2018). Caniglia et al. (2020) classified actions for sustainability into one of the three dimensions: intentional design, shared agency of multiple actors, and contextual realization. It has also been argued that instead of attempting direct change, research institutions involved in sustainability should aim

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to create conditions that allow change to manifest. One approach to enabling the change in awareness needed to arrive at these conditions is the use of simulation and gaming, and future design for debate between groups divided into a virtual future generation and current generation (Saijo 2020).

In recent years, continual efforts to improve literacy in sustainability issues have been socially implemented utilizing serious games. One example is the spread of SDG card games. In 2016, the Research Institute for Humanity and Nature (RIHN), to which the author belongs, started planning for the design and release of a serious game at the RIHN's open house. Since then, several other games have been planned, all focused on the theme of food.

This study expands the importance of gamification and supposes that games function as knowledge to motive actions while including elements of "play to stimulate the imagination," ranging from this kind of roleplay to simulation. The focus is on how such knowledge functions.

This article analyzes the sustainability issues addressed by original and review papers dealing with gamification and classified the elements of gamification that they possess. On the basis of the results, this article tries to examine the types of ways in which the gamification approach is discussed across all the fields of sustainability.

6.2 Play or Playfulness and Sustainability Actions

6.2.1 Stimulating the Imagination and Play Elements

Since games have themes, what constitutes a game is not merely its function, independent of the context of its field. The same is true when dealing with environmental and social sustainability. Although not a game-like function, it is also important to explore the "play" or "playful" aspect of sustainability, which is established only in the context of sustainability. According to Sicart (2014), investigating "playfulness" starting with games reveals that "playing gives us the world and through playing we make the world our own." Since games contain a story, they have an aspect that stirs the imagination, so those characteristics are included, but gamification tends to focus only on functional aspects.

However, Sicart argues that play depends on context, and the context of play is a messy network of people, rules, discussions, places, and objects. Sicart also distinguishes play and playfulness explicitly. He argues that play is an activity, while playfulness is an attitude. In addition, Sicart shows the seven properties of play: contextual, carnivalesque, appropriative, disruptive, autotelic, creative, and personal. On the other hand, playfulness is reflected in non-play activities by several properties of play. Playfulness makes the world reambiguate by utilizing play as a mode of existence.

On the other hand, there are various approaches to stimulating the imagination to think about challenges in realizing a sustainable society and more ideal visions of industry and lifestyles, including theater, roleplay, forecast methods, serious games, and gamification tools.

In this study, therefore, taking what is commonly referred to as gamification as a starting point, things that motivate playful actions and methods that stimulate the imagination are broadly examined to identify the types of ways in which the gamification approach is discussed in the fields of sustainability.

6.2.2 Overview of Investigation

The focus of this investigation is Scopus, the abstract and citation database by Elsevier. In this study, we narrowed our focus on the documents stored in Scopus to original and review papers. We did this because of the importance of avoiding duplicate findings as far as possible and ensuring that papers are peer-reviewed.

As search conditions, the search criteria included any of the terms "sustainability," "sustainable development," and "sustainable society" in titles, abstracts, author keywords, index keywords, and reference information, together with the term "gamification." As of October 19, 2020, this search yielded a total of 131 matching papers.

6.3 Literature Database Analysis Related to Gamification and Sustainability

6.3.1 Change Over Time

The search with the above search conditions could find articles going back to the year 2013. Figure 6.1 shows the total number of papers that either contain "gamification" in the title or abstract or that cite other papers that contain "gamification" in the title, for the years 2013–2020. There is a sharp rise beginning in 2016, with the number of papers reaching 40 in 2019. As of October 2020, there were more than 50 matching papers for the year.

6.3.2 Analysis of Sustainability Issues Using Abstract Information

Table 6.1 shows the results of a classification of the SDG-related terms included in the abstracts of the papers found in the search results, for the purpose of clarifying what kind of sustainability challenges gamification actually targets. The left-hand side of Table 6.1 shows the number of papers corresponding to all the terms

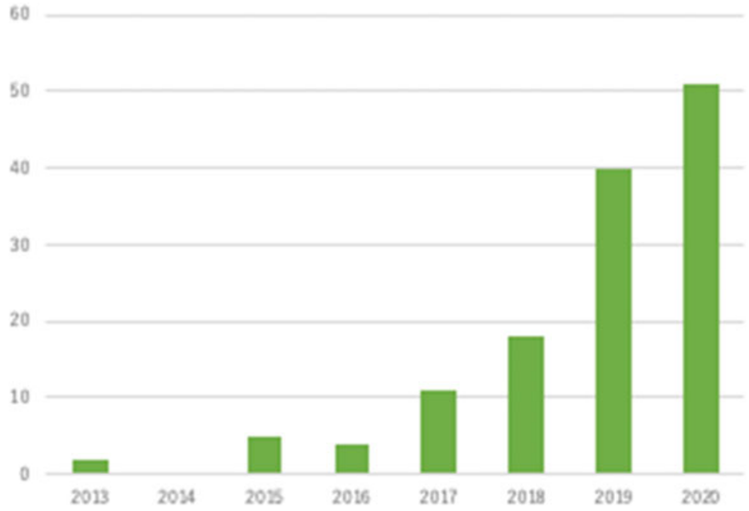

Fig. 6.1 Number per year of sustainability-related papers that cite the term "gamification" (up to October 19, 2020)

corresponding to each SDG. Note that occurrences of terms in the plural form were counted under the singular form (e.g., "cities" as "city").

In this article, the focus is on the terms contained in the description of the 17 SDG, as well as the terms "food" (5 papers), "ecology" (3 papers), and "culture" (8 papers) as related terms to the SDG.

The right-hand side of Table 6.1 shows the total number of papers for each SDG. These values are the sums of the numbers of papers for terms on the left-hand side.

The likely reason for the high number of papers for SDG 4, relating to education, is that gamification is itself discussed as an educational technique. In the case of SDG 8, relating to work and economy, it is possible that in some instances the term "work" is used in a different sense or context. Such irrelevant instances need to be eliminated. However, there were 29 papers with "economy" and 11 with "growth," which indicates a relatively high degree of discussion on the application of gamification to this field of sustainability. Other SDGs with high numbers of papers were SDGs 9, 11, 14, and 15.

In the case of SDGs 14 and 15, however, the terms "marine/ocean" and "land/island" appeared only in a few abstracts. Similarly, the number of papers corresponding to fields closely associated with the environment, as defined by terms such as "water," "energy," and "climate change," was fairly small. This indicates that discussion of gamification connected directly with global environmental problems within the context of sustainability has been limited.

Table 6.1 Terms relating to SDGs used in sustainability papers that mention gamification (units: no. of papers)

SDG	Term	Papers	SDG	Total
1	poverty	4	1	4
2	hunger	1	2	1
3	health	12	3	12
	well-being	1		
4	education	46	4	46
5	gender	2	5	2
6	water	7	6	7
	sanitation	1		
7	energy	14	7	14
8	work	50	8	70
	economy	29		
	growth	11		
9	industry	11	9	24
	innovation	15		
	infrastructure	2		
10	equity	4	10	4
11	city	18	11	21
	community	21		
12	consumption	12	12	17
	production	7		
13	climate	10	13	10
14, 15	life	21	14	22
14	marine/ocean	1		
15	land/island	4	15	25
16	peace	0	16	14
	justice	0		
	institution	14		
17	partnership	0	17	22
	goal	22		

6.3.3 Analysis of the Use of Terminology Relating to Action to Stimulate Imagination

To analyze the description in abstracts, five words relating to actions to stimulate imagination were examined: "play," "simulation," "gaming," "game," and "gamification." Table 6.2 shows the occurrence of each of these words for each SDG.

These terms were most frequently associated with SDG 4, relating to education, and with SDG 8, relating to work and economy. The next most frequent occurrences were associated with SDGs 6, 7, 14, and 15, which are all concerned with nature, and SDG 11, which is concerned with cities and community. Aside from SDGs 4 and 8, the term "gamification" was associated most frequently with SDG 7, relating to

Table 6.2 Total occurrences of terms relating to actions for stimulating imagination by SDG (units: no. of papers)

SDG	Play	Simulation	Gaming	Game	Gamification
1	0	1	0	1	0
2	0	0	0	0	0
3	0	1	0	1	0
4	11	8	2	19	7
5	0	0	0	1	0
6	3	1	2	5	2
7	2	2	1	3	4
8	8	5	2	14	13
9	2	0	1	3	3
10	1	1	0	2	0
11	2	2	0	5	5
12	2	1	1	3	2
13	0	1	0	2	1
14	6	2	0	7	3
15	6	2	0	8	3
16	2	1	0	1	1
17	4	0	0	6	2
Total	20	11	5	31	21

energy, and SDG 11, relating to cities and community, with four and five papers, respectively.

In contrast, "gamification" did not appear at all in association with SDGs 1, 2, 3, 5, and 10.

6.4 Types of Ways to Discuss Gamification Approach

6.4.1 Analysis of Paper Contents Based on Abstracts

The contents of all mentions of gamification in the 21 papers and reviews with abstracts containing the word "gamification" were analyzed. The results are summarized in Table 6.3.

6.4.2 Exploring Types of Ways to Discuss Gamification Approach

By analyzing, organizing, and categorizing how gamification is discussed in the fields of sustainability, this article attempts to clarify the relationship between gamification systems and internal and external elements. Organizing these findings as types of ways to discuss the gamification approach, four categories of such types

Table 6.3 Analysis of contents of mentions of gamification based on abstracts

ID	Title [year of publication]	Contents relating to gamification
1	Exploring gamification techniques and applications for sustainable tourism [2015]	This paper clarifies the effectiveness of gamification by analyzing the relationships between tourism organizations, travelers, employers, and local communities
2	Gamification: Strategies to optimize learning process and the acquisition of skills in university contexts [2015]	This paper discusses gamification with reference to blogs, wikis, and social networking
3	A review of water-related serious games to specify use in environmental multi-criteria decision analysis [2018]	This paper discusses the effectiveness of 43 water-related serious games and gamified applications at the early stage of multi-criteria decision analysis (problem structure, stakeholder analysis, definition of purpose, search for alternatives)
4	Gamifying collective human behavior with gameful digital rhetoric [2017]	This paper presents a design framework called gameful digital rhetoric and discusses individual design frameworks for expanding crowdsourcing by progressively adding new digital rhetoric and the question of how such frameworks can guide collective human behavior
5	Gamification in MOOCs: Engagement Application Test in Energy Sustainability Courses [2019]	Document ID20 explores the effects of applying the gamification strategies used in MOOCs dealing with energy sustainability on the engagement of participants and what types of interactive gamification media to try and establish for generating student interest and motivation
6	Towards a framework for designing and assessing game-based approaches for sustainable water governance [2019]	This paper on the theme of sustainable water governance emphasizes that a game-based approach should be distinguished by its "expected purpose," "target audience," and "space-time scales," and that it should not contain anything pushed by society
7	An IoT-based gamified approach for reducing occupants' energy wastage in public buildings [2018]	This paper discusses a gamification framework to promote energy conservation in public buildings, with a specific focus on identifying energy wastage. It attempts to motivate individual behavioral change through a combination of team competition, virtual rewards, and life simulations
8	Computational thinking and robotics: A teaching experience in compulsory secondary education with students with high degree of apathy and demotivation [2019]	This paper describes the development of practical experience in teaching computational thinking using robotics, as well as the use of gamification to motivate and assess individual knowledge. The needs of targeted students are met through daily monitoring
9	Beyond limitations of current behavior change apps for sustainable mobility:	This paper describes an app, Go Eco, designed for convincing people to change transport mode, showing automatic tracking

(continued)

Table 6.3 (continued)

ID	Title [year of publication]	Contents relating to gamification
	Insights from a user-centered design and evaluation process [2019]	of movement, eco-feedback, social comparison, and gamification elements. Most notably, in addition to multiple movement plans, it includes a feature that offers support and assistance relationships by promoting a sense of belonging to the community
10	Integrating simulation tasks into an outdoor location-based game flow [2020]	This paper describes the development of an educational game based on location, integrating ecological simulations in a location-based game flow
11	Inducing individuals to engage in a gamified platform for environmental conservation [2020]	This paper verifies how the design of gamification encourages users to make continual use of information systems for promoting environmental protection and shows that allowing autonomous support, visualization of achievement, competition, and interaction influence the level of user satisfaction
12	How to maintain the sustainable development of a business platform: A case study of Pinduoduo Social Commerce Platform in China [2019]	This paper discusses a platform business model and how the platform is stabilized through the experience in two stages, of expansion and evolution. It focuses on the formation of incentives for participants in the expansion stage, through a "low price + social contact" strategy and a "gamification + brand channel" strategy
13	Learning about sustainable mobility in primary schools from a playful perspective: A focus group approach [2019]	This paper, focused on sustainable movement, compares children who acquired information through learning activities designed using gamification techniques with children who acquired ordinary educational experience
14	Exploring determinants of consumers' platform usage in "double eleven" shopping carnival in China: Cognition and emotion from an integrated perspective [2020]	This paper shows that the determining factors of consumer behavior on a shopping platform are influenced by perceptions of factors such as price, gamification, and personalized services, and on emotional states such as arousal and delight
15	Food waste reduction: A test of three consumer awareness interventions [2020]	This paper examines three interventions relating to food waste, by comparing and verifying three different approaches: passive learning through handouts, community involvement, and gamification
16	Learning based on flipped classroom with just-in-time teaching, Unity 3D, gamification and educational spaces [2019]	This paper shows the impact of flipped classroom teaching using Unity 3D and gamification in classes for making the best decisions on climate change mitigation,

(continued)

Table 6.3 (continued)

ID	Title [year of publication]	Contents relating to gamification
		promotion of sustainable development, and rational energy use
17	The gamification Octalysis Framework within the primary English teaching process: The quest for a transformative classroom [2018]	This paper shows that the story of South Africa can become a gamified experience that can be applied as a method for teaching English in the classroom
18	Long-term perspectives of a school-based intervention to promote active school transportation [2020]	This paper looks at the follow-up of the experiences of participants one and two years after interventions based on gamification, empowerment, and social recognition theory for actively promoting transport to schools
19	WeDoShare: A ridesharing framework in transportation cyber-physical system for sustainable mobility in smart cities [2020]	This paper proposes the involvement of citizens in ridesharing activities through a gamification approach
20	E-learning platforms as leverage for education for sustainable development [2020]	This paper discusses various gamification techniques used at the stage of course design for online learning
21	Exploring the impact of gamification on users' engagement for sustainable development: A case study in brand applications [2020]	This paper analyzes how the mechanics of a game influence the gaming behavior of players and how positive emotions can be aroused to increase brand stickiness

were found and are defined as "types found from relationships with actors," "types found by comparison and combination with other system," "types found from tools, devices, and mechanisms," and "types found from targeted issues," reflecting the examination based on the descriptions in Sect. 6.4.1, as follows.

6.4.2.1 Types Found from Relationships with Actors

Types can be found through differentiation from the use by other users. Document 1 features various stakeholders involved in tourism, whereas Documents 3 and 6, which are focused on water governance, mention stakeholders and audiences, respectively. The essential requirement is to provide services based on the benefits found by each actor.

Also, the use of rhetoric in Document 4 can also be considered a type that reflects the relationship with actors.

6.4.2.2 Types Found by Comparison and Combination with Other System

Gamification may be characterized through comparisons with other web-based tools, as in the case of Document 2, or through comparison with existing educational methods, as in Document 13. Types may also be found by differentiation from other methods for understanding problems, as shown in Document 3, focused on water governance, and in Document 15, focused on interventions in food waste.

On the other hand, as evident in Document 12, there are cases in which types can be considered in combination with the separate approach of branding channels.

6.4.2.3 Types Found from Tools, Devices, and Mechanisms

The first is a type relating to tools when conducting gamification. In Document 5, a gamification board featuring tasks, badges, and leader boards is used.

The second is a type relating to devices and mechanisms in the gamification system. Document 10 describes a link with a technical system known as a simulation. Document 7, which deals with energy conservation, describes a way of trying to motivate individual behavioral changes by combining team competition, virtual rewards, and life simulations. Document 11, which deals with environmental protection, demonstrates that allowing autonomous support, visualizing achievements, competition, and interaction influence user satisfaction. Document 20 discusses recording and expressing the progress of learners, as well as roleplay and the like.

However, there are assumed to be devices and mechanisms that match the targeted sustainability issue and those that do not.

6.4.2.4 Types Found from Targeted Issues

In Documents 3 and 6, which focus on water governance, objectives were targeted in both cases. Sicart mentioned in Sect. 6.2.1 regards play as "self-purposeful" and as a "personal thing" in the context of analyzing play requirements, based on games. While fulfilling the individual purpose, it is also essential to successfully understand and respond to the "public purpose." This could be considered a type that is not used for promoting individual growth in that particular field.

However, Document 21 shows that, as a result of analyzing how positive emotions are aroused, one's own challenge is a preliminary factor that influences self-efficacy, joy, and social interaction. At the same time, self-efficacy and social interaction influence enjoyment. This point can serve as a clue to examining connections between personal and public objectives.

6.5 Concluding Remarks

This article analyzed original and review articles published in the fields of sustainability by means of the Scopus and attempted to find the types of ways in which the gamification approach was discussed in these fields. Looking ahead, there is a need to clarify the potential types of gamification and their contexts in the fields of sustainability by examining the relationship between gamification and science from a more comprehensive perspective. Through such an approach, it should be possible to exhaustively cover the actions necessary for explicating all gamification types.

The gaming and serious games presented in the following chapters deal with all kinds of global environmental issues including renewable energy (Chap. 7), fishery resources (Chap. 8), and Arctic sustainability (Chap. 9). In addition, the Serious Board Game Jam presented in Chap. 10 deals with a place for developing serious games. Each of such issues and places can play an important role as contexts to be discussed. I hope you will pay attention to not only gaming and serious games themselves but also their contexts throughout the course of Part II.

In the future, academic activities related to social-ecological sustainability will be developed and promote sustainability actions in cooperation with product design and expression activity. Gaming and serious games are also included as representative cases of such products or expressions. In fact, discussion for linking the arts and sciences for collaborative sustainability action can be found (Trott et al. 2020). The academic style in the future would involve a different mode from that in the present. Looking back to the present at the time, the discussion in Part II might be found to be a kind of pioneering effort.

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Chapter 7
The Unique Value of Gaming Simulation as a Research Method for Sustainability-Related Issues

Kengo Suzuki

Abstract This study describes the unique value of gaming simulation, also known simply as gaming, in the context of research on sustainability-related issues. The advantages and disadvantages of gaming are investigated through a comparative review with other research methods using games, such as game theory and social psychology experiments. Further, the uniqueness of gaming is explained through experimental results on the theme of energy transition from fossil fuels to renewables in a competitive market. The results of the comparative review suggest that the unique value of gaming lies in its ability to help researchers observe dynamic interactions between the subjective realities of players and the states of the complex technical–social–environmental systems they belong to. A retroductive analysis of experimental results suggests the existence of two mechanisms hindering energy transition among the players: price competition caused by a competitive worldview, and free riding behavior under a cooperative worldview.

7.1 Introduction

Sustainability-related issues have been widely recognized since the 1970s though the pioneering literature (Hardin 1968; Meadows et al. 1972). The community of sustainability science has sought to conduct further research on the interaction between environmental and social systems to transform these systems sustainable. (Kates et al. 2001; Komiyama and Takeuchi 2006). However, many issues remain unsolved even at present, and the situation has worsened over the last half century in some sectors. The energy sector, one of the foundations of modern society, is a typical example. In spite of the risks of resource depletion and climate change, 85% of world's primary energy consumption is still supplied by fossil fuels (BP 2020). Although renewable energy usage continues to grow, it has not kept pace with the

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rapid rise in total energy demand. Investments in renewable energy remained stagnant in 2017 and 2018 (IEA 2019), and the economic shock caused by the COVID-19 pandemic may further stagnate climate policies and cause an even higher emission trajectory (Le Quéré et al. 2020).

Jacobson and Delucchi (2011) and Delucchi and Jacobson (2011) pointed out that the diffusion of renewable energy is hindered by political and social factors rather than technical and economic aspects. For example, the mitigation of climate change requires the worldwide energy transition from fossil fuels to renewables. However, if the urgency and severity of climate change is not shared by the international community, some countries may consider that free riding on the contributions of other countries is a better strategy than making earnest contributions (DeCanio and Fremstad 2013; Nordhaus 2013). Therefore, the ideal path for ensuring global benefits can be hindered by strategic interactions between countries. Furthermore, in the real world, it is difficult to fully pinpoint the ideal path to the global benefit in advance because of complex interactions among the behaviors of various countries and the states of societies and the environment. For example, it is difficult to accurately estimate the amount of damage caused by human-induced climate change on societies and ecosystems, and the total social costs required to achieve the goals of the Paris Agreement. Thus, decision-makers are faced with uncertainty due to strategic conflicts and complex system structures. Given this backdrop, they interpret the same situation differently; some recognize climate change negotiations as a cooperative game, whereas others perceive it to be a competitive one. This pluralism in subjective reality appears to be the root cause of political and social conflicts hindering the selection of the correct sustainable path. To mitigate such conflicts, it is necessary to investigate the interactions among decision-makers in terms of the plural and subjective realities and the dynamics of the technical–social–environmental systems they participate in. For this purpose, the target systems need to be modeled as multi-agent systems driven by stakeholder decisions.

Gaming simulation (also known simply as gaming) is defined as "the playing of games developed to teach something or to help solve a problem, as in a military or business situation" (Flexner 1987). In the field of gaming, a game is regarded as a quantitative model of a target system driven by the decisions of its players. The players are given the role of stakeholders in the target system, and act to achieve their own targets. A result of gameplay is regarded as a kind of simulation showing a possible future path followed by a target multi-agent system. "It can be usefully employed for gaming perspective on complex circumstance; it is particularly useful for guiding speculation about future circumstances" (Duke 1974).

In recent years, gaming has been widely recognized as a communication tool for sustainability-related issues between professionals and non-professionals, and debates about its usefulness and the problems associated with it is ongoing (Madani et al. 2017; Stanitsas et al. 2019). Interestingly, many earlier studies have shown the usefulness of gaming for education and science communication in the context of sustainability-related issues, such as those concerning energy (Suzuki 2016; Ando et al. 2019), water resource management (Douven et al. 2014; Hertzog et al. 2014; Craven et al. 2017), agricultural system management (Farrié et al. 2015; Salvini et al.

2016), circular economy (Whalen et al. 2018), and climate change (Juhola et al. 2013; van Pelt et al. 2015; Matzner and Herrenbrück 2016). Further, gaming can contribute to policy discussions focused on realizing sustainable future paths by investigating the dynamic behaviors of target systems (Speelman et al. 2014; Ambrosius et al. 2019; Kitakaji and Ohnuma 2019; Clark et al. 2020). However, gaming is merely recognized as a method to accomplish such a social simulation compared with other methods using games, such as game theory and social psychology. To raise the awareness of gaming as a method of social simulation, it is necessary to clarify how gaming is superior to other research methods.

The purpose of this work is to show the unique value of gaming in the context of multi-agent systems research on sustainability-related issues. Section 2 presents the unique value of gaming through a review of sustainability-related studies using games as multi-agent models in the fields of game theory, social psychology experiments, and gaming. Section 3 explains the value additions of gaming through experimental research results themed around the energy transition from fossil fuels to renewables in a competitive market. Section 4 presents the conclusions and also discusses directions for future work.

7.2 Review of Research Methods Using Games

7.2.1 Game Theory

Game theory is defined as the study of the mathematical models of conflict and cooperation between intelligent and rational decision-makers (Myerson 1991). Here, a game involves players, strategies, and payoffs. In addition to such a game structure, the rule specifying the expected behavior of the players, called solution concept, is axiomatically given. The solution concept expresses the behavioral principles to be followed by the players in strategic situations; some of them may assume a competitive situation, such as the Nash equilibrium, while others assume a cooperative situation, such as the Core or Shapley values (Wood 2011).

Table 7.1 presents the payoff matrix for a simple two-player game called the Prisoner's Dilemma. Players A and B are given two strategies: cooperate (C) or defect (D). The numbers on the left and right in each cell of the table are the payoffs for A and B for each combination of strategies. The whole society benefits the most when both players choose C ($3 + 3 = 6$). However, each player gains more benefit by choosing D over C regardless of the opponent's strategy. As a result, the solution of this game is (D, D) when rational players choose optimal strategies. This solution

Table 7.1 Two-player Prisoner's Dilemma game

		Player B	
		Cooperate	Defect
Player A	Cooperate	3, 3	1, 4
	Defect	4, 1	2, 2

concept is called the Nash equilibrium. This example explains how the most desirable choice for the whole society is hindered by the rational behaviors of players who try to maximize their own profits.

Game theory has been applied to the field of environmental issues, including climate change, to elucidate how interactions between selfish players cause undesirable results for society as a whole, or to search for conditions that can realize desirable results for both players and society (Pittel and Rübbelke 2008; Diekert 2012; DeCanio and Fremstad 2013; Madani 2013; Honjo 2015; Mielke and Steudle 2018). For example, DeCanio and Fremstad (2013) examined which type of game can suitably represent climate change-related negotiations, and found that the most suited climate negotiation can be conducted through the Coordination Game, wherein cooperation can help players maximize their own profits. Mielke and Steudle (2018) regarded the climate change issue as the Coordination Game among investors with short-term perspectives. By analyzing the structure of the Coordination Game, they suggested two policy options to realize the most desirable solution for the entire society. The first option includes policies to raise the payoff of adopting green technologies, and the second option includes signals to raise the expectations of the players so that they also invest in green technologies.

Although most studies using game theory assume that all players aim to maximize their own profit, recent works consider situations in which some players aim for symbiosis or seek a comparative advantage over other players. For example, Honjo and Kubo (2020) developed a two-player non-cooperative game of wildlife viewing and investigated the influences of social value orientation (SVO) on the equilibrium solution of the game. SVO is a subjective weight on the objective profits of oneself and others (Murphy and Ackermann 2014). The results show that punishments for environmental destruction cannot change non-cooperative behavior of competitive players who recognize the gain of others as a loss for themselves.

Thus, game theory allows deductive reasoning via a preliminary assumption of a game structure and a solution concept that *appear* to represent the structures of real-world issues.

7.2.2 Social Psychology Experiments

While game theory infers the theoretical consequences of certain social situations, social psychology and its applications, such as behavioral economics, clarify the rules of human cognition and behavior in a certain social situation by analyzing the results of games played by human players. Similar to game theory, sustainability-related issues are modeled as games, where the benefits to individuals and the whole society do not necessarily match. Examples of such games are the Prisoner's Dilemma and the Coordination Game. These games are played under multiple conditions that simulate various social conditions and rules. Researchers statistically test the differences in variables representing the cooperativeness among players between conditions. Based on such strict inductive reasoning, the influence of these conditions and rules on the decision-making of human groups is inferred.

In the context of sustainability-related issues, the N-person Prisoner's Dilemma game and its variants have been adopted by many earlier studies. These works suggested that an increase in the number of players reduces the cooperation rate, communication between players encourages cooperation, anonymous decision-making reduces the cooperation rate, and high trust in other players results in high cooperation rates (Rapoport et al. 1962; Marwell and Schmidt 1972; Tyszka and Grzelak 1976; Dawes et al. 1977; Edney and Harper 1978; Fox and Guyer 1978; Dawes 1980; Yamagishi 1988; Hasson et al. 2010). Further, the impacts of sanctions and rewards on the cooperation rates of players have been discussed. Yamagishi (1988) showed that the increase in cooperation rate due to a sanction rule is relatively high in a cohort with low trust toward others compared with a cohort with high trust. Eek et al. (2002) suggested that a sanction increases the rate of cooperation in social dilemma situations by increasing the expectations against others for cooperation. On the other hand, Tenbrunsel and Messick (1999) suggested that a sanction reduces the cooperation rate, because players recognize the cooperate/defect selection as a business problem rather than an ethical one due to the existence of a sanction. Ostrom (2006) reasoned that a sanction system increases the cooperation rate as far as it is endogenously introduced by players themselves, while it reduces the cooperation rate when it is exogenously given by outsiders. Mulder et al. (2006) suggested that a sanction does not contribute to an increase in cooperative behavior when alternative non-cooperative choices exist.

Some studies pointed out that the conventional N-person Prisoner's Dilemma game and its variants are too simple to represent sustainability-related issues (Buckley et al. 1974; Stern 1976). In this type of game, the payoffs of players are determined only by a combination of their choices; none of the variables represent the status of the environment, such as the number of trees in a shared forest, remaining amount of fossil fuel reserves, or concentration of greenhouse gases in the atmosphere. However, in the real world, the state of the environment is affected by the actions of humans, and the changes in the state of the environment recursively affect the payoffs of their actions. Such a dynamic interaction between the environment and humans cannot be expressed in the conventional game. To respond to such criticism, some researchers began to adopt games with environmental variables that interact with players' decisions (Watzke et al. 1972; Stern 1976; Jorgenson and Papciak 1981; Sato 1987; Milinski et al. 2008; Bednarik et al. 2019). For example, Sato (1987) designed a game in which players aim to maximize their profits by harvesting trees from a shared forest. At each time step, players choose to wait for the tree to grow or to cut it; waiting is a cooperative action, whereas cutting is a non-cooperative action, because the value of the trees increases proportionally to their size. The results of the experiments showed that a sanction for cutting trees increased the rate of cooperative actions. Bednarik et al. (2019) also designed a game for maximizing profits from a shared forest. In this game, the regrowth speed of the forest depended on the number of remaining trees. Further, the remaining trees reduced the damage from floods that occurred depending on the settings of different experimental conditions. The results of the experiments suggested that communication among players encourages cooperation, the presence of flood risk reduces non-cooperative actions, and the egalitarian worldview of the players contributes to forest conservation.

Thus, experimental studies in the fields of social psychology and behavioral economics inductively infer the psychological factors influencing the outcomes of games by comparing the results of games played under multiple conditions wherein certain social conditions in the systems are controlled.

7.2.3 *Gaming*

Research on gaming simulations has been conducted in two contexts. In the first context, the gaming research inductively infers the factors influencing the results of the games based on the records of games played under multiple conditions, as in the case of social psychology experiments (Kitakaji and Ohnuma 2014; Kitakaji and Ohnuma 2019). For example, Kitakaji and Ohnuma (2019) designed an Industrial Waste Illegal Dumping Game to infer why illegal dumping unexpectedly increases when sanctions are strengthened. The participants of this game played one of three roles: generators of waste, intermediate treatment companies, and landfill companies. The generators emit industrial waste through their economic activities, and hand over the waste and commissions to the intermediate treatment companies, which can halve the amount of waste at a given cost. Thereafter, the intermediate treatment companies hand over the remaining waste and commissions to the landfill companies, which can dispose of the waste by paying a given cost. All the participants can illegally dump the waste to save on the commissions and costs. However, at the end of game, all the participants must pay the environmental restoration cost according to the total amount of illegally dumped waste. This game has a social dilemma structure in which proper treatment and landfilling are cooperative behavior, and illegal dumping is non-cooperative behavior. This game was played under three conditions: the reward condition, the mutual punishment condition, and the control condition. The results of the experiment showed that the amount of illegal dumping was higher under the reward condition compared to that under the control condition. The results of questionnaire survey showed that under the reward condition, the participants did not actively collect information about the payoffs of others, which is essential to maximize profit for the whole society. These results suggest that the presence of the reward changed the goal of each participant from mutual cooperation to attaining the reward, and therefore, the participants lost the incentive to communicate, which was required for mutual cooperation.

The game devised by Kitakaji and Ohnuma (2019) is different from social dilemma games generally applied in the field of game theory as well as the social psychology experiments for the following reasons. First, the selectable actions and payoff function differed between the roles. Second, the participants were not informed about the payoff functions of the other roles at the beginning of game.

Therefore, they needed to communicate with each other to calculate appropriate commissions based on their break-even points. Third, communication among participants was not controlled; the participants could freely decide upon the timing and density of the communication. These settings enable experimenters to infer the relationships between the results of the games and the changes in the subjective perceptions of the participants against the whole society.

Conversely, the second category of gaming studies observes the differences in the results and the behaviors of the participants using games played under a single condition, and they infer the conditions causing such differences (Nagasaka et al. 2012; Speelman et al. 2014; Ambrosius et al. 2019; Clark et al. 2020). For example, Ambrosius et al. (2019) designed a game focusing on the investment strategies of the Dutch pork sector to infer the perceptions of various investment strategies used by Dutch pig farmers and the impact of the social interactions among farmers on the adoption of these strategies. Participants play roles of pig farmers whose aims were to avoid bankruptcy for their own farms and to maintain a certain level of social acceptance for the whole pork sector. In the game, participants repeat the discussions about investment strategies and decisions. Based on the forms completed by participants and the video and voice record of games, the relationships between the adoption rates of the investment strategies, the contents of discussions, and influence of the opinion leaders (the players who made the largest number of accepted suggestions) were investigated. The results of the analysis suggested the following. First, under the influence of social interactions, only investment strategies with economic benefits, such as business expansion, were adopted at high rates. Second, positive communication among participants was necessary to increase the adoption rates. Third, the opinions of the leaders played an essential role in the adoption of investment strategies.

These findings were *retroductively* obtained from the results of games. It is well known that logical reasoning can be divided into three types: induction, deduction, and retroduction (Guthery 2008). Deduction uses preconditions and rules to draw conclusions; the game theory employs this logic. Induction tries to identify the rules linking the preconditions and results; social psychology experiments and the first type of gaming research adopt this logic. In contrast to these major reasoning, retroduction infers possible preconditions using rules and conclusions. For instance, Ambrosius et al. (2019) were the first to identify the difference in the adoption rate of investment strategies among the games. Next, the relationships between the adoption rates and the interactions among the players were investigated. Further, the conditions causing the differences in the interactions, such as the profitability of the strategies and the existence of the opinion leaders, were inferred. Figure 7.1 shows the differences in the logic applied in deductive, inductive, and retroductive reasoning in the context of multi-agent gaming research.

Regardless of their logic, both types of gaming research focus on the dynamic changes in the subjective perceptions of participants caused by interactions among them or between them and the social environment. Kitakaji and Ohnuma (2019) inferred the effects of social institutions, such as rewards and sanctions, on the dynamic process of mutual cooperation among players. Ambrosius et al. (2019)

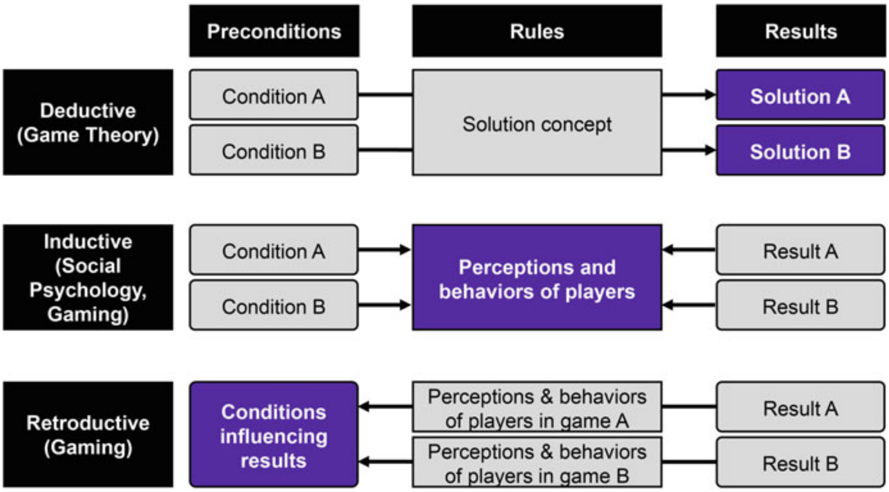

Fig. 7.1 Conceptual figure showing the logic in deductive, inductive, and retroductive reasoning in the context of multi-agent gaming research

discovered important dynamics, namely that opinion leaders lead the adoption of investment strategies by other players. These dynamic changes in the subjective perceptions can be observed by adopting games whose structures cannot be easily understood and in which players do not share information necessary to find an optimal strategy. The participants of such complex games form their own subjective realities through learning processes of unknown social structures. By including this learning process, gaming can express a multi-agent system with conflicts in dynamic and pluralistic values, and can infer the differences between games in which those conflicts are resolved and not resolved.

However, the adoption of such complex games makes the control of experimental conditions difficult because the process of forming subjective realities vary among players. Therefore, strictly speaking, all the experiments with different players were performed under different conditions when employing complex games. The conventional experimental studies appear to have controlled the dynamic changes in the subjective realities of players by adopting a relatively simple game for the strong inference; in a relatively simple game, the subjective realities of players are relatively static because they easily understand the structure of the game in advance.

In spite of such a disadvantage, gaming is useful to discover and demonstrate important possibilities that might have been missed without it and some notion of how these possibilities relate to the structure of the game (Schelling 1964). In other words, gaming emphasizes the observation of dynamic interactions between participants rather than the rigor of logic and verification (Kitakaji and Ohnuma 2014). These characteristics of gaming are suitable for discovering hypotheses about the dynamics of complex technical–social–environmental systems rather than testing the existing hypotheses for those systems. In other words, gaming is a kind of future

Table 7.2 Comparison between game theory, social psychology experiments, and gaming

	Game Theory	Social Psychology and Behavioral Economics	Gaming
Approach	Theoretical	Practical	Practical
Logic	Deductive	Inductive	Inductive/ Retroductive
System Complexity	Low	Low	High
Inference Certainty	Strong	Strong	Weak
Dynamics of Subjective Reality	No	No	Yes

mining, which heuristically searches for multiple paths that can be selected under varying uncertainties.

Table 7.2 shows the differences between game theory, social psychology experiments, and gaming based on the above discussions. Gaming in the context of multi-agent systems research using games is unique in that the dynamic changes in the subjective realities of players can be observed by adopting games that concretely represent complex issues in the real world. Since technical–social–environmental systems such as energy systems are very complex and involve multiple agents, it is difficult to derive hypotheses about their dynamic behaviors from direct observations. However, by modeling these systems as games and observing the dynamic interactions among and between players as well as the social environment, hypotheses about the factors influencing the behavior of entire systems can be heuristically inferred. As discussed in Section 3.1, in order to contribute to the solution of sustainability-related issues, it is necessary to investigate the effects of plural and subjective realities of stakeholders on the dynamics of technical–social–environmental systems. Gaming can contribute to this requirement of sustainability science in a novel way compared to other research methods using games.

7.3 Experimental Studies on Energy Transition

The energy transition from fossil fuels to renewables is one of the most significant policy issues globally, given the importance of ensuring a stable supply of energy and mitigating climate change. To achieve this transition, the supply cost for renewable energy must be lower than that for fossil fuels. The reduction in supply cost requires investments in research and development (R&D) and social implementation. Such investments will bring long-term benefits to energy companies because fossil fuel reserves are finite. However, in a competitive market, the energy companies must make efforts to reduce the selling prices of final energy to retain their customers. To reduce these prices, companies need to adopt relatively cheaper fossil fuels and/or cut their profits. Therefore, energy companies face the conflict between earning long-term profits from investments in new technologies and making short-term profits by retaining market share. This energy technology selection problem in a competitive market can be regarded as a social dilemma, as the interest of the whole society conflicts that of its individual members.

Previous studies have investigated the relationship between the subjective recognition of this dilemma structure in terms of market players, the intensity of price competition in the market, and energy technology selection for whole the market using gaming experiments. This research involved designing a multiplayer game that simulates a competitive energy market, conducting experiments consisting of gameplay and a questionnaire survey, and analyzing the experimental results. The formal model of the game and the results of preliminary experiments are reported in Suzuki et al. (2019), and the results and discussion of the main experiment appear in Suzuki et al. (2020). Here, the retroductive logic of these gaming experiments are explained using the same data as Suzuki et al. (2020); importantly, the viewpoint for explaining the results and discussing them are largely reworked for the purpose of this chapter.

7.3.1 Summary of Experiments in the Energy Transition Game

The energy companies cannot know in advance whether long-term investment in renewable energy or short-term price competition is more profitable. This conflict is brought about by the uncertainty in the intensity of competition among players, the effects of investments on the supply costs of renewables, and the changes in fossil fuel prices. The multiplayer game called Energy Transition is designed to represent a multi-agent system in which players select energy technologies under these uncertainties. Each player plays the role of an energy company participating in a competitive market. The game progresses by repeating a time unit called "term." The purpose of the players is to make as much profit as possible within a predetermined number of terms by selling the final energy produced from either renewables or fossil fuels. The number of players was set to five.

Figure 7.2 shows the model structure of the game. The status of a player is represented by three variables, namely money, demand, and unit price of renewables, to produce a unit of final energy. In addition to these variables, the unit price of fossil fuels is provided externally. In each term, all the players simultaneously enter the following decision variables: the amount of final energy supply using renewables and fossil fuels as materials, the selling price of the final energy supply, and the amount of R&D investment in renewables. Then, the status of the players is updated as follows. First, the money of a player increases according to the demand and selling prices, and decreases according to the unit prices and supply amounts of the two types of energy sources. Second, the demand changes according to the difference in the selling prices among players; customers move from players with relatively high prices to these with relatively low prices. Finally, the unit price of renewables is reduced according to R&D investments and the amount of final energy

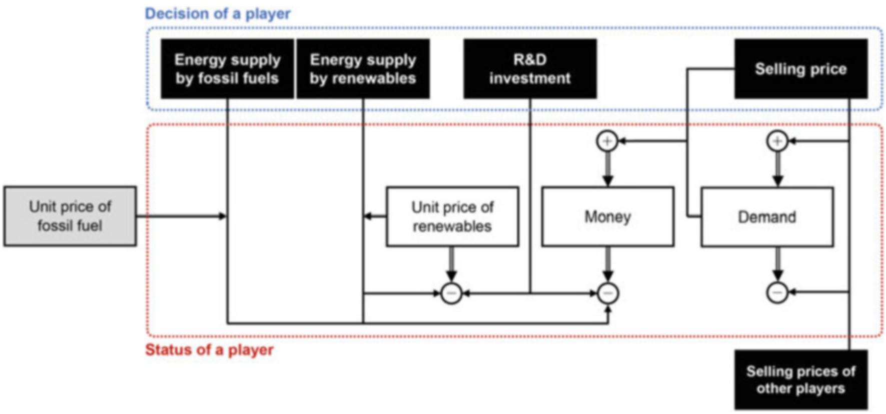

Fig. 7.2 Model structure of the energy transition game. The + and – signs denote the positive and negative influences of the players' decisions on their status. For example, the unit price of renewables is reduced by R&D investment and energy supply by renewables is increased

supplied by the renewables. The unit price of the fossil fuels rises in every period, independent of the players' decisions.

The parameters of the game were set to represent the social dilemma between the long-term profits of the entire market due to energy transition and the short-term profits of individual companies due to price competition. At the beginning of the game, the unit price of renewables is much higher than that of fossil fuels. The total profit of the market, namely the sum of money earned by all players at the end of the game, is maximized when the transition from fossil fuels to renewables occurs. However, individual players can increase short-term profits by prioritizing selling price reduction over the investments. Such a dilemma structure is expressed by adjusting parameters such as the rate of increase in the price of a fossil fuel, the sensitivity of the renewables unit price to investments, and the sensitivity of demand to the difference in selling prices among players. The details of the formal model and parameter settings are explained in Suzuki et al. (2020).

The experimental environment consisted of six laptop personal computers (PCs): five served as input terminals (one for each player), and one was used as the game server operated by an experimenter. These PCs were connected via wireless LAN. The game program was developed using Excel VBA and was installed on these PCs. All the variables shown in Fig. 7.2 were automatically recorded on the game server.

In this game, the conflicts among the players were caused by the uncertainties in the intensity of competition, the effects of investments, and the changes in the fossil fuel prices. Therefore, this study investigated the anxiety level of players with regard to these three types of uncertainties using a questionnaire survey. The survey contained three questions:

Q1: How strongly do you feel anxiety about the price competition?
Q2: How strongly do you feel anxiety about the return from investment in renewables?
Q3: How strongly do you feel anxiety about the future price of fossil fuels?

Players chose answers from among seven options, ranging from "1: I do feel no anxiety at all" to "7: I feel very strong anxiety." This survey was repeated six times: at the beginning of game and at the end of the 5th, 10th, 15th, 20th, and 25th terms.

The experiments were conducted seven times. All 35 participants were students at the University of Tsukuba, Japan. The data up to the 25th term were used for the analysis, while the length of game was set to 28 terms. This setting was devised to remove the influence of peculiar behaviors of any player immediately before the end of the game. After the experiment, the participants were rewarded according to the profits they made during the game. The rewards ranged from JPY 1,000–3,000.

7.3.2 Analytical Results

In this study, the amount of energy supply from renewables and players' profits were set as the evaluation indices of the experiment, because the research was conducted to analyze the conflict between energy transition and economic viability. Figure 7.3 shows the total renewable energy supply and total profit of all players at the end of the 25th term in each game. The serial numbers of the games are shown via Arabic numerals. The red, blue, green, and gray shapes show the results of classifying these

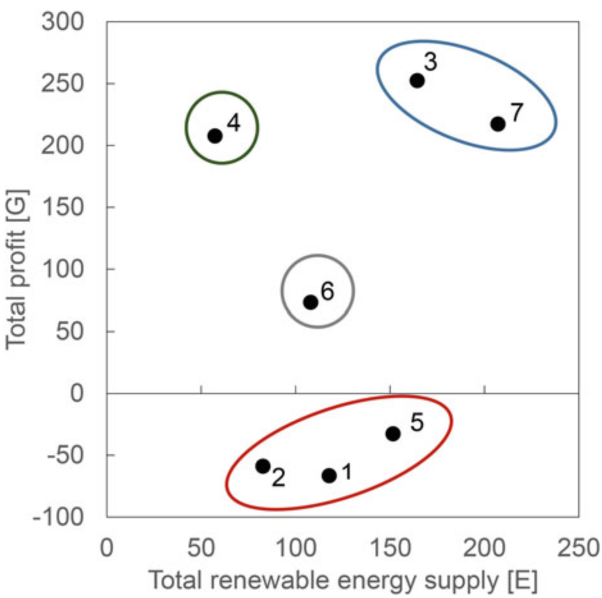

Fig. 7.3 Total renewable energy supply and profits of all players at the end of the 25th term in each game. G and E are the units of money and energy, respectively, in the game world

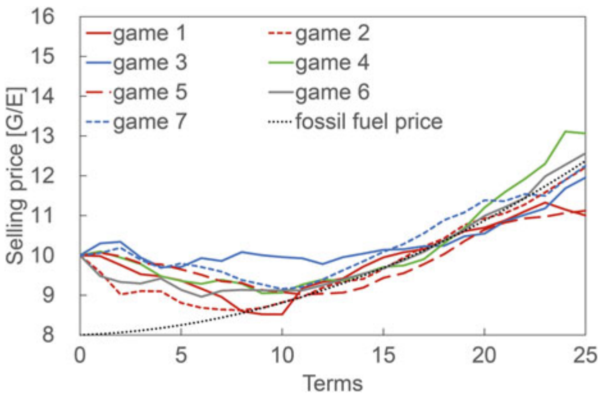

Fig. 7.4 Time series changes in selling prices for each game. G and E are the units of money and energy, respectively, in the game world

games into four clusters using hierarchical clustering; the same results were obtained from two major algorithms, the Ward method and the group average method (Hartigan and Wong 1979). The blue cluster includes games with relatively high profit and large amounts of renewable energy supply. On the other hand, the red cluster includes games with negative profits and low renewable energy supply. The green cluster presents a game with the lowest renewable energy supply despite the high profit. The gray cluster presents a game showing tendencies intermediate to those of the other six games.

The clustering results raise two questions. First, what factor induces the difference between the blue and red clusters: the games in the former achieved both energy transition and economic viability, whereas the games in the latter failed to achieve both aspects? Second, why did investments in renewables not progress in game 4 in spite of high economic profit?

Figure 7.4 shows the time series changes in the selling prices for each game. These values are the weighted averages of the market shares of the five players. The colors of the curves correspond to the clusters seen in Fig. 7.3. The black dotted line shows the exogenously given fossil fuel price. The selling price dropped immediately after the beginning for all the games. The degree of the price drop was relatively small in games 3, 4, and 7, which recorded high final profits, and it was relatively large in games 1 and 2, which showed low final profits. In the second halves of the games, the selling price increased following the rise in fossil fuel prices. However, in game 5, the selling price remained lower than the fossil fuel price until the end of the game. In Energy Transition, the decrease in the selling price indicates intense price competition, because the only advantage of lowering the selling price is to deprive the demand of others. Therefore, the price competition in games 1, 2, and 5 appeared to be relatively intense compared to that in the other games.

Figure 7.5 shows the time series changes in the unit price of renewables in each game. These values are the weighted average of the market shares of the five players. Similar to Fig. 7.4, the dotted black line shows the fossil fuel price. The unit price of renewables reduced faster as the amount of investment rose. The intersection of the unit prices of renewables and fossil fuels indicates the time when the energy

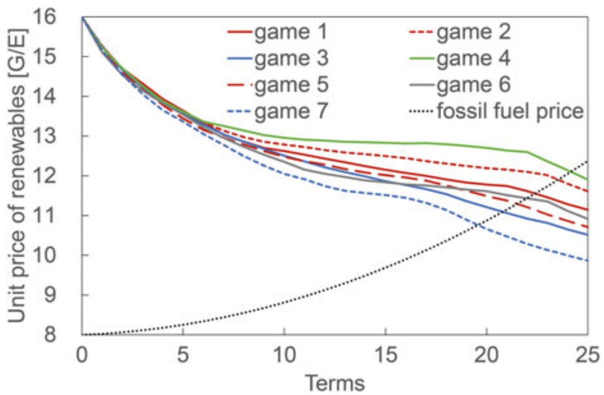

Fig. 7.5 Time series changes in unit prices of renewables for each game. G and E are the units of money and energy, respectively, in the game world

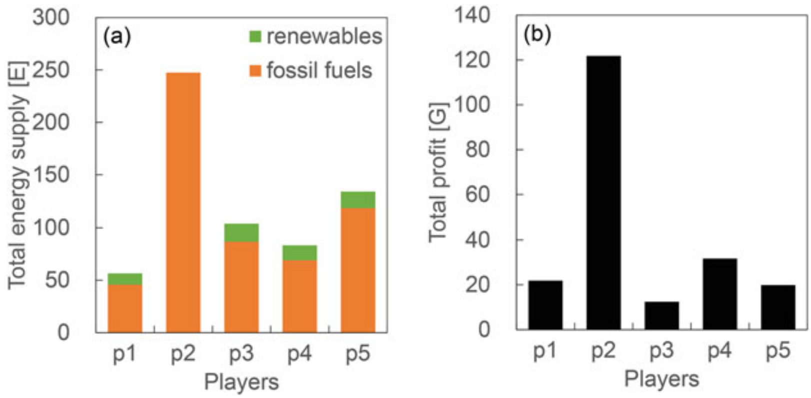

Fig. 7.6 (a) Total energy supply by renewables and fossil fuels and (b) final profits of the five players in game 4. G and E are the units of money and energy, respectively, in the game world. p1–p5 are the serial numbers of players that participated in this game

transition occurs. The timing of the transition was relatively early in games 3 and 7, where both renewable energy supply and profits were high, and relatively late in games 1 and 2, where both were low. The game with the slowest energy transition was game 4, which also had the lowest final renewable energy supply. Therefore, the timing of the energy transition roughly correlated with the renewable energy supply.

The players in games 3 and 7 were able to afford continuous investment in renewable energy as the price competition was relatively mild. On the other hand, in games 1, 2, and 5, the price competition was intense, and therefore, the funds to invest in renewable energy were limited. Accordingly, the difference between the red and blue clusters can be explained by the disparity in the intensity of the price competition. However, in game 4, the timing of energy conversion was the slowest even though the price competition was not so intense; the reduction in the unit price

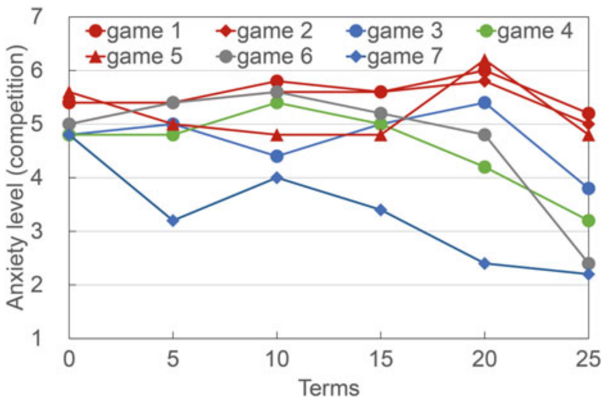

Fig. 7.7 Time series changes in anxiety level about price competition, investment in renewables, and fossil fuel prices

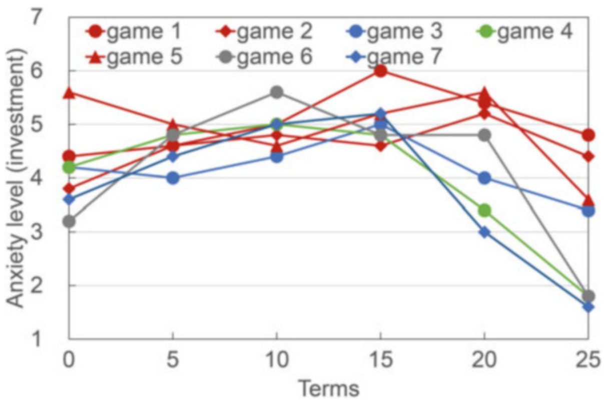

Fig. 7.8 Time series changes in anxiety level about investment in renewables

of renewables was almost stagnant after the 10th term. Therefore, the energy transition in game 4 appeared to be hindered by a different mechanism from those of games 1, 2, and 5.

Figures 7.6 (a) and (b) show the total energy supply and profits of the five players during game 4. In (a), the breakdowns for renewables and fossil fuels within the total energy supply are also shown. The player 2 supplied 247E, which equaled 40% of the total demand in entire market. The result indicates that player 2 increased the market share through price competition. Furthermore, player 2 did not use renewables at all; this player reduced the selling price by ignoring the investment in renewables. As a result, player 4 earned 122G, namely 60% of the total profit of all the players. Other players appeared to continuously fail in investing in renewables due to the decrease in the market share. In conclusion, player 2 behaved as a free rider who made a profit by hindering the energy conversion of the entire market.

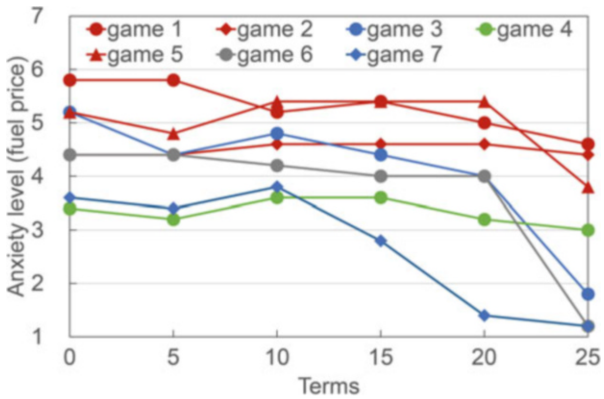

Fig. 7.9 Time series changes in anxiety level about fossil fuel prices

Figures 7.7–7.9 show the time series changes in the anxiety levels about price competition, investment in renewables, and fossil fuel prices obtained from the questionnaire survey. The responses of the five players were simply averaged. First, in games belonging to the red cluster, anxiety about price competition and fossil fuel prices was relatively high throughout the game play. Second, in the games belonging to the red cluster, the anxiety levels remained high level in the 25th term, whereas they dropped in the later terms in the other games. This tendency was observed for all three types of anxieties. These results suggest that the players of the games belonging to the red cluster formed a competitive worldview emphasizing short-term profits by sharing anxieties about market competition. These games showed possible interactions between the anxiety of the players and actual competition. On the other hand, the players of games belonging to the blue cluster may have arrived at a consensus of maintaining a price level necessary to continue investments in renewable energy, and as a result, they formed a relatively cooperative worldview. The decrease in anxiety in the final stages of the games appeared to be the result of the improvement in the profitability of renewables due to the continuous R&D investments.

In the game belonging to the green cluster, the time series changes in the anxiety levels are more similar to those seen in the blue cluster rather than those in the red cluster. In other words, the anxiety about market competition was relatively low in game 4. The monopoly in this game appeared to have been caused by this cooperative market environment. Creating a monopoly is relatively difficult in a market with a competitive worldview, because players with high anxiety levels tend to follow the reduction in the selling prices by others. However, a market with a cooperative worldview is vulnerable to a free rider, because players seldom follow the reduction in selling prices by the free rider.

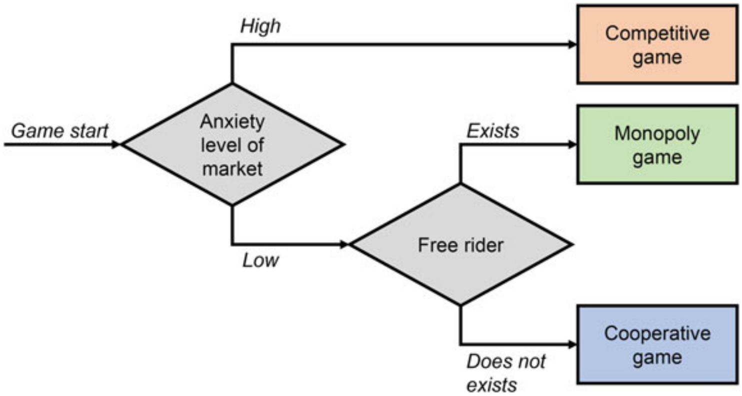

Fig. 7.10 Conceptual framework of mechanisms by which perceptions and behaviors of players diverge the results of games that are retroductively inferred from the experimental results

7.3.3 Discussion

The above results and discussions can be summarized as shown in Fig. 7.10. When the anxiety level of the market is high, that is, when players share a competitive worldview, the game becomes competitive, and both the renewable energy supply and total profit decrease. On the other hand, when the anxiety level of the market is low, that is, when players share a cooperative worldview, the game becomes cooperative, and both renewable energy supply and profit increase as long as there is no free rider. However, when a free rider slips into such a cooperative market, that player may monopolize the market, and the energy transition is hindered. In conclusion, there appear to be two mechanisms hindering the energy transition: the price competition under a competitive market environment and free riding behavior under a cooperative market environment. These mechanisms were inferred by retroductively analyzing the results of the above-discussed gaming experiments.

It is widely known that free riding behavior caused by cheap fossil fuels hinder energy transition. Therefore, many national and regional governments have introduced rules to reduce the difference between the cost of fossil fuels and renewables, such as sanctions for using fossil fuels and rewards for using renewable resources. These rules include carbon tax, subsidies for renewables, feed-in tariff, and feed-in premiums. Conversely, the negative impact of anxiety about uncertainty in deregulated markets during energy conversion has not been discussed in detail. The negative aspect of competition first became clear when researchers observed the dynamic changes in the anxiety levels of players who virtually experienced the subjective perception of real energy companies. This finding suggests that policymakers must not only provide incentives for renewable energy uptake, but also prevent the market from becoming too competitive, thereby allowing energy companies to invest in renewables for long-term profits at ease.

As discussed in the previous section, this retroductive suggestion should be examined more closely in future studies. One idea is to inductively infer the effect of competition by testing the difference in the results of games under different market competition intensities. The competition intensity can be controlled by parameters such as lower selling price limits and the maximum allowable changes in the selling price per term. Therefore, the two approaches in gaming studies presented in the previous section, namely identifying hypotheses by retroductive reasoning and verifying hypotheses by controlling conditions, can be regarded as different stages of a series of studies rather than completely different approaches.

7.4 Conclusions

This study identified the uniqueness of gaming through a comparative review of game-based research and the introduction of experimental studies on energy transition.

In the context of multi-agent systems research using games, the unique value of gaming lies in its ability to promote the discovery of hypotheses and facilitate observations of dynamic changes in the subjective realities of players by adopting models that concretely represent complex issues in real-world technical–social–environmental systems. This uniqueness of gaming can help in fulfilling the quest for sustainability in a way unlike that of other multi-agent research methods such as game theory and social psychology experiments.

The experimental study presented in this chapter focused on the transition from fossil fuels to renewables and suggested that two factors can stagnate the energy transition in competitive markets. The transition may be prevented not only by free riding, but also by the sharing of competitive worldviews among players. This second possibility could only be found by observing the anxiety levels of the players. While this work adopted a retroductive approach, the inductive technique may be useful in the next step. In this manner, the discovery of hypotheses by retroductive reasoning and their verification by controlling conditions can be regarded as different stages of a series of gaming research.

Although retroduction is a relatively minor logic compared with deduction or induction, it appears to strongly support the uniqueness and usefulness of gaming. As Bhaskar (1979) pointed out, scientific inferences must be analogical and retroductive, not simply inductive and/or deductive in the context of analyzing the causal laws behind social phenomena. Games are not only a mapping that objectively represents the structure of the real world, but also a metaphor that virtually expresses the subjective perception and thinking of real stakeholders. The characteristic of the game as a metaphor enables expression of the subjective realities of stakeholders who have pluralistic values, and the retroductive inferring of the technical, social, and environmental conditions influencing the outcome of the game. Future research may be able to further clarify the unique values of gaming by investigating its philosophical basis. The philosophical understanding of science developed by Bhaskar, called critical realism, may play an important role in this process; the critical realism is already regarded as the new foundation of ecological economics (Spash 2012).

As shown in Table 7.2, every research method has some disadvantages. Gaming is not good for drawing strong inferences because with increasing complexity of the games, control becomes weaker. Therefore, the use of a combination of different methods is essential in the field of multi-agent systems-based analyses. Retroductive inferences through gaming can heuristically find hypotheses on factors and conditions that are critical to the dynamics of target systems. The suggested hypotheses can be inductively tested by more controlled experiments. Earlier studies in social psychology and behavioral economics are helpful for designing experiments with inductive logic. If the characteristics of the agents are clarified through experimental studies, artificial agents behaving as human players can be designed. Deductive inference from gameplay by artificial agents, which is usually called agent-based simulation, provides the opportunity to apply a series of multi-agent systems that can test the consequences of multifarious conditions at a much lower cost compared with gameplay with human participants. As explained above, gaming should be positioned as a part of a series of multi-agent systems-based research rather than as a stand-alone research method.

This study introduced energy system research focusing on the transition from fossil fuels to renewables in competitive markets. Many other issues are deeply related to the characteristics of the energy system, given that it is a multi-agent entity. One example is the phenomenon called the Green Paradox, which was theoretically presented by Sinn (2008). According to him, political support for renewable technologies by resource-consuming countries accelerates climate change, because these countries try to sell all their fossil fuel reserves by reducing the selling price. Another example involves the paradox around the roadmap of fuel cell vehicles. In order to promote these vehicles, various stakeholders such as automobile companies, fuel companies, and plant companies need to establish an agreement for cooperative investment over the long term. However, some companies may believe that an investment in electric vehicles will bring larger returns, because the existing grids can be efficiently utilized. Future analyses are expected to identify the social and political conflicts behind these challenges. Moreover, researchers should not limit themselves to energy systems; gaming can be applied to a broader range of technical–social–environmental systems that suffer from sustainability-related issues.

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Chapter 8
Fish & Chips: Simulation of a Simple Problem That Is Not Easy to Solve

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Abstract In this chapter we review our "Fish & Chips" game, which simulates fisheries management. The game is based on a parsimonious mathematical model that we consider to be universal with respect to renewable resource management. Each player competes with the other players to win the game, while at the same time cooperating with them to clear game rounds. This simple game represents an attempt to show the difficulty of ensuring both ecological and economic sustainability and the complexity of such a situation in terms of the interactions among players. Based on comments from participants who played the game and demonstration of the background model, we discuss future game development opportunities.

8.1 Introduction

In this chapter, we review our simulation game, which we call "Fish & Chips," and discuss some of the related issues. As part of the Integrated Local Environmental Knowledge (ILEK) Project at the Research Institute for Humanity and Nature (RIHN), we designed "Fish & Chips" originally for the RIHN Open House, which introduces the activities of the institute to general public. In this respect, "Fish & Chips" was developed, in unique circumstances with specific and practical purposes. In the development process, a close and transdisciplinary collaboration was carried out by a theoretical researcher (HM), a fieldwork researcher (KK), and a research associate (AF) who bridged a gap between researchers—sometimes, researchers and non-researchers. We originally supposed the participants of the RIHN Open House as the players, and the purpose of the game is that the players realize unobvious

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results in a minimal model under a simple setting. After the RIHN Open House, local citizens, university students, and RIHN staff and researchers played the game in several exploratory sessions.

The game simulates the actions of a local fishing community, seeking to achieve the sustainability of the community. It is based on a simple mathematical model that we consider fundamental and considerably universally applicable to renewable resource management. Players of the game must cooperate with each other to ensure that each round of the game is cleared by satisfying certain conditions imposed on the group of the players. Under the condition that the rounds of the game are cleared, the players compete with one another to win the game.

We attempted to make the setting as simple as possible, so that the players could easily understand the rule of the game and mechanism. We designed the game to emphasize two important points: (1) the difficulty of optimizing a system under multiple conditions that are not compatible and (2) complicated situations appear even in a simple setting. Our game requires players to both maintain their own resources and earn a profit by acquiring and selling those resources. All the information necessary to make a decision is available to each of the players. However, the value of the action of one player depends on the actions of the other players. In this way, determining the optimal strategy is quite difficult, or perhaps even impossible.

As seen in the other chapters, many situations in our real society have been treated as games. "Gaming" is often utilized to simulate a real situation, in order to develop a plan or analyze a decision. By compactifying complex, large-scale situations and phenomena in time and scale, it can help us understand the situation in a comprehensive way. Moreover, gaming makes it possible to compare a situation under one condition with the situation—where the conditions may be artificial or unreal. This helps us evaluate the effect of specific factors on the situation.

In order to simulate a situation as a game, it is important to decide what elements in the situation should be included and what elements can be left out. The choice depends on the purpose of the game and many different forms are possible. In a fisheries game like "Fish & Chips," there are a number of elements that could/should be included: the conservation of ecological resources, economic profits, the cost of fishing and transport, and geographical structure, to name a few. For example, "Fishbanks"(2020) includes purchase and sale of fishing ships, where fishers catch fish—deep sea or coast, etc., to simulate the real fishing situation in more detail. In general, the more elements are validly included, the closer the game models the real situation.

In collecting and studying a variety of cases, we often find an analogy or a commonality. That is, for a pair of different cases, an element or a process in one case may correspond well to a similar element or process in the other. Following this idea, cases can be classified into groups (Sato et al. 2019). It may be possible to construct a universal model by including elements common to cases in the same group. Gaming based on a model constructed in such a way is then possible for any of the cases in the same group. In constructing "Fish & Chips," we followed this path. In particular we attempted to construct a game based on a minimal model in which nontrivial results can be produced even in a simple setting.

8.2 How to Play

8.2.1 Outline

The basic rules of the "Fish & Chips" are rather simple. Although the game is designed to be played by 4 players, it can, in principle, be played by any number of players, by appropriately tuning the rules. (In fact, tuning of the rules presents a very interesting problem and constitutes a good investigative exercise for future study aimed at fully grasping the mechanism of the game and clarifying how the property of the game depends on the number of the players.)

The players of the game are cast in the role of fishers in a local fishing community, each of whom has his or her own assigned fishing ground. All of the grounds are assumed to be equivalent. The game does not distinguish species of fish (or deal with just a single species). The fishers iterate a set of processes, to increase their assets. These processes include the following:

(1) Catching and Landing

To earn a profit, the fishers catch fish from their own fishing grounds, land their catch to the common market in their community. The amount of fish they catch and land is arbitrary, subject to the conditions noted below. The fishers must land all fish they catch and cannot throw away a part of their catch.

(2) Marketing and Earning a profit

The price of the fish is determined by the collective amount of fish landed in the market and each fisher earns a profit corresponding to the fish the fisher offered.

(*) Here, to maintain the community and the market, certain conditions regarding the amount of catch and the profit the fishers earn are imposed on the group of the fishers.

(3) Recovering

The quantity of fish in a ground varies after fishing, depending on the remainder; it increases in some cases, decreases in others.

(4) Dealing

Players can make a deal with other players to buy or sell fish in his/her fishing ground.

In the play of the game, the players hold cards representing their fish and receive chips corresponding to their points earned (hence, the name "Fish & Chips"). We use physical and commercial products for the cards and chips (see Fig. 8.1), but they are not essential. For example, the game could be designed for and played on a computer.

The fishing ground of each player can accommodate 10 fish; correspondingly, each player holds at most 10 cards. (In translating the situation to the real world, a single card would not actually correspond to an individual fish; rather, it would represent a unit amount of given resource). One round of the game consists of executing the processes (1) through (4) as described above. Players try to accumulate

Fig. 8.1 Cards and chips used in our game

points in each of the rounds. The number of rounds is determined in advance. The players can talk, discuss, and negotiate with each other during play. At the end of the game, the player who has accumulated the most points is declared the winner. Details are described below.

8.2.2 Beginning of the Game

Each player begins the game with 10 cards (fish) and no chips (point). This might correspond to a situation where fisheries are being established in newly developed fishing grounds.

8.2.3 Rounds

Processes (1) through (4) constitute a round. A single round can be regarded as one year or, more generally, one unit period of fishing.

(1) Catching and Landing

Each player decides how many cards to present (i.e., how many fish to catch and land) from the cards that he or she currently holds. This means that the number of cards presented cannot exceed the player's current stock. All players simultaneously place their cards in a common space (i.e., the marketplace).

(2) Marketing and Earning a profit

The unit value of the presented card is determined by the total number of cards presented by the players. Table 8.1 shows the assigned values:

Table 8.1 Points corresponding to a presented single card. They depend on the total number of cards presented by all the players

# of presented cards	Points for a single card
≤8	5
9–13	4
14–17	3
≥18	2

Table 8.2 Bonus points

		# of cards presented by the player		
		0	1	≥2
# of cards in hand before presentation	9	0	2	2
	10	0	2	4

The players receive chips corresponding to the points they have earned. That is, each player receives chips equivalent in value to the single card value multiplied by the number of cards that the player has presented.

(Bonus points)

If one player held 9 or more cards before all the players presented cards in the round, bonus points are added to the player's score. Table 8.2 shows the rule for the assignment of these bonus points. As indicated, the number of points depends both on the number of cards held by the player before presentation and the number of cards presented by the player.

We assume that in this case the fisher can catch fish in a good shape since the fishing ground provides a rich environment.

In processes (1) and (2), the number of cards that a player can present is restricted to the number of cards held by the player and the round-clearing conditions shown below:

Conditions to clear a round

To clear (validate) a round, the following two requirements must be met:

1. The total number of cards left in the hands of the players is greater than or equal to 18.
2. The total points earned by the players are greater than or equal to 30.

These requirements are intended to ensure that the game is sustainable. Note that the conditions are imposed on the group of players as a whole, rather than on the individual players.

(3) Recovering

Before entering the next round, the number of cards remaining in each player's stock is adjusted. In the early stage of game development, we followed the rule shown in Table 8.3 to make the adjustment:

Table 8.3 Rule for converting the number of cards left in a player's hand to the number of cards available to the player for presentation in the next round (Early-period or simple version)

# of remaining in hand	0	1	2	3	4	5	6	7	8	9	10
# of available for presentation in next round	0	0	1	2	6	7	8	9	9	10	10

Table 8.4 Revised rule (The main rule by which the game is currently played)

# of remaining	0	1	2	3	4	5	6	7	8	9	10
# of available for next round	0	0	1	2	6	7.5	8	8.5	9	10	10

We set this rule in order to simulate natural resource dynamics. In this case, the abundance of fish changes from one fishing season to the next through natural reproduction. It is worth noting that, according to the table, the number of fish generally increases as we move to the next round, but it can also decrease when there are too few fish remaining.

The law reflects the unnaturalness caused by the discreteness of the number of cards and the facts that the maximum possible number of cards is restricted to 10. For example, if the number of cards left in a player's hand is 7 or 8, at the end of the round, then the number of cards that will be available for presentation in the next round is 9. However, unexpectedly, this discreteness and unnaturalness opened the opportunity to explore the best strategy—that is, how to win or how not to lose the game. This issue will be discussed later.

We later improved the rule to the one shown in Table 8.4:

According to the revised rule in Table 8.4, if a player is holding 5 cards at the end of a round, the number of cards that that player will have available for play in the next round will be either 7 or 8, with an equal probability 1/2. To decide, we could simply toss a coin. The rule works similarly in the case where the player is holding 7 cards at the end of a round. With the introduction of this type of uncertainty, the unnaturalness of the game mentioned above is reduced and the game is made both more realistic and more complicated.

(4) Dealing: Exchanging fish and chips

At this point, players can exchange their fish and chips with other players. For example, a fisher, who has only a small number of fish in his or her fishing ground can buy fish from others. The exchange rate is determined by agreement between the players, without restrictions. Of course, the player(s) can refuse to accept any proposed deal.

The game then proceeds to the next round, where the four-step procedure is repeated. The number of round is set prior to the start of the game in order for the players to be able to plan the strategy from a long-term perspective and to offset any bias associated with the uncertainties described above. During lectures at the university and in an open event we played five-round games, due to the limited time; in other cases, we played ten-round games.

8.2.4 Ending

At the end of the final round, each player's score is calculated as follows:

(1) The points earned by the player in each round are summed.
(2) The cards still held by the player are converted to points. The number of points assigned to each card depends on the total number of cards remaining for all players combined, following the rule in Table 8.5.

This conversion means that we break the chain of rounds at this point, with the assumption that the game will continue after that.

The points earned in (1) and (2) are summed, and the player with the largest total is the winner of the game.

8.2.5 Recording

In nearly all instances, we recorded the actions of players in each round, along with their results, in order to retrospectively evaluate the effectiveness of their actions. When the game was played during a lecture period, we asked some of the students in the class to do the recording. Almost invariably, we found that these students came to a much better understanding the mechanism and structure of the game and were able to think of more effective actions or strategies.

Figure 8.2 shows our way of recording; however, the user can develop other effective approaches. The figure features the first two rounds of a multi-round

Table 8.5 Points assigned to each card remaining in a player's hand at the end of the game

#(Remainder)	Points of a single card
≤20	5
21–24	4
≥25	3

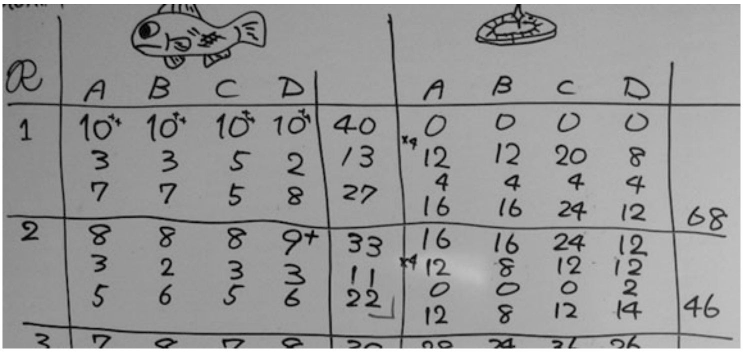

Fig. 8.2 An example of the recording of the game

practice. The round number appears in the leftmost column. The left half of the recording sheet is the "Fish" part, showing the number of cards that each of the players holds, presents and has left. The right half is the "Chip" part, where the points scored by the players are recorded. A, B, C, and D indicate the individual of the players.

As shown, each player began the first round of the game with 10 cards and no points. In the rightmost column of each part is the sum of the cards or points for the group of players as a whole. These numbers are used to judge whether the round is cleared or not, and to determine the value of the cards presented. In the first round of this particular game, the players presented 3, 3, 5, and 2 cards, respectively. According to the rule in Table 8.1, the single card value is thus 4 points, since a total of 13 cards were presented. This is indicated by the "$\times 4$" entry on the left side of the "Chips" part. Accordingly the players were, respectively, awarded 12, 12, 20, and 8 points. In addition, since each player held 10 cards at the beginning of the round, 4 more points are added as a bonus. The possibility of the bonus points is indicated by a "+" (indicating a possible 2-point bonus) or "++" (indicating a possible 4-point bonus) superscript on values in the first row of each round. The "10^{++}" entries in the first row of the "Fish" section of round 1 for all four players and "9^{+}" entry for the player D in the second round indicates the possibilities. The bonus points realized are written in the third row in the "Chip" part; the final row shows the total points awarded to each player in the round. As shown in the figure, the total points awarded to each player in round 1 were 68, with 27 cards remaining (i.e., not presented). Thus, both conditions for clearing the round were satisfied.

The game now proceeds to the second round. At the beginning of this new round, the number of cards available for presentation by each of the players is determined according to the rule in Table 8.4. Players A and B have 8 cards each to play, based on the 7 cards that each of them held at the end of the previous round and the stochastic 50-50 rule. Similarly, player C has 8 cards available (based on 5 cards held at the end of the previous round and the stochastic rule). Player D has 9 cards and a chance to earn bonus points. The first row of the "Chip" part for round 2 shows the sum of the first and the fourth row entries from the previous round for each player, representing the cumulative points earned by the player at this point. Similar operations are repeated through until the final round.

If a round is not cleared, the results are canceled and a line is drawn through the actions and results from the round, as displayed in Fig. 8.3 (if the game is not forcibly closed). The upper section of Fig. 8.3 shows a round in which the first total points earned in this round are less than 30 (in this case, it was 29), meaning that, according to the rules, the round was not cleared. In such a case, the first results are nullified and the round is restarted.

In instances where there is an exchange of cards (fish) and points (chips) by players, the results of the exchange are written as subscripts, as shown in the first line of the lower round in the figure.

As depicted in Fig. 8.4, the game record is displayed, as a scoreboard, to the players during the game play so that the players can refer to it as they plan their actions and develop their strategies. The players are given as much information as

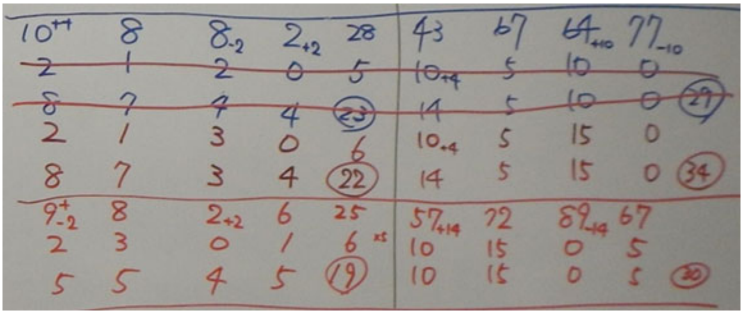

Fig. 8.3 Example of the recording in cases where the round is not cleared or a deal is made

Fig. 8.4 The record is open to all of the players

possible and are encouraged to use the information to guide their choices. (An interesting future project would examine the ways in which the actions and strategies of the players would change if the information were restricted—i.e., not all of the information were available to the players.)

8.3 Practice

8.3.1 Example

Figure 8.5 shows a 10-round practice game played by volunteer participants at RIHN in November 2016. (Figure 8.2 is an excerpt from the first two rounds of that game.)

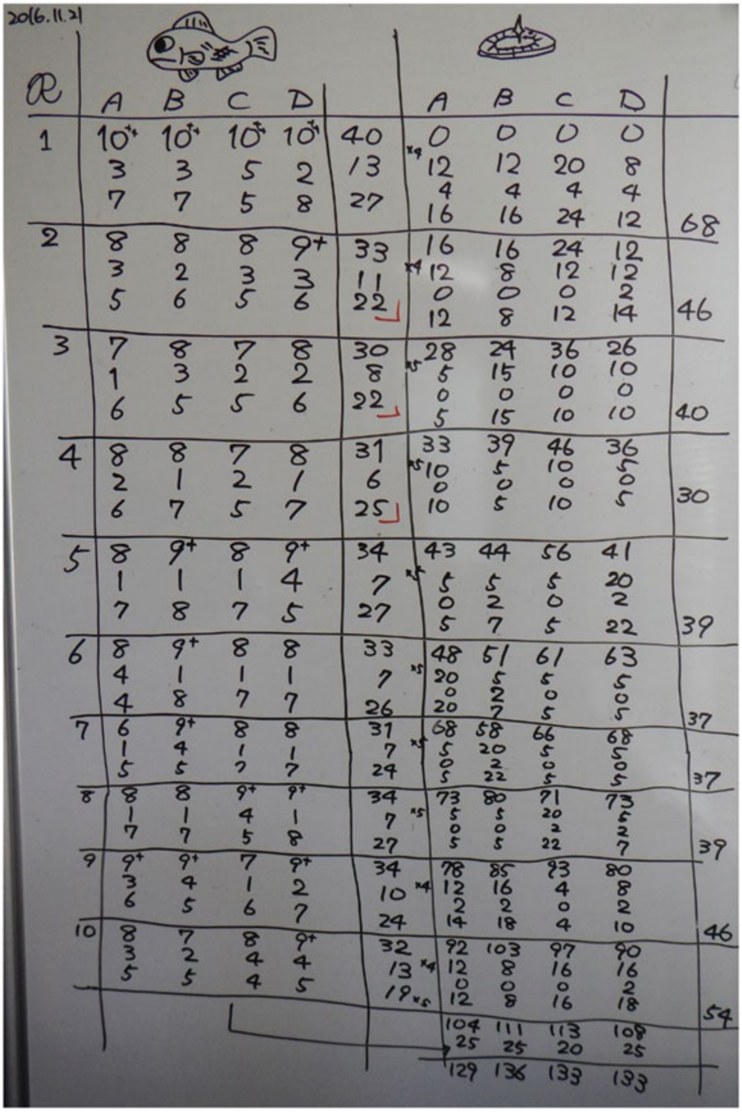

Fig. 8.5 An example of "Fish & Chips" practice

This practice consists of 10 rounds and follows Table 8.4 for the variation of the number of cards. As mentioned in Sect. 8.2.4, the number of cards held by the players at the end of the final round is not adjusted, as there is no next round. Rather, the held cards are converted to points following the rule in Table 8.5. Adding these points to the players' prior point totals give the final tallies, as shown in the bottom row of the record sheet. The game winner here is the player B, with 136 points. In this game, all rounds were cleared with a single set of actions and no deal was made between players.

An interesting series of actions takes place in round 5 through 8, where the players control the value of the cards by keeping the total number of presented cards constant. The players in this game are not strangers. This controlled action was generated not by any external instruction, but spontaneously through a mutual understanding and discussion among the players regarding the situation and mechanisms of the game during the game play. In a real situation, such spontaneous efforts to manage resource would seem important, even though players will try to win the game by earning more points than the others. We will discuss this issue again later.

8.3.2 Sustainability of Effective Strategies

In our game, the players are both cooperators and competitors. The conditions for clearing a round are imposed on the group of the players as a whole, rather than on individual players. Thus, the players' actions are not wholly arbitrary, but rather considerably restricted. On the other hand, to win the game, a player needs to earn more points than the others. Consequently each player must develop effective actions and strategies subject to the restrictions imposed on the group. Deciding how to succeed or how not to fail in such a situation is an extremely interesting problem.

In the early stage of game development, we used the rule described in Table 8.3 to link the number of cards left in a player's hand at the end of the round to the number of cards that would be available to the player for presentation in the next round. Under this rule, identifying the most effective strategy seems achievable. According to Table 8.3, when proceeding to the next round, the number of cards available to a player increases by at most 2. The best action, then, would appear to be presenting 2 cards from 9 cards held, since, in the next round, the number of cards will increase by 2 and bonus points will be added. In the practices we conducted at open events and in lectures, some of the participants discovered this strategy. If all four players adopt this strategy, a total of 8 cards are presented, which means a single card corresponds to 5 points. In this way, the players can guarantee the highest the single card value.

Is this strategy stable? To consider this problem, let us assume that three of the four players adopt the strategy, while the fourth acts arbitrarily. In this case, the three players can persist in maintaining the strategy, since it is possible to satisfy the round-clearing conditions with only their actions: Together, the three have 21 cards and earn more than 30 points, including the points added as a bonus. In fact, the fourth player can act freely, but cannot continue to present a large number of cards round after round, without sacrificing his or her resource. Thus, a player using the suggested strategy is, in the long run, going to win—or at least not to lose. This development was quite remarkable to us, since we did not intentionally construct the game with this in mind.

However, for the case where only two players adopt this strategy while the other two act differently, the two alone cannot maintain the strategy, since they are unable to satisfy the round-clearing conditions by themselves. For example, if we assume that, in a certain round, two players do not present any cards at all, then in order to satisfy the conditions to clear, at least one of the remaining two must present more than 3 cards. Thus, in this case, the strategy is unstable. It is interesting to us that the stability of the strategy depends on the number of players who adopt it.

In general, the effectiveness of a strategy depends on the actions of the other players. Thus, evaluating the effectiveness is difficult since many conditions are added. Moreover, the effectiveness of a strategy strongly depends on the parameter settings (for example, the settings shown in Table 8.1). Attempting to determine settings for which there exists a way to establish how to win or how not to lose the game poses another interesting challenge.

Using Table 8.4 makes the situation even more complicated. Here, uncertainty is introduced when the number of remaining cards is 5 or 7. In the case of 5 remaining cards, the (average) increase in the number of cards is greatest. Thus, even if the player maintains the same action, the results will vary. We only know that generally a minority player takes advantage. When the others present many cards, it is desirable for the player to present only a few cards, since the value of a single card will be relatively low. In contrast, when the others present only a few cards, it is effective to present many cards in order to earn more points. However, to keep the card value high and maintain the resource, it is necessary not to present too many cards.

8.3.3 Comments from Players

Players of the game were told in advance that we might use their comments for our discussion and study, and we confirmed their acceptance. Many of the comments provide useful insights and perspectives.

One of the most frequent comments was:

- "I have not yet found out how to win the game, though I have considered and tried many strategies."

As mentioned before, we have only a general idea of how to win—it is to be a minority. We have not yet found out specific strategy that universally works best.

Receiving comments convinced us that our game has meaning and fulfills a certain role, even with a game setting that we tried to make as simple as possible.

Some comments were about the structure of the game:

- "Are the others cooperators or competitors?"
- "It is interesting to try to win the game while supporting the others."
- "If one acts thoughtlessly, the others must support him. I recognize the importance of cooperation."

As noted earlier, the players are both cooperators and competitors. These comments point out, once again, the importance of this feature.

Some of the comments proposed ideas for future game development:

- "It becomes more interesting when the value of the cards depends on the species."
- "It seems more interesting if the value of the cards not only depends on the total number of the cards presented, but also varies stochastically or by a certain external accident such as a natural disaster".

These comments represent proposals for making the game more complicated. However, as stated, our purpose was to create as simple a setting as possible, one in which all relevant information is open to the players, and to show that, even in such a simple setting, finding the optimal way is quite difficult. These types of comments are natural, since a game simulating all the details of a complex "real" situation has strong appeal. On the other hand, we received comments indicating that the game is already too complicated for children to play and understand. In actuality, the players need to make various calculations as they play. Currently, the players are given more information, perhaps too much, than in a real situation. Placing restrictions on the information provided is one way to further develop the game and opens an avenue for future study.

Some comments linked our game to other real situations:

- "It looks quite real that overfishing causes a reduction in price."
- "It looks similar to the recent price reduction of vegetables."
- "It is very convincing that the desire for both short-term profit and a stable supply may cause mass disposal or price competition."

These comments went far beyond what we had expected. It was surprising for us that some players found analogies to other situations, even though we designed the game as a universal simulation of resource management situations. Such comments motivated us to recognize the importance of universality.

8.4 Background Model

8.4.1 Basic Model

The mathematical model on which our "Fish & Chips" game is based seems considerably universal in renewable resource management. The model is described below.

Let us consider an N-agent interaction process in which r_j^t denote the amount (or density) of a resource that agent j holds and manages independently. The resource varies in time and is renewable. At time t, agent j takes a portion of the resource, y_j^t, and sells it to earn a profit. The unit price of resource V is determined by the combined units taken by all the agents, $V = V\left(y_1^t, y_2^t, \ldots, y_N^t\right)$. Let a_j^t denote the asset value of the agent j. The time evolution of the asset value is written as

$$a_j^t = y_j^t V\left(y_1^t, y_2^t, \ldots, y_N^t\right) + G_j\left(a_j^{t-1}\right), \tag{8.1}$$

where G_j is a function which describes the internal change in the value of the asset (specified to the agent j). For example, for a case where the interest rate in the unit period is b_j and the cost is c_j, we could define G_j as

$$G_j(x) = \left(1 + b_j\right)x - c_j. \tag{8.2}$$

The profit from selling the resource at time t is $y_j^t V\left(y_1^t, y_2^t, \ldots, y_N^t\right)$.

The amount of resource available at time t + 1 varies, depending on the units remaining at time t. This is written as

$$r_j^{t+1} = F_j\left(r_j^t - y_j^t\right), \tag{8.3}$$

where F_j is a function which describes the variation of the resource (of agent j). Eqs. (8.1) and (8.3) are the basic equations for this process.

Generally, in population ecology, the function forms a curve such as that shown in Fig. 8.6:

The curve has several characteristic properties: (a) there is a maximum value, denoted by K in the figure, within which the population can stably exist. This maximum is called the carrying capacity; (b) the population grows most at some moderate point; (c) there is a critical value r_c at which the population will decrease. This decrease is known as the Allee effect.

Hereafter, for simplicity, we assume that the functions F_j and G_j are independent of the agent; thus, we omit the agent index: $F_j = F$, and $G_j = G$. Additionally, we assume that the unit price V is a function of the total the amount of resource which is taken by the agents:

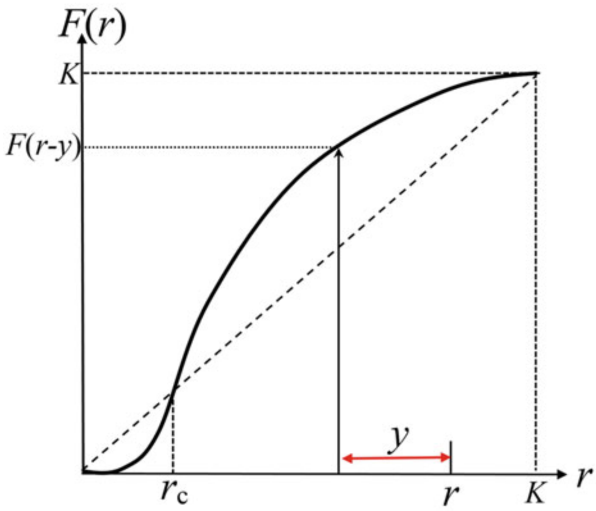

Fig. 8.6 Function describing the variation of ecological resource

$$V = V\left(\sum_{j=1}^{N} y_j^t\right). \tag{8.4}$$

$V(x)$ is a non-increasing function of x, which is derived from the market principle: under constant demand, the greater the supply, the lower the price.

Note that in our "Fish & Chips" game, V corresponds to Table 8.1 and F corresponds to Tables 8.3 and 8.4.

8.4.2 *Relation with Classical Theory*

Let us consider the single-agent case and show the relation of the model with the classical theory of fishery resource management. The basic equations given in the previous subsection are written as

$$a^t = y^t V(y^t) + G\left(a^{t-1}\right), \tag{8.5}$$

and

$$r^{t+1} = F(r^t - y^t), \tag{8.6}$$

where the agent index j is omitted. Then, we assume

$$G(x) = x, V(y) = V_0 = Const. \tag{8.7}$$

That is, the asset value of the agent is a simple accumulation of the profits and the unit price of the resource is constant. The stationary state equation for the resource is written as

$$r = F(r - y). \tag{8.8}$$

Here, since the unit price of the resource is constant, the best approach is one that gives the maximum y among the set of (r, y) that satisfies Eq. (8.8). This is known as the maximum sustainable yield (MSY) in classical fishery resource management theory (Gordon 1954; Schaefer 1954). Nowadays the MSY is criticized for not appropriately describing the real situation. However, its underlying idea and simplicity underlie the development of renewable resource management theory.

For reference, let us show below the relation with the continuous-time formulation, which is often used in theoretical studies. We introduce the time increment δ and rewrite Eq. (8.5) as

$$r^{t+\delta} = r^t - y^t + \delta f(r^t - y^t), \tag{8.9}$$

where $f(x)$ is the growth rate of the resource and $F(x) = x + \delta f(x)$. By changing variable $R^t = r^t - y^t$ and taking the limit $\delta \to 0$, we obtain the basic equation for the resource in continuous time:

$$\frac{dR}{dt} = f(R) - y, \tag{8.10}$$

where the time index t is omitted in R and y. This equation indicates that the variation of the resource at time t equals the natural variation minus the catch. For example, the logistic growth is often used for the growth rate:

$$f(R) = aR\left(1 - \frac{R}{K}\right), \tag{8.11}$$

where a and K denote the internal growth rate and the carrying capacity, respectively. Assuming steady state $dR/dt = 0$, we find that the MSY is the maximum catch, $y_{\max} = aK/4$.

Although the cost of catching fish is ignored in our game, we can consider it here. If we assume that the cost is inversely proportional to the amount of resource, which seems reasonable since smaller amount of a resource mean that more cost and effort will be needed to find it. Then, Eq. (8.1) is modified to

$$a^t = a^{t-1} + y^t V_0 - y^t \frac{C}{r^t}, \tag{8.12}$$

where the third term on the right-hand side describes the effect of the cost, and C is a positive constant. In this case, in the steady state, the solution that produces the highest profit is the one that gives maximal y ($V_0 - C/r$), which is called the maximal economic yield (MIY).

We can also consider the definition of sustainability in this formulation. Daly's first principle of sustainable resource management, which states that "the withdrawal of resources cannot exceed the regeneration of resources" (Daly 2007) can be expressed as

$$r^t \leq F(r^t - y^t). \tag{8.13}$$

Additionally, we can consider simple economic sustainability. If we assume an implicit constant cost of living during a round, C_1, then the economic sustainability condition could be given as

$$a^t \geq C_l, \tag{8.14}$$

which means that the asset value cannot be less than the cost. An alternative definition of economic sustainability, one that is somewhat stronger than Eq. (8.14), would require that the incremental change in the asset value should not be less than the cost:

$$a^{t+1} - a^t \geq C_l. \tag{8.15}$$

Such definitions can be included in the game as a rule.

8.5 Discussion and Outlook

So far we have described how to play our game, what we learned from multiple practice sessions, and the mathematical basis for the game. In looking ahead, a number of issues arise and a number of adjustments are possible.

Some variations of the game that would make it more real or more enjoyable have already been suggested. There are others that are worth exploring. As described in Sect. 8.2.3, in each round present their cards simultaneously. This rule is simple, but occasionally a round may, accidentally, not be cleared. As an alternative, one possible variation of the game would have the players present their cards in order. The order would be different for each round, determined, for example, by simple rotation. In this way, the situation in any particular round depends on the order of the players, and the players must be continually aware of out the conditions for clearing the round. Notably, however, the impact of this variation scarcely influences the essential structure of the game.

One of the characteristic features of our game is that the resource is assigned to each player and managed independently. In other words, the resource domain and rights domain (Giordano 2003) for each fisher in this case have exactly the same geographic range. The fishers (players of the game) interact each other through the price determination of the resource and the conditions for clearing a round, rather than through resource management itself. In fishery resource management, however, it is natural for the resource to be shared by all players. That is, fishing resource is so-called commons. Moreover, even if we assume cases where the resource is not an entire commons, for example, assigned quota or cultivation, it is a reasonable setting that the resource is weakly connected each other, where part of the resource of one player might move and become part of the resource of another player. Hardin's well-known Tragedy of the Commons (Hardin 1968) argues that common resource ownership inevitably leads to overexploitation and degradation. To reflect this, a rule could be introduced to maintain the commons as a condition to clear a round. In the current rules of "Fish & Chips," the first condition of having to maintain a certain number of fish at the end of each fishing season means collective nature of resource management. It combines individually parceled rights to flow and shared rights to an intact stock, as described by McKean (2000).

As shown in the discussion of MEY in Sect. 8.4.2, introducing the cost of catching fish is another interesting possibility. In the game as currently constructed, there is no mechanism which reduces the points that a player has earned, other than making a deal to exchange points for resource. By introducing costs, it may be possible to define and discuss sustainability in more detail from an economic point of view.

Another possible modification involves the availability of information. Currently, all relevant information is provided to the players (see Tables 8.1, 8.2, 8.3, 8.4, and 8.5). In reality, however, this is rarely the case, and efforts to obtain information are necessary and important (Dietz et al. 2003). Therefore it would be interesting, as a future project, to explore how the actions and strategies of the players would change if access to information was restricted. Would the situation be more complicated or simplified?

As mentioned in some of the comments in Sect. 8.3.3, the game can be seen as analogous to other real situations. Indeed, the set of core processes in the game:

1. An agent takes a portion of resource and presents it to the market.
2. The price of the presented resource is determined in the market and the agent receives a profit.
3. The resource recovers (but sometimes decreases).

is universal and widely applicable to many kinds of renewable resource management situations. For example, in the case of vegetable oil or beekeeping, the subject resource is managed more independently than in the case of a fishery. Thus, the game may be more suited to modeling these types of cases. In any event, the universality of the game's basic mechanism makes it possible to apply knowledge obtained from one case to another, and it promotes a comprehensive understanding of many different cases (Sato et al. 2019).

For the players, there are two aspects in this game: competition and cooperation. Although the element of competition is highlighted as player seeks to win the game, the cooperation is much more important in real resource management (Levin 2014).

How effective cooperation occurs is a long-term problem discussed in game theory. We hope to gain insight into this issue through our game simulation (as seen in an example of which we saw in the game play reported in Fig. 8.5).

In connection with this, one might question whether, after all, the conditions for clearing a round are really necessary. In fact, cases have been reported and discussed in Ostrom (1990) where commons have become sustainably managed spontaneously. Therefore it would be interesting to observe whether the players could find how to stably continue the game, that is, how to manage their resources and earn a profit sustainably, regardless of their levels of insight into the essential of the game.

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Chapter 9
Gaming for Arctic Sustainability

Hajime Kimura and Yuka Oishi

Abstract Rapid changes in the Arctic environment have threatened the lives and livelihoods of the Arctic's inhabitants. Various researchers and science communicators developed the board game "The Arctic" in 2019 in order to convey the current status and anticipated future of climate change in the Arctic. The game represents a new type of outreach regarding Arctic issues; it highlights the need for scientific knowledge and a broad perspective in policy and decision-making. This chapter examines the board game's design and impact in detail. It shows that the game has a remarkable effect on people who are not at all familiar with the Arctic or Arctic-related climate change issues, and that the game's design is flexible enough to be used in a variety of ways for different learning purposes.

9.1 Introduction

Northern societies in the Arctic are on the frontline of climate change and globalization. The Arctic is warming twice as fast as the global average. Changes in the Arctic environment have impacts on the rest of the world. For instance, the Arctic Ocean could be largely free of sea ice in summer as early as the late 2030s, which would dramatically alter the global climate system, given the Arctic Ocean's influence on ocean circulation and its impacts on mid-latitude weather. Furthermore, Arctic snow cover is declining, glaciers and ice sheets are receding, and permafrost is thawing (AMAP 2017). In these and other ways, climate change poses an existential risk to residents of Arctic regions. On the other hand, climate change

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Fig. 9.1 Photo of "The Arctic," our educational board game. ©JAMSTEC/ArCS

might also enable the extraction of oil and natural gas from previously inaccessible places and the rapid loss of Arctic sea ice might lead to the creation of new shipping routes between Europe and Asia.

In order to convey the current status and anticipated future of climate change in the Arctic, we developed a board game, "The Arctic," as a learning tool in 2019 (Fig. 9.1). The game's content introduces players to information regarding Arctic climate change and its various impacts on people and societies in the far north. In the game, players negotiate as scientists, business people, diplomats, and indigenous people and strive to balance the need for economic development with the need for environmental protection. The game was designed by researchers, science communicators, and museum professionals from various fields with the help of some professional game designers.

In general, we face challenges in finding effective strategies for the mitigation of environment changes with the good social understanding. This is perhaps because there is a considerable gap between the knowledge, perspectives, and convictions of scientists, laypeople, and political institutions. It is necessary to bridge this gap to emphasize and enhance the use of scientific knowledge as a basis for policy and decision-making. "The Arctic" is a new type of outreach initiative, one that engages the public on a complex and essential issue and highlights the need for both scientific knowledge and a broad perspective in policy and decision-making. We hope that it will encourage people to learn and think about the Arctic and help the development of effective Arctic policy.

In this chapter, we briefly describe the game's development and test it in Japan from the perspective of indigenous peoples in the Arctic.

9.2 Developing the Board Game

9.2.1 The Game's Development as a Researcher-led Initiative

In January 2018, the Arctic Challenge for Sustainability (ArCS) project and the National Museum for Emerging Science and Innovation (Miraikan) held a lecture meeting at Miraikan about environmental changes and human societies in the Arctic. Lecture meetings are a common way to present research results and conduct outreach. However, lecture meetings can only convey information to those in attendance, and most lecture meetings are held on days and at times inconvenient for students and working people, such as weekday afternoons, so they are usually attended by elderly people. Moreover, when researchers from different fields speak at lecture meetings, it can be difficult to express how their research relates to one another's, and furthermore it is rare for researchers in the natural sciences to give lecture meetings alongside researchers in the humanities and social sciences.

Accordingly, ArCS researchers from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the National Institute of Polar Research (NIPR), Hokkaido University, and other science communicators from Miraikan launched an initiative to develop game-based teaching tools to convey the status and stakes of Arctic climate change to a wide audience. None of the researchers involved in the creation of "The Arctic" was knowledgeable about board games. The game's initial design involved players rolling dice to advance pieces along a track. This is the most common type of board game in Japan. However, this kind of game did not illustrate the connections between research and society as well as we had hoped. Therefore, we set out to investigate board games that are currently on the market and apply their elements to the design of our own game. We played through various board games, tried games created by other research projects in Japan, and studied board games created by research organizations outside Japan. Our investigation found that in order to successfully reach and impact a wide audience, the design of our game should balance educational value, fun, and straightforwardness of gameplay. Therefore, we set out to create an uncomplicated and fun game that could easily convey educational information to its players. The next section discusses our decision to create a role-playing board game.

9.2.2 Decision to Develop a Role-playing Board Game

The value of role-playing in education has been pointed out many times (Wu and Lee 2015). In "The Arctic," each player takes on one of six roles: oceanographer, cultural anthropologist, fishery (or marine industry), indigenous peoples, general industry, and diplomat (*see* Fig. 9.2). Three parameters are specified in the game: Environment, Culture, and Economy. These three parameters are designed to guide players' notions of sustainability (Stanitsas et al. 2019). However, sustainability is

Fig. 9.2 Six Role cards

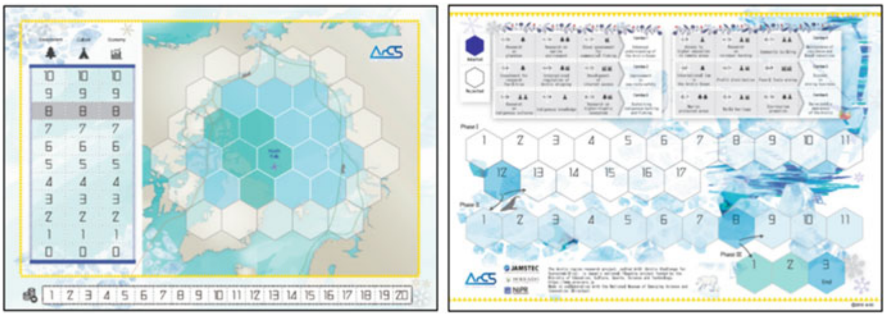

Fig. 9.3 The game's main board and side board. The main board contains three Arctic score tracks: Environment, Culture, and Economy. The main board also contains a map of the Arctic, and the thickest tiles in the game are placed where the sea ice is actually thickest in the real Arctic

complex: Everybody agrees with it, but nobody seems to know much about it. An UN document stated that sustainable development has economic, social, and environmental dimensions (UN 2015). In this game we switched the word "cultural" for "social." As the game proceeds, the values of these parameters change (*see* Fig. 9.3). When a sea ice tile is turned over, one of three kinds of events occurs: an event, a decision, or a vote. Events are unavoidable. Examples of events include ocean acidification. Decisions force the player turning over the tile to decide whether to adopt a particular policy. Votes see all players decide whether to adopt a given policy. Discussion between players determines whether or not they adopt a particular policy.

We decided to incorporate role-playing into our board game because it is difficult for most people living in Japan to visualize the Arctic; most Japanese people only know that the Arctic is cold, and many believe that it is uninhabited. In this context, it seems likely that if most Japanese people were asked their opinions on, for example, the development of Internet access in the Arctic, it would be difficult for them to make their own judgments and express their own opinions. We hope that by giving each player a role, we can spark their imagination and stimulate discussion. There are no right answers in this game; players consider how to act in the interests of their respective roles. Similar to real-life politics, decision-making within the game is constrained by a budget, so players must pick and choose which policies they want to adopt. Thus, each player must make judgments about what policies to adopt in accordance with their role, the budget, and the needs or arguments of other players. Furthermore, because the players are not competitors and cannot win without one another's cooperation, their roles in the game are not as competitors, that is, at the end of the game, players will realize that no players can win without cooperation. Post-game debriefing sessions allow players to reflect on and discuss their findings.

9.3 Concept of "The Arctic" Board Game

In developing the game, we sought not to give players a robustly academic experience, but instead to describe the connection between various research activities, the effects of climate change in the Arctic, and socially relevant outcomes of both research and climate change.

In order to represent the social benefits of the Arctic and articulate elements of Arctic research and governance, we relied upon the "International Arctic Observations Assessment Framework" report, co-authored by an American non-profit corporation and the Sustaining Arctic Observation Network (SAON), a network of scientists and research institutes that coordinates Arctic data management (IDA Science and Technology Policy Institute and Sustaining Arctic Observing Networks (2017)). This report reviewed and revised a framework for assessing the societal benefits that can result from Arctic research. The report's value tree framework consists of societal benefit areas (SBAs), sub-areas under each SBA, and domain-specific objectives. It states that it aims to help support decision-making, define thematic concepts, and identify and prioritize objectives. The SBAs define the environmental, economic, and social domains in which services, operations, and research provide societal benefits. Sub-areas represent the natural thematic divisions of each SBA. Each sub-area is composed of key objectives: service, operational, or research activities that are clearly supported by and can be linked to Earth-observing systems and their data and information products.

Inspired by this report, we replaced SBAs with problem areas caused by changes in the Arctic environment in designing our board game. Sub-areas were translated into stakeholders in the Arctic (the six roles available to players), because stakeholders have their own smaller goals and objectives attached to their interests within the larger SBAs/problem areas that they face together. Our science communicators offered their knowledge and experience to help us incorporate these stakeholders' goals and objectives into the game, which we eventually did by linking these goals and objectives to in-game events and their impacts. Researchers who participated in the game's creation infused the in-game Events with their own research findings (*see* Figs. 9.4, 9.5, and 9.6). Through this process, we tried to help players visualize the relationship between urgent problems in the Arctic and various research activities.

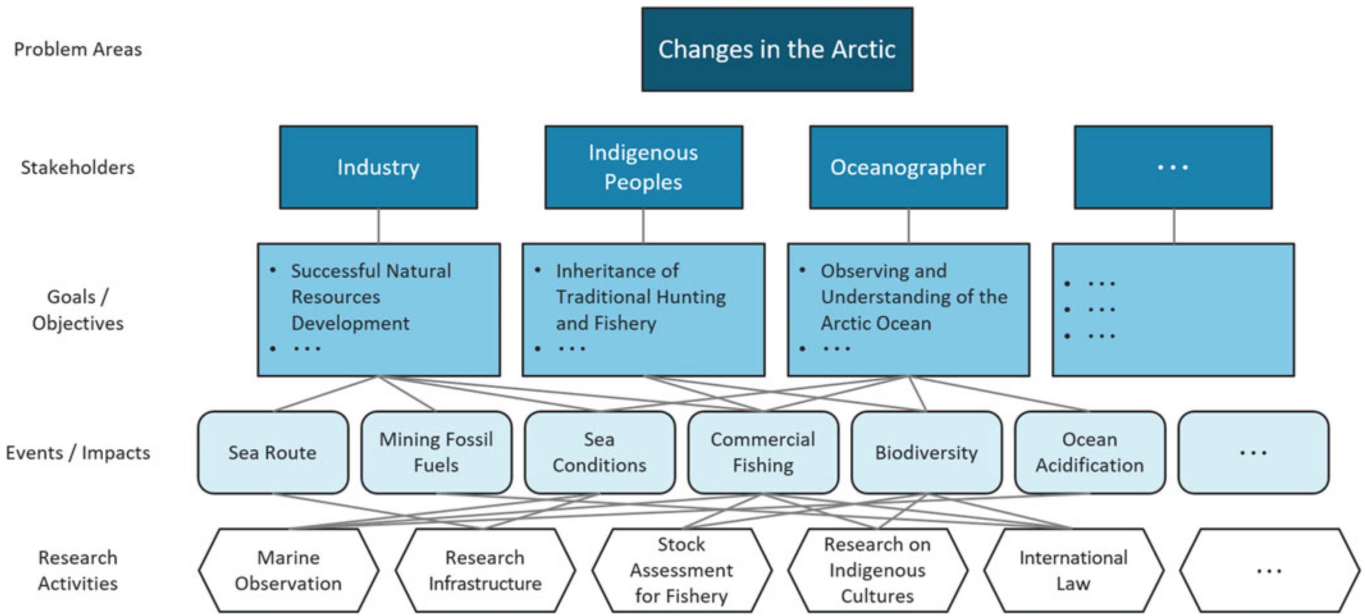

Fig. 9.4 Value tree approach and notional example for constructing “The Arctic” board game

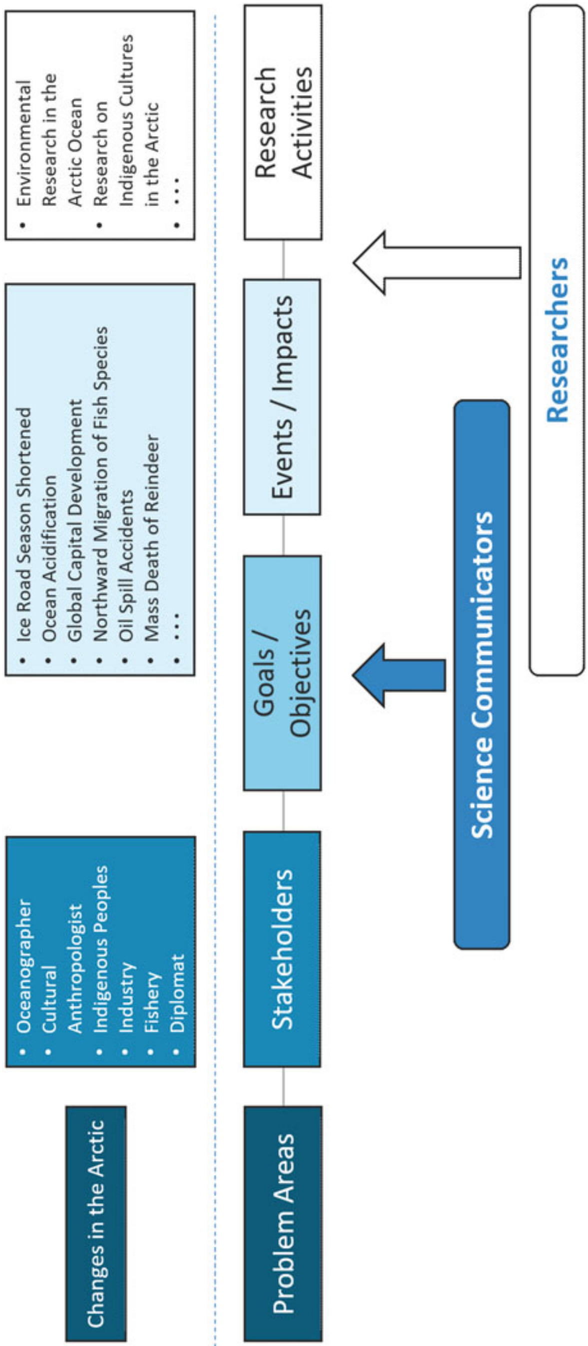

Fig. 9.5 Value tree approach applied to the process of making "The Arctic."

- I-1 【Occur】 Ice Road Season Shortened
- I-2 【Occur】 Dog-Sledding Season Shortened
- I-3 【Occur】 Ocean Acidification
- I-4 【Occur】 Change in Sea Conditions
- I-5 【Occur】 Global Capital Development
- I-6 【Occur】 Northward Migration of Fish Species
- I-7 【Vote】 Legal Regime for the Arctic Ocean
- I-8 【Vote】 Investment for Research Infrastructure
- I-9 【Vote】 Improvement in Higher Education in Remote Areas
- I-10 【Vote】 International Regulation of Arctic Shipping
- I-11 【Vote】 Profit Distribution Between Company and Local
- I-12 【Vote】 Improvement in Information Infrastructure
- I-13 【Decide】 Research on Arctic Plankton
- I-14 【Decide】 Environmental Research in the Arctic Ocean
- I-15 【Decide】 Research on Reindeer Herding
- I-16 【Decide】 Research on Indigenous Cultures in the Arctic
- I-17 【Decide】 Stock Assessment for Sustainable Commercial Fishery
- I-18 【Decide】 Advancing Modern Science with Indigenous Knowledge

- II-1 【Occur】 Depreciation of Natural Tourism Resources
- II-2 【Occur】 Social Polarization
- II-3 【Occur】 Changes in Lower Trophic Level Biodiversity
- II-4 【Occur】 Oil Spill Accidents
- II-5 【Occur】 Inhabitable Ground Lost
- II-6 【Occur】 Mass Death of Reindeer
- II-7 【Vote】 Establishment of Marine Protected Areas
- II-8 【Vote】 World Heritage Registration
- II-9 【Vote】 Mining Fossil Fuels
- II-10 【Decide】 Ecotourism
- II-11 【Decide】 Community Building
- II-12 【Decide】 Scientific Survey on Higher Trophic Levels

- III-1 【Occur】 Marine Pollution
- III-2 【Occur】 Catastrophic Change in the Arctic Ecosystem
- III-3 【Occur】 Ruin of Local Infrastructure
- III-4 【Occur】 Extinction of Indigenous Cultures
- III-5 【Occur】 Collapse of International Cooperation

Fig. 9.6 Events finally adapted for "The Arctic" board game

9.4 Case Study: Playing "The Arctic" to Understand the Impacts of Climate Change on the Arctic's Indigenous Peoples

9.4.1 Players' General Lack of Knowledge About the Arctic's Indigenous Peoples

In this section, we will examine some actual game play to show how the board game can push players to learn and think more about the lives of the Arctic's indigenous peoples and how they might be affected by climate change. The Arctic's indigenous peoples are less widely known than Arctic environmental changes and the effects of climate change. Their way of life is very vulnerable to climate change and political economy because their lives depend on subsistence hunting-gathering and reindeer herding and they live in remote areas where transport and information infrastructures are few and far between (Fig. 9.7). Thus far, they have adapted to climate change in a resilient and flexible manner and have even contributed to and applied Arctic research. Arctic's indigenous peoples' lives and their reactions to the environmental and social changes taking place there can be perceived as essential indicators for evaluating human activities and for undertaking measurement studies in the Anthropocene era.

Although the Arctic has become a focus of documentaries, films, and other reports in the era of global climate change, there has not been much mass media

Fig. 9.7 A reindeer herder in the Western Siberian forest where Oishi conducted anthropological field work (photo taken by Yuka Oishi in the Khanty-Mansi Autonomous Region, November 2011)

coverage about Arctic indigenous peoples or how their lives might be affected by climate change. When we conducted trial workshops for the board game at two Japanese universities, some participants stated that they had never known that people actually live in the Arctic until the day of the workshop. Other participants had some basic knowledge of Arctic indigenous peoples. Participants were interested in learning more about Arctic climate change, but they mostly imagined the Arctic as a barren place inhabited by polar bears, seals, and whales. They assumed that the only humans who set foot there were explorers and researchers. We were shocked to realize the general public's lack of knowledge about the Arctic.

This section has three major parts. First, it examines the roles of indigenous peoples in the board game. Second, it examines players' reactions to the game from the two trial workshops. Third, it analyzes the workshop attendees' feedback about the game—and specifically about how the game enhanced their knowledge of Arctic indigenous peoples—which was obtained from informal conversations and two short surveys.

9.4.2 Indigenous Peoples and Their Role in "The Arctic" Board Game

There are over 100 ethnic groups living in the northern forest zone outside of the Arctic Circle and 13 ethnic groups living within the tundra zone of the Arctic Circle. Each of these groups has their own distinct history, language, and culture. The Arctic landmass contains tundra low- and highlands, vast coniferous forests, wetlands, great rivers, coastal regions, and so on. The indigenous peoples living there hunt, gather, fish, and herd animals across this varied landscape, adapting their activities to the climate, fauna, flora, and socio-economic circumstances. They have also been colonized for hundreds of years and are still under the influence of the state. Nowadays some of them live and work in cities, and others live in remote villages, forests, or plains. Therefore, although there is great variety between their individual lives, they have some experiences in common, especially with regard to climate change.

Indigenous peoples feature in both playable roles and in-game events in "The Arctic." For example, they function as barometers of climate change, as they are exposed to disasters caused by extreme weather, environmental pollution caused by extractive industries, forced migration, and disrupted or destroyed transportation and information infrastructure. However, their situation is not entirely vulnerable, passive, and hopeless. They have two positive roles in the game. The first revolves around the concept of indigenous knowledge. The game's "Event Book" explains indigenous knowledge as follows:

> Tremendous wisdom comes from the land.
>
> Indigenous peoples in the Arctic, through coping with the environment of the region, have developed their own knowledge and techniques. This knowledge of the climate and of plant and animal ecology is called indigenous knowledge and is recognized as comparing

> well with modern science. In recent years, scientists have been interviewing indigenous peoples in the hope of creating more effective environmental protection, resource management, and disaster responses (The Arctic "Event Book" 2019: 36–37).

Indigenous people have their own knowledge systems comprising knowledge about the natural environment, techniques to survive in it, and various other religious and cultural belief systems. This body of knowledge can sometimes serve as a good source of clues for natural scientists because it is different from the modern natural sciences and enables them to know what indigenous peoples see, feel, and think. Furthermore, indigenous peoples can be good partners of Arctic researchers. Because they live in the field, they can help scientists monitor organisms, the weather, and other elements of seasonal or climate change. In this way, we can interpret indigenous peoples as symmetrical scientists whose knowledge is equal to or more that of modern Arctic researchers.

The second positive role indigenous people play in the board game revolves around community-building. The "Event Book" explains community-building as follows:

> Scientists and residents can work hand-in-hand.
>
> The changes in the Arctic natural environment caused by warming and resource development may lead to unprecedented damage to nature and environmental pollution. To meet new threats, scientists, businesses, residents, and local governments must build communities to cooperate on disaster responses, environmental monitoring, resource management, and so forth. By sharing and continuously working on the region's challenges, they can protect the lifestyles of the residents and invigorate the region's industries (The Arctic "Event Book" 2019: 58–59).

Although indigenous peoples have proven to be adaptable and resilient, it can be difficult for them to deal with sudden changes in the climate, extensive environmental pollution, structural wealth inequality, and poor infrastructure. Their communities could become exposed to risks and collapse as a result of climate change. Arctic researchers are potential partners in trying to build and sustain indigenous communities. Indigenous people and researchers explore research questions, social problems, and future risks together. In this light, indigenous peoples' role in community-building in "The Arctic" board game represents an ideal model of collaboration.

Indigenous peoples are not located on the margins of Arctic politics in our board game. Their role is equal to those of other players, and their claims and actions have the power to influence the results of the game. Although each player decides how to play their role, we suggest that whoever plays the role of indigenous peoples in the game use the following principles to guide their actions and decision-making. First, they should protect themselves from unreasonable industrial development and policies that do not benefit them, and claim their right to live off the land. Second, they should cooperate with researchers, local governments, and others in order to survive future risks. Third, they should attempt to thrive (rather than merely survive) and promote their own cultures and languages. To enhance the importance of this third principle in the game, we included "Culture" as a major parameter.

In short, our game positions indigenous people as international actors whose impact on and voice within discussions regarding Arctic climate change are equal to those of other international actors. In the game, if climate change accelerates to the point where indigenous peoples lose their land and the sustainability of their culture, no players can win the game. Thus, in the structure of our game, indigenous peoples can affect the balance of the Arctic power in ways that they cannot necessarily do in real life. They both indicate the state of Arctic affairs and shape them. Indigenous peoples' role in "The Arctic" board game highlights why it is important to raise the public's awareness regarding the status, lives, rights, and culture of the Arctic's indigenous peoples. It also highlights how climate change and related environmental and political changes will substantially impact their way of life in the future and how integral they are to both the Arctic and the world's political economy.

9.4.3 Workshopping the Board Game with a Focus on Educating Workshop Attendees About Arctic Indigenous Peoples

One of this chapter's authors organized two workshops in which participants played "The Arctic" and gave feedback through a brief questionnaire and interview. This explores how the board game helped some members of the general public learn about the Arctic's complex circumstances and its indigenous peoples.

9.4.3.1 Workshop at Mie University

The workshop at Mie University was held on December 4, 2019. Its participants included 13 students in a class titled "Future Earth," 10 undergraduates, 2 graduate

Fig. 9.8 Workshop at Mie University (photo taken by Yuka Oishi, December2019).

students, and 1 researcher majoring in meteorology, food systems, and natural disasters (Fig. 9.8).

Oishi, one of this chapter's authors, facilitated the workshop. She first explained the purpose of the workshop, to learn about the complexity of the Arctic and ponder its future subjectively through game play, and then explained the rules. Oishi did not provide the participants with information about the Arctic's indigenous peoples or the other actors. Players determined their action principles for themselves. Oishi encouraged players to communicate with each other during the game. The participants played twice or more, changing their roles in each round.

Participants were surveyed before and after the workshop. In the pre-workshop survey, 5 of the 13 participants answered that they recognized the importance of the preservation of indigenous peoples' culture and livelihood. Eleven answered that they were interested in learning more about the factors causing the reduction of Arctic sea ice. In the post-workshop survey, 10 participants answered that they considered it important to preserve indigenous peoples' culture and livelihood. Five participants answered that the event involving reindeer had the strongest impact and were interested in learning more about indigenous people who live with reindeer. The results indicated that workshop participants who were studying natural sciences did not have much knowledge about indigenous peoples and their way of life, but they became interested in them via gameplay. Further, one of the participants who was studying meteorology and climate stated that he understood the Arctic's environment and climate, but he only found out about the economic and cultural aspects of life in the Arctic through the game. The participants were natural science researchers, so it is reasonable that they are not very knowledgeable about culture, society, and politics.

Some aspects of the survey solicited feedback about players' in-game communication. Each participant answered that they listened to other players' opinions. Eleven participants answered that they sought to win or gain profit for their own role during their first round of game play, and seven answered that they considered the impacts of their actions for all players during their second round. One participant answered that he did not listen to others' opinions or involve himself in the game's voting mechanic during his first playthrough, but changed his tactics during his second playthrough because this approach affected him negatively in the first round. He came to realize that one action can influence other players or other elements of the game because of how the game's events, industries, roles, and cultures are deeply intertwined. This led him to realize that it must be very difficult to solve these kinds of policy problems in the real world. The feedback we gleaned from this workshop indicates that participants learned that cooperation and collaboration are necessary to solve the deeply complex and entangled problems they faced in-game.

9.4.3.2 Workshop at Osaka Kyoiku University

The workshop at Osaka Kyoiku University was held on November 27, 2019. This workshop was held as an extracurricular seminar and had a total of 15 attendees

(6 undergraduates, 5 graduate students, 3 faculty members, and 1 other person). This workshop's student participants majored in education. Because these participants are hoping to become teachers, Oishi modified the feedback survey to include questions about the educational value of "The Arctic."

One question asked whether student participants would consider using this board game in their future classrooms. This question was very effective in obtaining participants' opinions about the board game and the way the workshop was conducted. One participant stated that we could improve players' understanding of the various roles available to them and the gameplay itself if players were briefed on their roles' real-world equivalents before playing. Some participants strongly desired a manual that would tell them how to act in their role, but Oishi did not give in to this request as participants' own ideas and actions are crucial to the game's intended educational effect and players' self-reflection. Some participants asked to play multiple times, and others suggested that multiple rounds with briefs on the various roles available to players between rounds could help students reflect on and change their in-game priorities and values. In addition, one participant who is a board game enthusiast suggested that we allow players time to discuss each role before playing the game and include a visual aid (a polar bear on the ice tiles) to help players better visualize the crisis of mass Arctic ice melts.

9.4.4 Players' Interest in and Understanding of Indigenous Peoples

The feedback we gleaned from our workshops indicated that the board game gave participants a chance to think about the Arctic and indigenous peoples' way of life, to learn how indigenous people survive in the midst of various actors with different positions in difficult social and environmental situation, and to actively think about the Arctic environment as a human being living on the Earth. Some participants suggested that we could enhance this element of the game by adding or modifying some of the game's rules. For instance, one participant suggested that two people should take on the role of indigenous peoples and two others should play the role of industry to make the game more of a negotiation over sustainability and climate change's impact on the Arctic. Although this participant stated that he was not very knowledgeable about the indigenous peoples of the Arctic, he was driven to make this suggestion because he noticed the relative differences in these two roles' political power during gameplay.

Because workshop participants' in-game actions were guided by their own subjective sense of how to fill their role, we saw a wide variety of actions and gameplay in the workshops. This provoked many players to think about their chosen roles and how they might act within that role, given how vague or incomplete most players' knowledge of indigenous peoples was at the outset. However, although the game and some in-game events sparked some players' interest in Arctic issues and indigenous peoples, we suggest that the game might be more effective if players were briefed on their roles beforehand instead of merely imagining themselves in indigenous peoples' situation without having much background knowledge. Briefing players beforehand might also encourage them to reflect on what they learned after gameplay. This also applies to the other actors/roles in the game. We also found that a facilitator can influence players' communication, learning, and the outcome of their game.

9.5 Conclusion

In conclusion, we found that our board game can function as an effective learning aid in three ways. First, the game format promotes communication among players and thus deepens their understanding and broadens their thought processes as they share their knowledge, interests, opinions, and what they have learned. Second, the game helped players better grasp the complexity of the Arctic and the results of the ArCS research project and engage with these issues (as we can see from their feedback). Third, the game format allows workshop facilitators to respond to a variety of learning objectives by adding rules and devising pre- and post-learning activities. Thus, the game has many possibilities to learn various aspects of the Arctic environment and the people depending on the ingenuity, and the players or facilitators themselves exploring effective ways to use the game can expand them widely.

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Chapter 10
Serious Board Game Jam as an Exercise for Transdisciplinary Research

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Abstract This paper describes using a serious board game jam as training for transdisciplinary collaboration and provides tips for organizing similar events. Entangled socio-environmental problems are considered "wicked problems." An effective way to tackle these problems is a transdisciplinary approach. The transdisciplinary approach facilitates a systemic pattern of collaboratively addressing wicked problems related to various stakeholders. However, many people lack collaboratively working and mutual learning experience in transdisciplinary situations, so special training is necessary for maturing actual collaboration. In planning such training, it will be essential to consider several factors; small-scale, experimental, safe-to-fail, easy-to-focus, and fun, since such training must be easily repeatable for achievement capacity building. Based on these principles, the author and

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colleagues hosted serious board game jams in 2018 and 2019 at a research institute in Kyoto, Japan. These case studies will help readers who are interested in the social and collaborative aspects of game-based learning.

10.1 Introduction

Socio-environmental problems, such as climate change, significant environmental impacts on poverty, and increasing urban resilience, are diverse environmental issues that arise through the interactions among society, technology, and ecosystems (Barthel et al. 2015; Kabisch et al. 2016; Griffin et al. 2017). The diverse problems related to the transition to a sustainable society are known as "wicked problems," ill-structured problems that are difficult to solve; they are widely recognized across several academic disciplines, including environmental studies, policy studies, education, and civil engineering (Levin et al. 2012; Fabricatore and López 2012; Yearworth 2016; Lehtonen et al. 2019).

The notion of wicked problems stems from Churchman's (1967) and Rittel and Webber's (1973) paper on public policy studies and is where many of today's transdisciplinary projects are tackled. Rittel and Webber identified a wicked problem as comprising ten points, as follows: (1) There is no definitive formulation of a wicked problem; (2) wicked problems have no stopping rule; (3) solutions to wicked problems are good-bad rather than true-false; (4) there is no immediate or ultimate test of a solution to a wicked problem; (5) every solution to a wicked problem is "one shot," i.e., it cannot be undone; (6) wicked problems do not have an exhaustive set of potential solutions; (7) every wicked problem is unique; (8) every wicked problem is the symptom of another problem; (9) the existence of a discrepancy in a wicked problem can be explained in numerous ways; and (10) the policy planner has no right to be wrong.

Wicked problems are distinguished from problems that can be labeled as tamed "simple" and tamed "complex." Simple problems (e.g., caries treatment by a dentist) are sufficiently explicit and easy to share both challenges and solutions, whereas complex challenges (e.g., landing a person on the moon) are challenges. It is understood that the solution is not always immediately explicit, and that many solutions can be expensive to implement. However, both simple and complex problems are solvable problems. With wicked problems (e.g., the COVID-19 pandemic, addressing climate change, etc.) it is impossible to articulate both challenges and solutions, and the situation can change while trying to do so. This is characterized by the fact that the structure is fluid (Roberts 2000; Farrell and Hooker 2013; Head 2014; see Fig. 10.1).

In addition, in considering troublesome problems, such as environmental and social problems, a further problem arises due to the complicated interactions of social, technical, and ecological factors, with countermeasures to one problem potentially causing another problem. Moreover, there are many stakeholders with different interests and wickedness in the current situation, and the feature of a troublesome problem that "there is no solution that everyone can satisfy" (Camillus 2008) often appears more controversially.

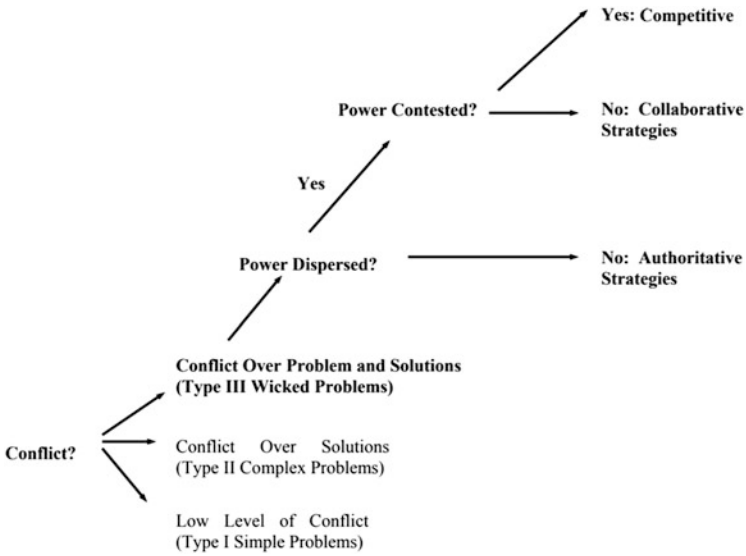

Fig. 10.1 Simple problems, complex problems, and wicked problems (Roberts 2000)

Termeer and Dewulf (2019) point out that two unproductive reactions to wicked problems, known as paralysis and overestimation, increase their risk. Paralysis occurs when people experience or define wickedness, are overwhelmed by it, and think they cannot do anything about it ("it confirms what we already thought. . .there is nothing we can do about this problem anyway.") Paralysis may lead to negative consequences, such as planning delays and increased costs. Overestimation occurs when policymakers and others are influenced by high levels of public demand or political pressure, focus on one aspect or a single point of view, and think that a wicked problem is perfectly solvable ("further simplification is needed. . . .we will solve this problem once and for all"). Overestimation does not take into account the uncertainty, ambiguity, and complexity inherent in wicked problems.

Since wicked problems are part of the society that creates them, any decision-making requires accompanying social changes (changes in values, lifestyles, governance, infrastructure, etc.). This means that tackling wicked problems requires not only conducting research but also making decisions or resolutions based on that research. Therefore, rather than following the trajectory of existing research pathways, investigators and decision-makers need to conduct a range of research, seek contributions from different disciplines, collaborate on building knowledge, and share and apply that knowledge. This open mode of research that aims to meet the needs of individuals, communities, professionals, and influential organizations is today described by the term "transdisciplinary" (Brown et al. 2010; Pohl et al. 2017b; see Fig. 10.2). Transdisciplinary research combines imagination and perspectives, such as design thinking (Wahl and Baxter 2008), social labs (Boylston 2019), future research (Neumann and Deppisch 2017), small winning strategy (Termeer and Dewulf 2019), and it is anticipated that it will become more strategic and practical.

Fig. 10.2 Transdisciplinary approach for tackling wicked problems (Envisioning Labs 2014)

However, in much transdisciplinary research and practice, collaborative failure and cognitive gaps remain issues that greatly hinder cooperation among different occupations and fields. Collaborative failure, for example, is associated with practically damaging trust in the field and over-strengthening power structures. Over- or under-estimation of contributions, unclear division of roles, concealment of facts in good faith, over-adaptation to the other party's wishes, and dysfunctional consonance are among the causes (Morrison and Glenny 2012; Freshwater et al. 2014). In addition, "cognitive gaps" can occur due to factors such as the methodologies and practices established within each field, problem recognition, estimation of necessary resources (e.g., funds, equipment, staffing, time, etc.), evaluation criteria for results, and so on (MacLeod and Nagatsu 2018; Jacobi et al. 2020). This means that many people do not have experience in collaboratively working in transdisciplinary teams, and special training is necessary for effective collaboration. Such activity should be small-scale, experimental, safe-to-fail, easy-to-focus, and fun since it must be conducted multiple times.

"Serious games" are an attractive tool for tackling these obstacles and exploring the preferred future and the governance enabling it (Girard et al. 2013; Mayer et al. 2014; Perttula et al. 2017; Vervoort 2019; Hallinger et al. 2020). Serious game functions related to transdisciplinary research and practice have the following characteristics: sharing "wickedness" of a specific social issue through experience of gameplay and debriefing (Orduña Alegría et al. 2020), creating a safe space that helps stakeholders express their views (Speelman et al. 2014), facilitating inclusive business as a bottom-up approach (Speelman et al. 2019), making opportunities to recognize the current situation from different stakeholder perspectives through role-play, and exchanging opinions among fields through test play (Flood et al. 2018; Goodspeed et al. 2020).

The effect of these bridges mainly occurs during the "play phase" of a serious game, but the same effect is also exerted in the "developing (discussing and repeating test play) phase" of serious games. Recently, the process of developing serious game jams, such as Game4Change, has attracted attention. Game jams are often framed as a "compressed development process" (Zook and Riedl 2013). In

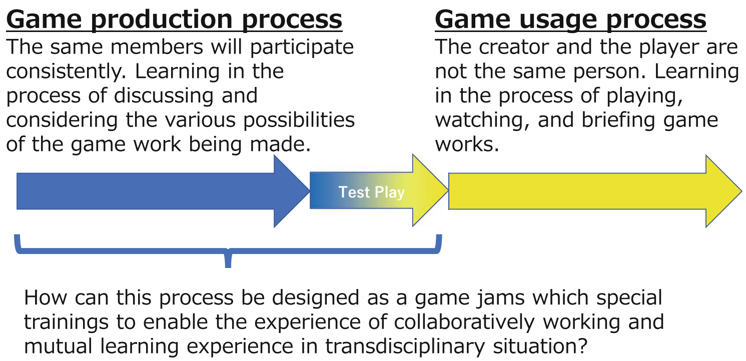

Fig. 10.3 Research framework

short, game jams are an attractive place for trial and error by game creators because they can enable various steps of game development to be performed in a short time (Fowler et al. 2016).

The effects of game jams have been studied from various angles. Game jams have been used in teaching and learning (Merilainen et al. 2020). The main effects include prototyping experiments (Musil et al. 2010), inspiration and idea acquisition (Ho and Tomitsch 2019), catalyzing a community (Goddard et al. 2014), and the interactions among game jam participation and formal learning in game education (Fowler et al. 2018).

However, there are not yet enough case study reports and analyzes to design game jams as special training to enable the experience of collaboratively working and mutual learning experience in the transdisciplinary situation. In particular, it is essential to organize the knowledge and practical tips necessary to make game jams function as special training for maturing actual collaboration for tackling wicked problems. Moreover, since such activity must be easily repeatable for achievement capacity building, it is desirable to consider several factors: small-scale, experimental, safe-to-fail, easy-to-focus, and fun. Game jams meet these factors.

Of course, playing serious games and Gameplay workshops can be expected as collaboratively working and mutual learning training. For example, a workshop using the board game "Catan: Oil Springs" will provide participants with valuable insights and experience in managing the Commons (Chappin et al. 2017). Participants of the game jam playing there works with game jams by transdisciplinary team are expected to further enrich the experience. However, in this case, researcher should consider too many variables when measuring the effects. Therefore, this paper focused on analyzing the process of game production by a transdisciplinary team (see Fig. 10.3).

Based on this background, the author and colleagues hosted serious board game jams in 2018 and 2019 at the Research Institute for Humanity and Nature in Kyoto, Japan. Each event comprised a two-day camp with transdisciplinary participants, including researchers, game creators, students, non-profit organization staff, and game fans. A total of 63 people (17 teams) created serious board games with the

Fig. 10.4 Overview of the Serious Board Game Jam 2018

themes of "What is good food for you?" (2018) and "No One Eats Alone" (2019). Two of these games have gone through multiple phases of improvement and revision and are now available to purchase. The survey results and interviews with the participants indicate that they learned from other participants' expertise and skills through game development and actively and continuously worked on the theme. They often found cognitive gaps between team members but worked through this by visualization and making simple models. The participants also evaluated whether several support items prepared by the organizers were beneficial in promoting transdisciplinary collaboration. For example, open space technology for team building, rubrics for self-assessment, and regular test play events were well used. On the other hand, posters summarizing information in various fields and "future school lunch" models were not utilized as much. These results suggest that serious board game jams are a promising method of training for transdisciplinary collaboration and important future directions of support suggest options for improving their effectiveness.

Section 10.2 presents some background on the design of serious board game jams through a review of research into game jams and game-based learning. Section 10.3 briefly introduces a case study of the Serious Board Game Jam 2018 (SBGJ2018; see Fig. 10.4) and summarizes the ten-step process of organizing the Serious Board Game Jam 2019 (SBGJ2019; see Fig. 10.5), which reflected feedback from the SBGJ 2018 experience. Section 10.4 explains, based on the experience of SBGJ2018 and SBGJ2019, some tentative rules to make serious board game jams more effective as exercises in transdisciplinary research for tackling wicked problems. Finally, section 10.4.2 discusses the conclusions and directions for future work.

Fig. 10.5 Overview of the Serious Board Game Jam 2019

10.2 Review of Research Methods

10.2.1 Game Jam Studies

In considering the above research issues, the characteristics of game jams are summarized below. A game jam is a type of workshop in which participants design and create a game from scratch with a limited time frame, theme, regulation, and expertise (Goddard et al. 2014; Kultima 2015).

Grace (2016) pointed out two main features of game jams and hackathons: [A] Organized as an event, with a start and end time. There is also a physical or online community where participants can come together and reflect on their jam experience and play with artifacts when it is over. The constraints imposed on participants provide them with structure (focusing gives a reason, reason gives goal, goal gives meaning to work) and motivation (especially maintenance of concentration). [B] Organized as a community activity, where people with different abilities solve some problems. In this sense, a game jam played by one person is a contradiction. This is practice, not a jam. For example, running a marathon among other marathon runners is different from running 42.195 km alone. Also, working with several people reduces the sense of isolation when tackling unknown problems that may be difficult to solve. Grace indicates that in game jams, [A] the event aspect provides participants with reasonable goals, and [B] the community aspect encourages participants to make irrational commitments and efforts.

Game jams for education also take the positive effects of [A], the event aspect, and [B], the community aspect. For educational game jams, Merilainen et al. (2020)

noted there are three main themes, targeted for: (1) Game development skills; (2) STEM/STEAM skills; and (3) personal and interpersonal skills. In particular, there is a lot of expectation around the potential for learning STEM (science, technology, engineering, mathematics) or STEAM (STEM and arts) skills through game jams (Arya et al. 2013; Fowler et al. 2016; Pirker et al. 2016; Pollock et al. 2017; Gaudl et al. 2018). A game jam can be considered as a process that inspires creativity within a community, and it is expected that the performance of the participants in this process will cross academic disciplines, social issues, and artistic design (Locke et al. 2015; Kennedy 2018). The inter- and trans-disciplinary co-design process and boundary spanning activities that occur as the combined effect of [A] and [B] can be considered to be definitive attributes of a game jam for teaching and learning [C].

Creating great productions that can be scaled up in game jams is a valuable achievement, but not the only one. Rather, in game jams, the process of transitioning from concept to production, innumerable ideas, and the experience of countless micro-decisions (which means "thinking while moving the hands") and its reflection are more valuable. Within the constraints provided by the event and the community, how the game was made with others is the most critical factor (Grace 2016) [D].

On the other hand, educational game jams are consistently regarded as informal programs. This has to do with the unstructured nature of game jams. Kultima (2018), who has conducted field research on game jams around the world for more than 10 years, summarizes the iterative nature of game development in the following five categories: (1) Game design is timely and particular, (2) game design is value pluralistic, (3) the game design process is opportunistic, (4) the game design process is a plethora of ideas, and (5) game design practice is "natured and nurtured" by the surrounding ecosystem. In particular, in category 3, "Opportunistic" attitudes and behaviors are visible at multiple levels of game development (Cross 2001; Bender and Blessing 2004). An opportunistic approach can be compared with structured processes. Opportunistic behavior refers to a strategy where the designer deviates from a structured plan or methodology and moves to a partial solution that gets more of the designer's attention, thereby obtaining a better idea and reducing the cognitive cost. However, opportunism in game design does not mean that production processes are at the mercy of chaotic management (e.g., poor scheduling, bad leadership, or insufficient resources). Game design requires both structured development conditions and playful flexibility [E]. As with structured development conditions in game jams for education and learning, compatibility with existing curricula or social issues, orientation to participants, and the abilities and experience of the organizers are required (Preston 2014; Merilainen et al. 2020).

In summary, game jams have [A] event aspects and [B] community aspects. Game jams for education and learning take advantage of these aspects and expect participants to perform [C] boundary-spanning performance and learning. The unique artifact of a game jam is [D] "thinking with your hands" experience and its reflection. Finally, game design [E] requires both structured development conditions and playful flexibility.

10.2.2 Experimental Studies: Serious Board Game Jam 2018

10.2.2.1 Framework

The authors organized the Serious Board Game Jam 2018 (SBGJ2018) at the Research Institute for Humanity and Nature (hereinafter, RIHN), in Kyoto, Japan, on November 23 and 24, 2018. Researchers and non-researchers co-produced serious games on various social issues of the day. Participants visualized data and scientific knowledge, created characters and stories, and coalesced them into nine role-playing-type board games. Some teams continued to work on their games after the event and the two games have since been turned into salable products.

Normally, digital games, rather than board games, are developed at game jams. In this case, the choice of board games was made for three reasons:

1. Lower barriers to entry: Unlike digital games, participants are not required to have programming knowledge to create board games. This lowered the barriers to entry for the event and encouraged researchers and citizens who were interested in the development of serious games but hesitated to participate in a digital game jam because they do not have programming knowledge (Sens 2015).
2. Improved focus on the process of visualizing scientific knowledge for storytelling: One of the problems with Serious Game Jams is that as the event moves closer to conclusion, it becomes harder to reflect the opinions of the experts [6]. Since the development of a board game does not require programming, participants are able to invest their time and energy focusing on integrating their expertise and views on certain social issues to design the game's meta-story, characters, rules, and components.
3. More flexibility and opportunities to make adjustments: At SBGJ2018, continued game development was encouraged after the two-day (30-h) jam event. However, from previous experience, the organizers had learned that even if many members of the development team are interested in continuing game development, the activities of the team will stop because those with skills such as programming tend to leave the team. Therefore, the authors chose board games as a more flexible alternative to digital games, making it easier to adjust rules and winning conditions, and add new components on a trial basis (Castronova and Knowles 2015).

10.2.2.2 Event Roadmap

In July 2018, the authors planned the following road map for SBGJ2018 (See Fig. 10.6).

Six meetings between July and November were held with the co-authors/co-organizers at Ritsumeikan University, Kyoto Seika University, and a local gaming company in Kyoto. The focus of the discussions was on themes and rules. The theme of SBGJ2018 had to be something that researchers in various fields could relate their research interests to, something that citizens found familiar and relatable, and

Fig. 10.6 SBGJ2018 road map

something that would engage the students' intellectual curiosity. In the end, the theme was set as "What's a good food for you?" Furthermore, to reflect the viewpoints of anticipatory governance for sustainability transition (Vervoort and Gupta 2018), a rule specifying that the games must "incorporate 'a lapse of time' as a game component" was set.

The venue used for SBGJ2018 was RIHN, which has a large lecture hall that can accommodate approximately 100 people (for the opening and closing ceremonies, and talk sessions), a dining hall, five seminar rooms that can accommodate more than 20 people each, and a shower room. The managers provided the seminar rooms with whiteboards; the dining hall was equipped with refreshments and different board game materials, including paper, stationery, wooden blocks, a printer, samples of famous board games (such as Catan and Viticulture). RIHN guesthouse rooms were made available for a fee to those who wished to use them. The managers distributed a PR video and flyers online before the event, and participants were informed that no programming or other technical skills were required.

After the call for participants was posted on the SBGJ2018 website and SNS, we received 39 applications from a diverse group that included researchers, game creators, students (majoring in game research, design, policy, food, etc.), NPO staff, and freelance writers.

Of the nine researchers who participated in the event, seven were from RIHN. Their areas of expertise ranged from sociology, geography, and resource management to feminism and information security. Of these nine researchers, five had no programming knowledge and eight had never participated in a game jam. However, all of them had experience playing serious games involving natural resource management, and all recognized the value of connecting games to academic outcomes.

The 30 other participants included 10 game creators and 12 students. Many of them were invited by the organizers (two game creators and five students joined after

Fig. 10.7 Scenes from SBGJ2018. Top left: A visualization of social issues and scientific knowledge (urbanization and food policy); Top-right: A presentation (child poverty); Bottom: A game development session (RIHN dining hall)

seeing the announcement on SNS). Of these 30 participants, 11 had no programming knowledge, and 15 had never participated in a game jam. The main interest of the participants (including the game creators and students) was to experience creating games with researchers and others from various professions.

The 39 participants were divided into nine teams. Each team included one researcher and one or two game creators. Most members of the various teams had not known one another before the event. The teams were announced on the day of the event.

As with many other game jam events, SBGJ2018 began at noon on Saturday and finished on Sunday evening (see Fig. 10.7). At the beginning of the 30-h event, we organized talk sessions on three topics: the process of game development, food system challenges and sustainable transitions, and how to use RIHN's academic resources.

After this introductory session, the participants began brainstorming with their teams. Naturally, they looked first for similarities in their interests. For most teams, the game creators led the brainstorming. (The organizers had asked the game creators to serve as team engines before the event's start.)

A dinner was held on Saturday so that the participants would have more time to focus on design and development during the event. Dinner time also offered an opportunity for conversation with members of the other teams. The participants were free to come and go from the working space. The building was open throughout the

Table 10.1 Game works at SBGJ 2018

Team	Title	Topic	Scientific Knowledge	Brush up
A	Turners	Urbanization	Food policy	★★
B	Poo Diary	Parenting	Nutrition	
C	Santa's Challenge	World hunger	Food aid	★★★
D	Kitchen for Children	Child poverty	Resource allocation	
E	Scott Free	Spaceship Earth	Material circulation	
F	Eat Me If You Can	Climate change	Livestock	★
G	Keep the Chain	Globalization	Distribution	
H	Tragicomedy of the Commons	Soil degradation	Tragedy of the commons	★★★
I	Last Supper	Harassment	Well-being	★★

event, except for late at night. Many researchers and game creators returned home at night, while some of the other participants used the RIHN accommodations. Event footage and interviews with the participants were intermittently distributed online.

During the two-day event, each of the nine teams created a board game that visualized the contexts and expertise of various social issues such as urbanization, world hunger, and poverty—reflecting them in their stories, rules, and component designs. Five of the nine teams decided to continue their work after the event had concluded (see Table 10.1). In support, the organizers provided six half-day test play events on weekends. Unfortunately, while the November dates seemed generally convenient for participants, many of the students needed to concentrate on writing their graduation thesis, which prevented several teams from continuing development. Nonetheless, two teams completed their games (*Santa's Challenge* and *Tragicomedy of the Commons*).

10.2.2.3 Result

An open-ended questionnaire survey and interviews were conducted after the SBGJ2018 event; 29 of the 39 participants responded. All who had participated in other game jams said that the process of creating an analog game produced more conversation than they experienced in creating a digital game. Participant #19 (a game creator) noted that, compared with other game jams he had attended, he spent the most time in discussions with his team members during SBGJ2018.

However, the increased time devoted to discussion did not necessarily mean that the visualization of scientific knowledge and social issues was wholly successful. Fifteen participants said it was difficult to incorporate scientific knowledge and social issues into their game. For example, participant #10 (a game creator) said that he did not know how to express "governance." Participant #27 (a freelance consultant) noted that they talked about social issues, but as their game development progressed, the political elements were removed. Participant #25 (a researcher) pointed out that they had rich discussions about social issues and scientific knowledge, but this might not be reflected in the game. On the other hand, all the teams that succeeded in integrating the game's meta-stories and rules with scientific knowledge and social issues (the teams that wanted to brush up) spent their entire time on day one discussing rather than creating game components. Therefore, taking ample time for discussion appeared to be a necessary but not sufficient condition for success.

Based on our results, Game Jam organizers would do well to set aside time for looking back and debriefing participants. In doing so, participants will appreciate the value of their discussion time and realize that the inevitable conflict that emerges is perhaps the most productive part of the process.

Both completed games were released for sale in November 2019. The teams had continued to work intermittently during the year following SBGJ2018 without external financing or technical support. We found several common features in the two teams:

1. The team members who had provided academic knowledge and specialized in designing the vision remained with their teams. They identified with their teams and cheered their teammates after the event.
2. The game design changed dramatically over the course of the two days of SBGJ2018. In the process of change, strong tensions emerged between team members; however, the continued exchange of ideas helped sublimate the conflict. Another unique commonality was that one member in each group was dedicated to facilitating the exchange of ideas, which contributed significantly to the group dynamics.
3. A combination of online and offline communications was effectively incorporated. At SBGJ2018, dedicated online working space on Slack had been set up by the organizers. The two teams were particularly active on Slack after the event. They routinized sharing information and materials on Slack, exchanged ideas on Skype, and test-played face-to-face after each member had worked independently.

Santa's Challenge is a card game. The players role-play Santa Claus and mitigate world hunger on Christmas Eve. Players combine four different powers represented by coins (food aid, sustainable production and distribution, political stability, and improved ecosystem services) to mitigate the problems of hunger in various countries and collect cards. Each card has a score according to hunger levels in the country; the player who collects the most points receives the "Best Santa of the Year" award. The game visualizes the interaction of multiple factors causing hunger. In a high school workshop, students voluntarily added their own rules; for example, "If you can explain the reasons for poverty in the country represented on the card you picked, you get additional points."

Tragicomedy of the Commons is a Monopoly-based role-playing game where players cultivate grasslands into farmlands. The more a player cultivates the grassland, the higher the yield will be. However, if cultivated too much, the grassland will become a wasteland, and the player loses his/her farmland. Thus, players need to cultivate to the extent that the land's environmental carrying capacity can sustain—

Fig. 10.8 Components of *Tragicomedy of the Commons*

negotiating with other players and investing in environmental conservation—to not lose their farmland. Factors that have long-term adverse effects on the land's productive capacity, such as climate change and soil runoff, are visualized. Players can be (1) a farmer who wants to maximize yield, (2) a space-invader who wants to devastate the land, or (3) a person from the future who wants to protect the land. Players progress in the game with various victory conditions (See Fig. 10.8). The game is available for purchase on the team's website (Sandbox 2020).

10.3 The Ten-Step Approach for a Serious Board Game Jam

10.3.1 Overview

Pohl et al. (2017a) noted the ten reflective steps necessary to render research societally relevant. The purpose of the ten-step approach is to critically review to what degree and in what way(s) a research project is embedded in the realms of science and practice. The ten steps are organized into three main stages. Applying their model, we categorized the serious board game jam process into three phases (see Fig. 10.9).

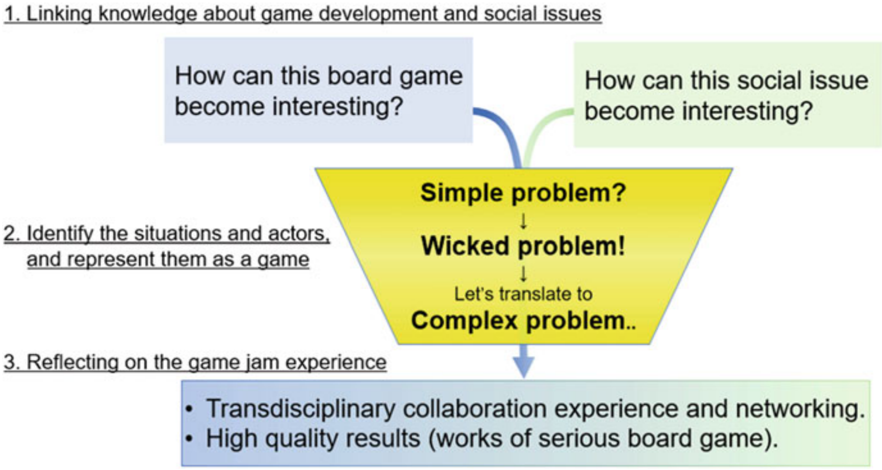

Fig. 10.9 Wicked problems and the transdisciplinary approach involved in the ten-step approach

The process of turning wicked problems, such as entangled socio-environmental problems, into tame problems, by expressing them as a game with rules and winning conditions is wicked in itself. Therefore, organizers of serious board game jams must be careful about how the process these three phases in guiding participants.

Phase 1, "Linking knowledge about game development and social issues," involves team building. In their transdisciplinary teams, participants must have the tenacity to examine various possibilities and the tolerance to accept many failures if team members interested in game development and team members interested in social issues cooperate successfully. This phase is analogous to the identification of complex natural compounds. When we wish to identify an unknown compound, we use various reagents and test methods to determine what substance the compound is composed of. The identification process comprises a series of trial and error stages as well as feedback. At a serious board game jam, the way to convert an actual wicked problem into an interesting game is quite different in each case. Therefore, team members must use their knowledge and experience to explore the shape of the game to be created.

Phase 2, "Identifying the situations and actors and representing them as a game," involves game development. In this phase, wicked problems identified via the interests, knowledge, and experience of team members in Phase 1 are turned into tamed problems through designing games. Participants face challenges specific to transdisciplinary collaboration in the process of co-developing games as a team. Transdisciplinary collaboration involves dynamic change and progress during a hands-on engagement. As one factor is reduced, another will be created as a side effect. Issues to be addressed arise not only within the components of the game but also in the relationships among the team members. Mutual learning and acceptance of fallibility are keywords of this phase.

Phase 3, "Reflecting on the game jam experience," involves the socialization of the experience. Participants will consider questions such as: What was discovered during the process of developing a serious game as a mimic of a wicked problem? What members contributed? What could not be expressed as game components or rules because they were aspects of social issues that were too complex? Through these reflections, it is possible to create an opportunity to reflect on the experience of serious board game jams in the next transdisciplinary collaboration.

10.3.2 Linking Knowledge about Game Development with Social Issues (Steps 1–4)

Phase 1 can be divided into four steps, summarized in Table 10.2. The table includes the following items: Description (what do participants do in this step?); Rationale (why do participants do it? How do participants make sense of the steps?); Aim (how do organizers and game jam researchers make sense of the steps?); and Exercise (how does that step relate to training for transdisciplinary?)

In Step 1, participants recognize their interest in serious game jams: When signing up, participants are surveyed about what they expect from a serious game jam event. Through this questioning, participants can recognize that there are two different interests in serious game jams: "I want to make an interesting game" and "I want to make a game that allows us to experience social issues deeply." Participants can also include their interests here.

In Step 2, participants are asked to link the two interests. This provides an opportunity for participants to think about how two different interests, "I want to make an interesting game" and "I want to make a game that allows us to experience social issues deeply," are related. For example, creatiters and students majoring in game development and game enthusiasts tend to have the former interest. In contrast, researchers, students who are non-game majors, and non-profit organization staff tend to have the latter.

In Step 3, teams are built with respect to topics. Teaming is done using Open Space Technology (OST). OST is a method for holding discussions at a meeting (Owen 2008). Some of the meeting participants propose issues, recruit members for discussion, and create projects to solve the issues. OST is known to arouse participants' sense of ownership and spontaneity, as well as encourage participants to take the initiative in their ideas and dialogue. OST comprises the steps "Marketplace," "Session," and "Harvest." In the Marketplace, participants ("callers") who wish to think about topics of interest give presentations. At an SBGJ, each caller writes the social issues he or she wants to express as a game on a single slide or a sheet of A4 paper and gives a brief presentation (no more than 3 min) to the other participants about the importance of the topic. If some callers present similar topics, they are encouraged to integrate. During the session, participants engage in dialogue centered on each caller. Participants are free to move on to other topics if they feel they are not

Table 10.2 Linking knowledge about game development with social issues (Steps 1–4)

Step	Description	Rationale, Aim, and Exercise
Team building • Participants: Participate in situations where the ability to deal with wicked problems in daily life is used to form specific tame problems. • Researcher: Observe how each agent formulates problems and situations from the bottom up and treats them under top-down limits (themes, regulations, time limits, etc.). • Exercise: Build a transdisciplinary team to turn specific wicked problems into toy models (games) to make them tame problems.		
1	Ask to recognize participants their interest in serious game jams.	• At the time of signing up, participants introduce themselves according to capacity, interest and talk about what they expect to gain from a serious game jam event. • Researchers predict what type of game it is likely to be. In some cases, the original plan can be adjusted. • Exercise: Embody aspects to work on via transdisciplinary collaboration. Collect the factors concretely (even if the whole picture is not known).
2	Ask them to link their two interests.	• Participants think about how two different interests, "I want to make an interesting game" and "I want to make a game that allows social issues to be experienced deeply," are related. • Researchers observe whether problem-solving incentives change with this step. • Exercise: Limit the direction of the issue and make it easier to handle, allowing the exchange of ideas. Stakeholders have various interests and evaluation criteria. For collaboration, it is important to limit the axis of value evaluation to some extent.
3	Build the team with respect to topics. *Teaming is done using Open Space Technology. "Callers" announce the social issues they would like to express as a game.	• After a short presentation by the callers, the other participants are free to have discussions with the callers and form their respective teams. • Organizers set up Open Space Technology, respecting the independence of participants and encouraging team building. The researcher observes the conversations among participants. • Exercise: Main topic selection. Along with this topic, the participants will create specific constraints for tackling wicked problems.
4	Identify which of your abilities will be needed in the team or topics you wish to join.	• Participants in each team will consider the various knowledge, skills, and ideas provided to the members and compare them with the knowledge and skills required by the game that the team

(continued)

Table 10.2 (continued)

Step	Description	Rationale, Aim, and Exercise
		(priority) wants to make. • Researchers and organizers do not need to do anything at this point. • Exercise: Show candidates for knowledge, skills, experience, and materials can be connectors of mutual interest in building a team. What can be used depends on the composition of team members and the situation, e.g., the main topic.

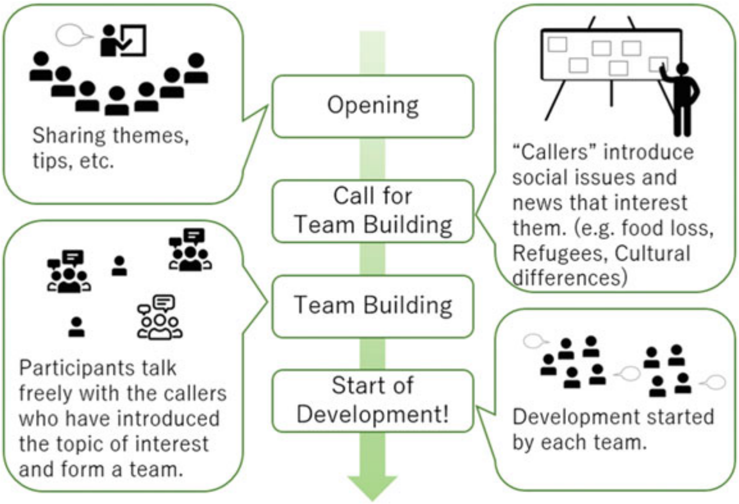

Fig. 10.10 Open Space Technology used for the Serious Board Game Jam 2019

interested in expressing a caller's topic as a serious game. During the Harvest, callers and participants share the findings of the results of the dialogue. At an SBGJ, participants build teams. They can create serious games about their topics of interest (see Fig. 10.10).

In Step 4, participants in each team explore what they can do to develop the game. They are free to use or not use their expertise. Participants are also allowed to bring tools to the event (at the two previous SBGJs, many participants brought laptops or tablets, while some people brought clay and others brought books on game mechanics). The venue should have one whiteboard for each team. Alternatively, provide plenty of A0-size graph paper and packs of post-it notes. Step 4 can be described as the process of visualization.

10.3.3 Identify the Situations and Actors and Represent Them as a Game (Steps 5–9)

Phase 2 begins once the team has been decided, summarized in Table 10.3. Disagreements may lead to intense debate and conflict during this phase. It is not always a comfortable time, but the survey results suggest that sharing the experience of overcoming this disagreement among the participants is essential for continued collaboration. Also, in serious game development, participants may need to understand that there is no winning strategy. Therefore, you cannot always make an interesting game, even if certain conditions are met.

In Step 5, participants identify the social actors involved in the game. Through discussion and dialogue in Steps 3 and 4, the characters, story, rules, and components that appear in the game are developed. Six to ten key actors are established (these are not necessarily people, they do not even have to be living things), and the relationships, powers, and tradeoffs among them are visualized. Finally, participants will extract some of these and turn them into game elements.

In Step 6, participants use the rubric to identify the appeal of their own game (see Fig. 10.11). Rubrics help team members analyze their games from different perspectives and place them in a broader context. It is almost impossible to make a perfect game within the time limit that will satisfy everyone. Therefore, instead of aiming to get a score of 5 for each rubric item, choose which items should aim for a 5 and which items should be (at least) 3 or more. They should verbalize the reasons why some items should take precedence and share this with other team members.

In Step 7, participants identify the actors involved in the game and what the player can expect to experience. Test play is used to see whether the participants' game is trying to create can bring out the desired effect. The actors identified in Step 5 should be swapped several times to build expressions that enable the experience you want your players to acquire. Also, adding playfulness that does not upset the game's balance tends to produce breakthroughs (e.g., putting aliens or werewolves in character or setting the game to take place in the past or the future).

In Step 8, participants make a prototype and perform a test play. Step 7 is then used to clarify the experience of the actors and players. This translates an unsolvable wicked problem into a solvable tamed problem. At this time, record any elements that participants wanted to express as a game but could not be included in the game. These represent the complications of real-world problems. Serious games are always reductive, and sometimes the play experience can deviate from the complexity of the real world. Game creators can make materials that facilitate players' discussions after playing the game by recording what the game could not express and attaching this as a booklet to go with the game.

In Step 9, participants make the game components and adjust the game balance. This is done to enhance the player experience but rarely ends during a game jam. At SBGJ2018 and SBGJ2019, 10 out of 17 teams continued to brush up after the event. (See Tables 10.1 and 10.4) If a team continues to develop after the event, it is recommended that team members share future development plans before the event

Table 10.3 Identify the situations and actors and represent them as a game (Steps 5–9)

Game development • Participants: Face various aspects of wicked problems and tackle newly discovered problems through making games with a transdisciplinary team. • Researcher: Observe which new wicked problems arise in participants' actions (new problems arise from not only rules and components but also from other factors, such as team relationships). • Exercise: Transdisciplinary collaboration changes dynamically.		
5	Identify the likely knowledge and capacity needed from your role in the team.	• Rationale: Participants dynamically present their abilities and roles that have been approved or mutually decided in discussions with team members. • Researchers observe the process of interaction order formation. How do participants perceive their role concerning the task? • Exercise: Promote order formation by clarifying the goals of the team (something that controls the whole as a goal).
6	Identify the social actors involved in the game. *In this step, each team member makes proposals based on the caller's remarks; there is no need to make a decision as a team.	• Participants associate the characters, story, rules, and components in the game with steps 3 and 4. Next, establish six to ten key actors and visualize the relationships, powers, and tradeoffs among them. • Researchers observe participants to see how selected actors treat not only the intended meaning(s) but also the sticky meaning(s) associated with unintentionally. Recall that participants are trying to limit the elements in this step. Setting actors adds unintended complexity to the game. When incorporating this complexity into the game, participants should consider it from different perspectives. • Exercise: In the process of limiting the elements of the problem according to a purpose, participants experience unintended complexity in the field.
7	Use the rubric to identify the appeal of your game.	• Participants use rubrics to help team members analyze games from different perspectives and place them in a broader context. • Researchers design and provide rubrics. Then, they observe how the participants use the rubrics to converge the design direction. Finally, the researchers themselves get hints about how to improve the rubrics. • Exercise: Using rubrics, evaluate information and knowledge as a description of value, verbalize which elements take precedence, and share this with team members.
8	Make a prototype and perform a test play.	• Participants create and adjust a prototype to handle complex and wicked elements and go through test play to clarify the rules,

(continued)

Table 10.3 (continued)

		actors, and components. • Researchers observe where participants encounter new wickedness in the process of tackling wicked problems and how they dealt with this. • Exercise: Dealing with emerging issues in transdisciplinary collaboration (e.g., friction between team members).
9	Make the game components and adjust the game balance.	• Participants tentatively finalize the game and record their experience with deliverables. This step rarely ends during a game jam, so if they wish to improve their own game further, it is recommended that future development plans are shared before the event ends. • The organizer encourages participants to leave a memorandum of understanding on what they intended when creating their serious board game to connect the creators of the game with the players of the game. • Exercise: Focus on what comes after the project. Experience of releasing the results of transdisciplinary collaboration as new items in society. Development plans are shared before the event ends.

ends. Of course, continued development is not mandatory, and members can retire. This helps us understand that collaborations are dynamic over time.

10.3.4 Reflecting on the Game Jam Experience (Step 10)

Phase 3 reviews the lessons learned from a serious game jam experience, as summarized in Table 10.5. Step 10 builds on the nine steps so far and examines the potential impact on your daily activities. It is recommended that this be done in a group discussion with team members and other participants. Community balls are a good support tool. This step helps you discover your potential strengths and weaknesses (see Fig. 10.12).

◆ SBGJ2019 Rubric◆

You don't need to score a 5 for everything. This is a rubric to help team members understand the appeal of their game and share which elements are more important.

	5	4	3	2	1
A. Seriousness Expression of social issues in stories, rules, components, etc.	Deep and realistic experience. Through game play, as a member of society, a player can learn about specific social issues. (e.g., My Child Ravensborn)	Through game play, a player can learn about social issues and problems and how to improve them.	It is not impossible to learn about social issues in the game. A player can learn knowledge but cannot learn how it works.	It touches on some social issues. However, there is a mixture of metaphors and fiction, so players do not believe it.	It is hard to say that it expresses social issues. (e.g., UNO)
B. Governance Dialogue between players and interactions with the field. Initiation of dialogue and interactions.	There are many opportunities for dialogue and interaction. Looking back after the game is also fun. Players can develop relationships that match real world role play. (e.g., Pandemic, Serious TRPG)	There are many opportunities for dialogue and interaction. Looking back after the game is also fun.	There are many opportunities for interaction between players and interactions with the field.	There are a few opportunities for interaction between players.	No dialogue or interaction. (e.g., Solitaire)
C. Beginner Friendly Is it easy for the beginner to play and understand rules?	Beginners can imagine the charm of the game within 3 minutes. Everyone finds it enjoyable. (e.g., UNO)	Beginners can understand how to play by playing the game 1–3 times. Simple rules and components.	Beginners are supported. Components, annual, playing time not too long. However, it is not always easy to understand how to play.	Beginners need patience and time to understand the rules and have fun playing the game. Instructions and play videos are required.	It is difficult to understand unless beginners have considerable board game experience. Complex design. Play time is long. (e.g., Mahjong)
D. Flexibility Players can get various playing experiences depending on the number of players, changing winning conditions and the field.	Attractiveness of the game can be increased by changing the number of players, winning conditions, and the field. (e.g., Magic the Gathering)	Flexible extensibility is part of the appeal of the game. The feeling of play varies depending on the number of players.	Expected to be expanded. Feeling of play varies depending on the number of players and initial conditions.	It is possible to increase the elements of the game to some extent.	There is no room for expansion.
E. Originality Uniqueness of viewpoint	There are experiences that cannot be had without playing the game. Views on social issues will change. (e.g., Papers, Please)	The fun of the game and the depth of social issues are mixed.	The existing game is applied well to the expression of social issues.	When expressing social issues in the game, some arrangements must be added to the template.	Simply expresses social issues with well-known game templates. (e.g., Chocolate Covered Broccoli)
F. Completeness Rules, components, manual, story and tutorial video	Players can fully enjoy the game without a creator.	Players can enjoy the game without a creator. However, there is a place where the fun may not be understood if there is no producer.	Players can enjoy the game without a creator. If there is no producer, there are places where participants do not know how to play.	Players do not know how to play without a producer.	The players cannot play.

Fig. 10.11 Rubric from the Serious Board Game Jam 2019. *other file

Table 10.4 Game works at SBGJ 2019

Team	Title	Topic	Scientific knowledge	Brush up
A	Share happy	Sharing economy	Circular economy	
B	FPC simulator	Food policy	Food policy council	★★
C	Breakfast with refugees	Accept refugees	Relief activity	★
D	Table manners?!	Cultural differences	Negotiation	★★★
E	Losters	Food waste	Opportunity lost and overstock	★★★
F	Murasake	Sake brewing	Local food system	
G	Gudzilla Raids Again	Nuclear waste	Military–industrial complex	★★
H	Mining town	Child poverty	Mutual aid	

Table 10.5 Overview of the ten-step approach

Reflection/socialization		
10	Review the lessons learned from the experience of a serious game jam.	• Participants will look back for the next transdisciplinary collaboration. This step builds on the nine steps taken so far and examines the potential impact on participants 'daily activities. It is recommended that this be done in a group discussion with team members and other participants. • Researchers understand and report on how the effects of serious board game jams are derived. • Exercise: A series of serious board game jam experiences that are organically linked and meaningful.

Fig. 10.12 Test play party during the Serious Board Game Jam 2019

10.4 Conclusions

10.4.1 Overview

The ten-step structure of a serious board game jam was created in response to feedback from the SBGJ2018. Further input from SBGJ2019, which practiced the ten steps, resulted in qualitative conclusions: the ten-step approach to a serious board game jam provides guidelines for those who want to work on interdisciplinary research through game jams. These conclusions are basic considerations for enriching your event.

1. Be sure to complete your work once to experience the process of turning awkward problems into complex ones. A game jam is not intended to build a game within an event. A game jam is simply a jam (the point is to enjoy the process of converting a wicked problem to a complex problem being addressed by an interdisciplinary team. See itself as an achievement). However, it is important to tell the participants that they should shape it themselves if it is not entirely satisfying. The experience of solidifying indeterminate objects in stages is especially important in the transdisciplinary research process. The timing of decisions is also crucial. Participants will experience that making decisions too early may not be too late and, in some cases, if they do not work, they need to go back. Therefore, it is recommended that the organizer provides an opportunity for an interim presentation.

2. Of the ten steps, what can be substituted depends mainly on where the SBGJ is conducted, the profile of the participants, and the context. This is a good reason to ensure the event is more interdisciplinary. In any case, a safe space must be created. Through game jamming with members of different backgrounds and skills, participants can expect to broaden their values and overcome language barriers, boosting their employability (Pirker et al. 2016; White et al. 2019). Even if the final goal is the same, if the approach taken is completely different, there is a concern that the team will go in and out unless someone is quite familiar with making things. Let us know that there is a relaxing environment or place to put together your thoughts when each expectation is different. Time and space allowances are significant.

Sharing of unspecified norms will occur among diverse participants of various backgrounds (nationality, culture, sex, generation, social status, economic background, values, etc.) while participating in game events. The loose sharing of norms between participants, such as understandings among people, mutual respect of their backgrounds, and the fact that the talks among participants are not diffused unnecessarily can lead to collaboration.

- Loose membership: Not only are certain members always present, but not entirely fluid. Centered around core members, various strengths of commitment can be made to the event (including by visitors), which helps expand a network. Stakeholders, such as those involved in web systems, data analytics, advertising, legal services, and providers, are also involved in sharing knowledge and building customer relationships. Publishers, investors, the public sector, and research institutions are also interested in participating in games for business or public good.

- Equal relationship: There are many casual efforts between companies, and there is no dependency relationship in the value chain (not necessarily linked in work). Can you talk to each other? Also, because competition between schools is not very intense, cooperation between schools can be achieved through events (e.g., BitSummit: Japan's largest indie game festival held every year in Kyoto. It was launched in 2012. The first BitSummit in 2013 was a small event for peers, with around 200 visitors. In 2018, the number of visitors exceeded 11,000, an opportunity for many creators and players to interact. It was held online in 2020.)
- Collaboration with specialists: At BitSummit, specialists in various fields give guest talks to encourage participants to share their expertise (keywords and contexts) loosely.

3. An essential point about serious board game jams is that these events are games in and of themselves. Some participants and management staff pointed out that serious board game jams have a TRPG-like aspect. This Gaming aspect of the event helps prevent people from being too shy of each other and allows relationships to become deeper and more focused. In many cases, the role of the game master (those who think "who plays what role makes the place interesting?") was appearing in each team. Perhaps this happens unknowingly.

10.4.2 Discussion

The ten-step approach for a serious board game jam also faces challenges and open issues.

1. Attention to geographical and cultural conditions is the first step of any SBGJ. Whether enough participants attend is highly dependent on the context. The number of people who are accustomed to such workshops is also an important factor. This depends on how well the gaming community is developing. Many participants and organizers have said that Kyoto, which has a side-by-side connection with a small gaming community, is a lucky case. In many cases, companies have rivalries. Creating a "safe space" cannot be done overnight. BitSummit played a significant role in Kyoto. Fortunately, we held this event in cooperation with other people who already hold game events. The infrastructure, or "ecosystem," under which game jams are made possible has not been thoroughly analyzed. GGJ founder Gorm Lai emphasized in 2015 that the most important role of global game jams is to "create a space where [creators not only share knowledge but also gather and share passion]" (Kultima 2018). A game jam is not only fun for participants but can also improve their skills and expand their network. Social game-themed game jams can also affect

the surrounding area where the event is held (Hrehovcsik et al. 2016). Therefore, it is important to keep an eye on the area around the event.

2. Do game creators should game development together? This is a big question. We think seriour board game jam events need playfulness. Experiences that have made games can work both positively and negatively. More important may be enjoying the role. “The experience of participating in TRPG is important,” one participant said. The reason we originally chose a board game jam is that board game development can satisfy small group work and is an interactive way to freely access materials at a lower cost than digital game development (Pollock et al. 2017). Additionally, interactions via physical components may be more interesting for TRPG-like interactions.

3. The COVID-19 pandemic requires us to collaborate online. However, the ten-step approach does not yet address this. When it comes to team building online, it is expected to have completely different challenges to face-to-face team building. Interviews have also found that not physically touching components can be a barrier. However, developing online serious board game jams is a fascinating prospect because online activities can reduce geographical distances.

The ten-step approach to a serious board game jam provides systematic thinking about exercises in transdisciplinary interactions using game jams. The ten steps should not be considered to be a fixed procedure; steps can be added as necessary, individual steps could be performed in different ways, or steps could be performed in a different order.

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Part III
Simulation and Gaming for Social Entrepreneurship

Chapter 11
Amalgamating Agent and Gaming Simulation to Understand Social-Technical Systems

Masaaki Kunigami and Takao Terano

Abstract Agent simulation is a tool to know about a could-be world. Also, gaming simulation is a language to communicate the future. This chapter discusses a new approach to understand complex socio-technical systems through both concepts. We start basic features on complex and/or complicated socio-technical systems, which address both technical and social issues with human decision-making processes. Then, we explain the importance of new ways of system thinking with human-in-the-loop manners. For the purpose, we propose a methodology to amalgamate agent- and gaming simulation. The characteristics of the methodology are summarized as follows: (1) Systematic analyses on users' behaviors in gaming simulation; (2) Machine learning based log analyses methods about agent-simulation processes; (3) A formal description method applicable to both agent- and gaming simulation models; (4) The description of each process is grounded into a could-be case, which, in this paper, we mean a latent case induced by a simulation result and this can be utilized as a text of case method learning, and (5) Descriptions on practical application in socio-technical problems.

11.1 Introduction

As the scale and complexity of the Systems of Systems (SoS) and socio-technical systems becomes increasing, in order to design and implement SoSs, in conventional ways of thinking, their systems boundaries must be clearly defined. However, in today's world, we must assume that the boundaries are constantly shaking. On the other hand, the existing system theory and technology for these areas are still in their infancy. In this chapter, we discuss a new approach with agent simulation and

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gaming simulation in order to develop and practice new SoSs with both humans and machines in an open and ever-changing social environment. As Epstein (2007) describes, agent simulation is a tool to know about a could-be world. Also, as Duke (1974) mentions, gaming simulation is a language to communicate the future. We believe that the amalgamation of the two methods is indispensable.

One of the unique characteristics of our approach is that it is a human-in-the-loop type participatory methodology, which extends the concept of not only gaming simulation often used in design thinking and systems thinking workshops, but also agent simulation recently used to design and analyze complex socio-technical problems. In this approach, we systematically describe and analyze scenarios obtained from agent simulation results and evaluate their validity by gaming simulation with both human and computer players. Using the approach, thus, decision-makers involved in system development, operation, and use can understand system requirements and specifications in a dynamically changing environment.

This paper is mainly based on our recent work on agent simulation, gaming simulation, log analysis methods for agent simulations; formal methods of describing agent modeling; and practices related to application issues.

The remaining structure of this chapter is as follows: In Second section, we describe the difficulty of defining system boundaries in the implementation of a socio-technical system; In Third section, we explain unique features of the constructivist approach and agent-based simulation; In Fourth section, we summarize the significance of constructivist approach; Then in Fifth section, we introduce a formal description method to systematically understand both agent-simulation and gaming-simulation results; In Sixth section, we give a perspective on the integration of constructivist and participatory approaches; and finally in Seventh section, some concluding remarks follow.

11.2 Difficulty in Defining the Boundaries of a Socio-Technical System

SoSs including socio-technical systems are intrinsically co-evolutionary systems that emerge in an interdependent manner as a result of rapid technological advancement and social activities such as the roles and relationships among various kinds of technologies, individuals, and social and/or organizations changes. In other words, recent developments in communication, transportation, and distribution technologies have brought about significant changes in the interaction between individuals and organizations. Those changes are further accelerating technological changes by creating new demands and innovations. In addition, the large amount of aggregated and visualized information provided by information and communication technologies affects the decision-making process of individual actors as well as institutions involved in the planning and execution of economic and social policies. Thus, the coevolution mechanisms of SoSs definitely create and annihilate a variety of new micro-macro-links in our society. The accumulation of information through the emergence of new social agent behaviors makes possible new technological innovations. In this way, technology and society form the co-evolutionary system, then, the roles of technology and the roles of individual agents and organizations in our society also change in the process of coevolution.

In SoSs, it is difficult to define the boundaries of a system although the existence of the system boundary has been an obvious prerequisite for traditional system implementation with conventional systems thinking. When we look at this difficulty from the outside and inside of a system, we can see that not only the external environment of the system changes, but also the boundary between the environment and the system change due to the coevolution of the external environment and the system. On the other hand, within a system, the behavior of subsystems and individuals, or their connections, change during the process of mutual coevolution. In the interior of a system, not only the organization (roles of components) and structure (connections among components) can change, but also, the components themselves undergo aggregation and decomposition. Therefore, the boundaries and their properties change both within the system and among the system, subsystems, and individual components. In other words, in a socio-technical system, the boundaries are fluctuating both inside and outside of the system, and it is difficult to describe the system in a stable manner.

Fluctuations in the boundaries of socio-technical systems as co-evolutionary systems also change the relationship between the system and stakeholders, who would like to observe, describe, design, implement, and control it. This means that the invariance or constancy of the positions and assumptions of observation and control over the system cannot be assured. Not only that, but the positions and perspectives of various stakeholders on the system also change from external observing and controlling agents to internal decision-makers, or from inside to outside of the system, due to fluctuations in the boundary between the external and internal in socio-technical systems (Fig. 11.1).

This is one of the difficulties in defining the boundaries of a socio-technical system compared to a conventional engineering system. For example, aerospace

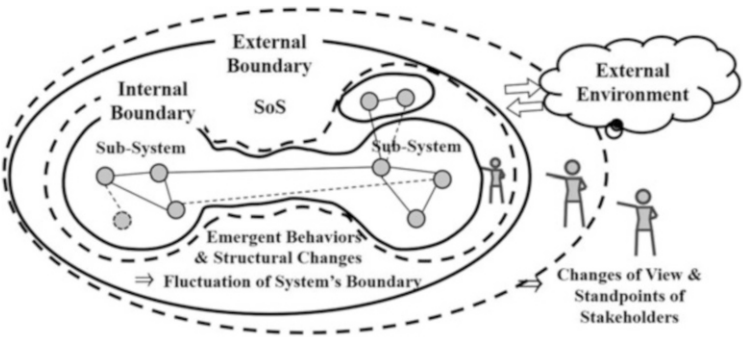

Fig. 11.1 Relation of the fluctuation of the boundary and the standpoints of stakeholders in a socio-technical system

systems and/or nuclear power generation systems are oriented toward rigid and stable systems, in which they try to guarantee the inherent stability of the internal system by strictly separating the subject and object of control. In contrast, the socio-technical system is a loose and inherently unstable system, in which the boundaries between interior and exterior and between subject and object are ever fluctuating.

11.3 Constructivist Approach and Agent-Based Simulation

The constructivism approach is effective to apply to socio-technical systems with fluctuating boundaries due to the coevolution mechanisms described so far. It is complementary to reductionism, which analyzes the necessary conditions for the existence of an object by breaking it down into its elements.

For the purpose, agent-based simulation (ABS), or agent simulation in short, a typical constructivist approach, is a good tool to elucidate social phenomena. Agent simulation treats the minimum components of a society as groups of individuals. ABS tries to model systems from the bottom-up using multiple actors called "agents," each with an internal state, decision-making and/or problem-solving capabilities, and communication ability, and then to analyze the resulting generative phenomenon and scenarios based on their interactions. ABS has several unique characteristics as follows.

1. At the micro-level, agents have individual internal states, and behave and adapt autonomously in their attempts to exchange information and solve problems.
2. Macro-level properties of the target system emerge from the collective actions of the agents.
3. Micro–macrolinks are created between agents and the surrounding environment, and the system state changes as they affect each other (Fig. 11.2) (Terano 2020).

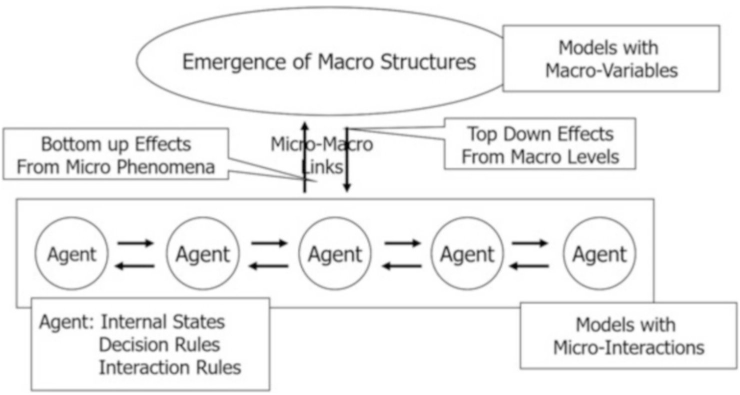

Fig. 11.2 Structure of agent-based simulation model (Terano 2020)

This approach is useful in analyzing macro-phenomena created by agent–agent interactions at the micro-level, as well as the phenomenon of micro–macro links whereby agents are subject to top-down effects. In this respect, ABS is applicable to the system of co-evolutionary interaction between technology and society, as we have described so far. For more information on this, please refer to previous commentaries (Terano 2020, 2021).

One of the examples to apply constructivist approach in our group is to reveal the conditions for the establishment and collapse of money concepts by means of a simulation model. The basic idea of the model comes from the historical observation that some goods have become common objects of exchange in a society (Yasutomi 1995; Kunigami et al. 2010). The model in Kunigami et al. (2010) is unique in the sense that, to represent the interaction of social learning on the social network, they use double structure of inter-agent social networks and inner-agent recognition networks. This double structure of networks enables us to describe and to analyze the emergence of common knowledge or organized/collective recognitions in the society. Doubly Structural Network Model handles social propagation of agents' knowledge and recognition such as exchangeability or acceptability of commodities. The structure of this model is illustrated in Fig. 11.3. The model allows us the following advantages.

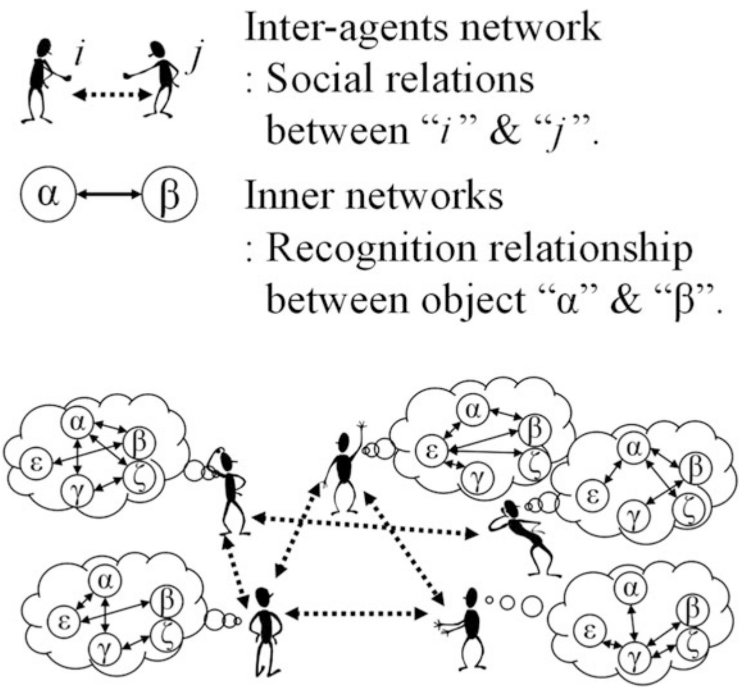

Fig. 11.3 A doubly structural network of a society to explain the emergence of money phenomena (Kunigami et al. 2010)

1. To directly describe the personal recognition of each internal network by shape.
2. To define autonomous evolution into the internal networks.
3. To describe the micro/macro-interaction among agents with these inner evolutions.

However, the model is a conceptual one without a particular social learning/propagation mechanism, so we need to implement specific inter-agents and inner-agents' interaction for "the emergence of money." ABS is one of the techniques to implement the model to derive interesting results on this important classical problem in economics.

Another example by Mukai et al. (Mukai and Terano 2018, 2019; Mukai 2019) is to study constitutive analyses of structural changes in subsystems in a rapidly changing external environment using agent simulations. Mukai et al. developed functions of an agent for the inter-business trading structure model, an inter-business trading structure model in which a group of firms spontaneously constructs and reorganizes their trading networks by changing production items and trading relationships in order to gain profits in a dynamically changing inter-firm trading environment. In the paper, Mukai et al. show that a transaction structure model that incorporates a decentralized structure with constraints on decentralized inter-firm transactions that allow firms to flexibly adapt to environmental changes explains the changes in actual transaction data in the Japanese software industry. Also, the boundaries from which the decentralized to centralized structure of its inter-firm transactions effectively arise are shaky even in the same domain of industry (Mukai and Terano 2018, 2019, Fig. 11.4).

Because of the above characteristics, ABS has the following implications for systems in which not only technology and society interact in a co-evolutionary manner, but also the boundaries in their internal structures are fluctuating. First,

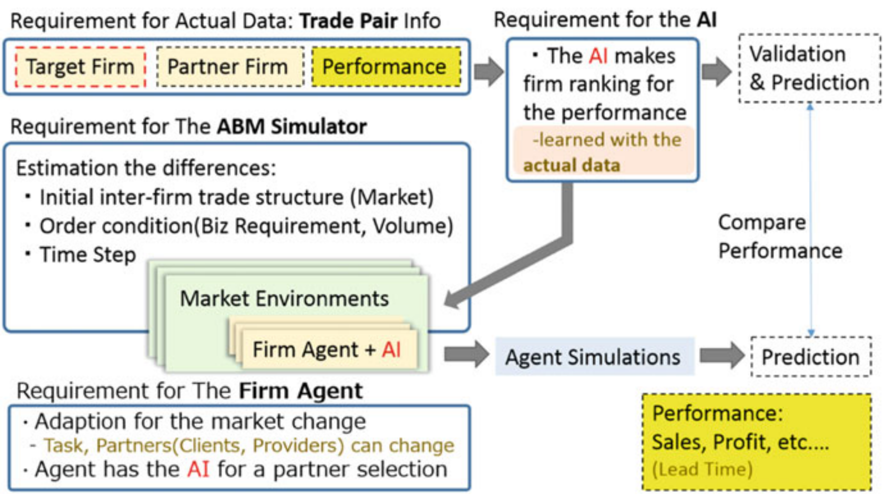

Fig. 11.4 Framework of inter-business trading structure model with ABS (Mukai 2019)

ABS enables us to observe changes in the social behavior of agents caused by changes in the boundary conditions of technology, such as the functional differentiation of agent groups and the creation and disappearance of hierarchies due to changes in the network structure. This makes it possible to realize the fluctuation of the internal boundaries of a social system as an emergent phenomenon of functional differentiation and network structure by agent simulation. Second, ABS allows us to observe bidirectional effects between technology and society, such as changes in the propagation and diffusion of new technologies because of the differences in social network structures and the emergence of new social network structures that follow them. Therefore, ABS is significant as a constructivist approach to techno-social systems.

11.4 The Significance of the Constructivist Approach

In co-evolutionary systems such as socio-technical systems, constructivist approach is indispensable. Co-evolutionary systems often show path-dependent structural and behavioral changes. This causes adaptive evolution of the system with the outside world and functional differentiation within the system, because of the shift of the boundary between the inside and the outside. The evolution and change of such systems cannot be predicted from the properties of the elements alone; therefore, a constructivist approach is necessary, adding to the conventional reductionism approach. In particular, for social phenomena where there are no first principles, various attempts have been made to extend ABS principles. These attempts include selecting adequate models to ensure objectivity and to apply evolutionary computation techniques to solve the inverse problem for data assimilation.

For example, Kurahashi (2018) proposes inference methods for agent model parameters and inverse simulation methods for verifying validity for socio-technical systems study. The previous studies have had the issue that simulation could achieve the results as expected because the designer would set the parameters. Given this issue, the inverse simulation method was proposed in order to solve large-scale inverse problems. Adjusting parameters can possibly create a predetermined result. While on the other hand, inverse simulation is executed based on the following procedure (Fig. 11.5).

1. Design the model based on a large number of parameters that express the real world.
2. Set the evaluation functions that are actually used.
3. Execute simulation by using the evaluation functions as objective functions.
4. Evaluate the initial parameters obtained.

However, it is generally difficult to adjust such a large number of parameters for the objective functions. Given this fact, we have developed inverse simulation method. Inverse simulation is able to adjust so many parameters necessary for agent simulation programs. We apply both the evolutionary computation and

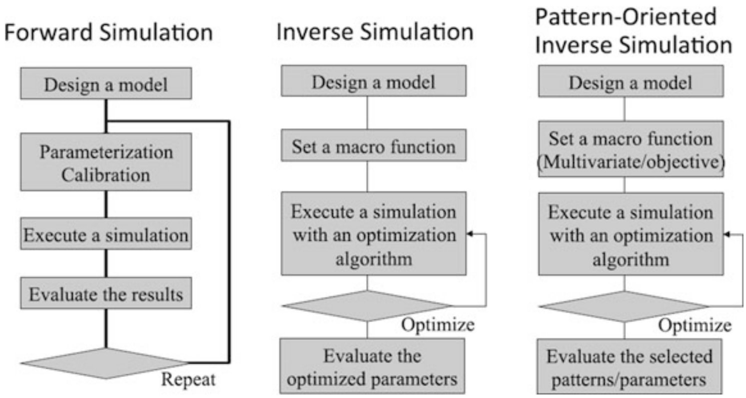

Fig. 11.5 Flows of forward simulation (left), inverse simulation (middle), pattern-oriented simulation (right) (Kurahashi 2018)

reinforcement learning techniques to inverse simulation, which can optimize functions with complicated and a large numbers of variables appeared in the simulation model. Please refer to the other articles for detail (Terano 2007; Mori and Kurahashi 2011; Yang et al. 2009, 2012).

In the following, we introduce new approaches to content analysis of agent simulations. We propose two methods for tracing agent decisions in a run of the simulations. The one focuses on agent decision-making in a run, and then analyzes the simulation log of each trial as a case. The other approach is to classify and to describe the various simulation logs as a set of possible outcomes, focusing on the overall structure of the agent simulation trials as the set of path-dependent outcomes. These two approaches, although still in development, are an important keystone of integration with the participatory approach via the case description methodology described below.

The first methodology for content analysis is Kobayashi's method of generating virtual cases from the logs of individual trials of agent simulations (Kobayashi et al. 2012). The summary of Kobayashi's method is as follows.

1. Simplify the agent simulation model and create a case design template based on the model.
2. Use it to generate a virtual case while checking the consistency of the simulation results.
3. Convert this virtual case into a realistic case (Fig. 11.6). By comparing with real business case, we can confirm the explanatory range of the model. In Fig. 11.6, a "could-be case" means a latent case induced by a simulation result.

This method allows us to evaluate the behavior of a complex system once abstracted from the agent simulation, and then ground it back into the case to improve the explanatory power of the simulation.

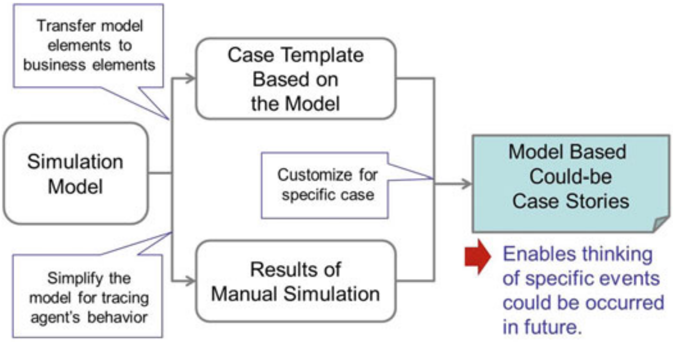

Fig. 11.6 Framework of could-be case generation through ABS (Kobayashi et al. 2012)

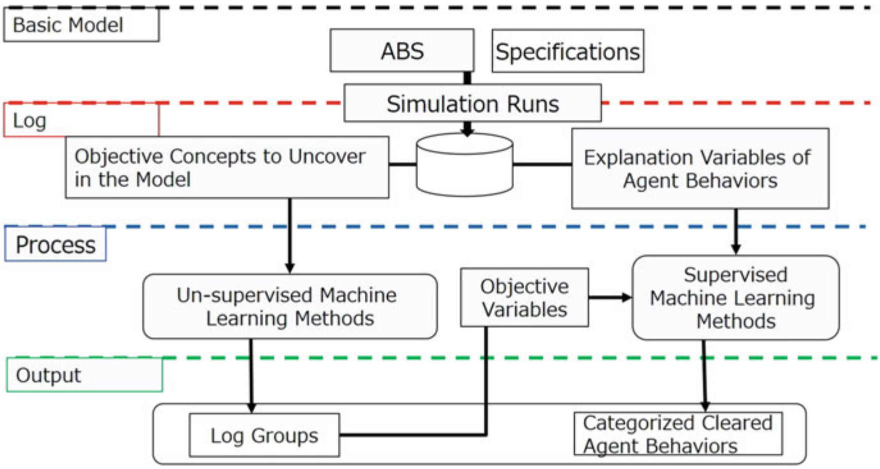

Fig. 11.7 Framework of classification of ABS logs (Tanaka et al. 2017)

The second methodology for content analysis of agent simulations is the method of classification of simulation results by Tanaka et al. (2017). This involves the following steps.

1. Decomposing the entire set of simulation logs into clusters according to the model structure.
2. Analyzing the decision-making processes in the central logs of the clusters compared to each other using machine learning methods, such as decision trees.
3. Allows known behavior of the simulation and understand the relationship between unknown behaviors as differences in the size and distance of clusters and decision-making involving each trial (Fig. 11.7).

11.5 Formal Description of the Results of Agent Simulation as Could-be Cases

In order to connect the two methods of content analysis of agent simulations and to bridge the gap to a participatory approach, we propose a new management decision description model (Managerial Decision-Making Description Model; MDDM). MDDM formally describes real business cases, virtual cases in Kobayashi's method, or virtual cases generated from logs that characterize clusters in Tanaka's method. Furthermore, MDDM is a visualization and inter-comparison tool for stakeholders of socio-technical systems to understand similarities and/or differences occurred in the system behaviors. Thus, this approach will play a role in linking the participatory approach, which will be discussed below, towards the integration of gaming simulation and cases, and the constructivist agent simulation and cases approach.

MDDM as a case description model has been proposed as a business case description model of innovation (Kunigami et al. 2019, 2020) and is being applied to the analysis of the results of agent simulations (Kikuchi et al. 2018, 2019). MDDM is able to represent business innovation processes as a decision scheme; that is, by linking changes in business structures (Objective-Resources Pairs) with changes in actor decision-making (Observation-Action Pairs). This allows us to formalize and express the changes in business structure due to decision-making within an organization (Fig. 11.8). The details of MDDM related discussions will be presented elsewhere.

This formal representation makes it possible to compare the structural differences between cases by drawing the MDDM diagram from the same point of view. On the other hand, while describing the same case from a different point of view, the

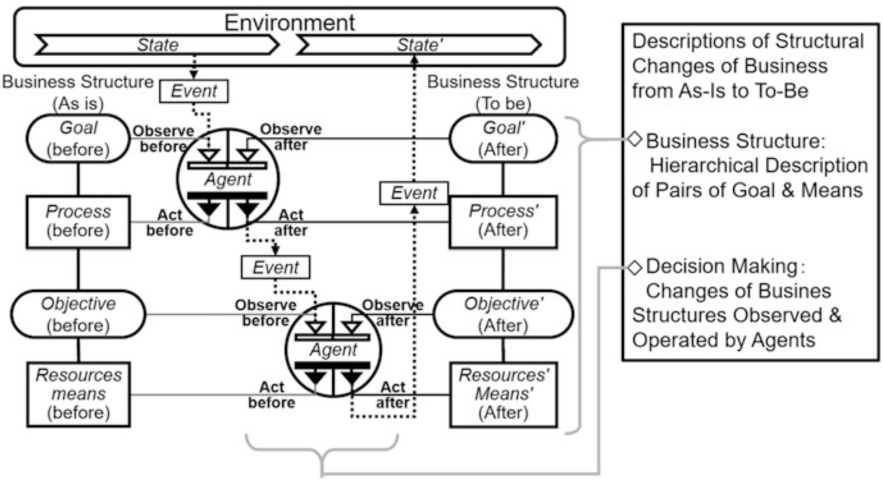

Fig. 11.8 Scheme of managerial decision-making description model (MDDM) (Kunigami et al. 2020)

diagram reflects the differences in understanding of the different perspectives. Kikuchi applies the MDDM scheme to the analysis of agent simulation logs by Tanaka. The paper reports a comparative study between virtual cases and real cases obtained from a cluster of organizational simulation logs.

11.6 The Importance of a Participatory Approach

In a co-evolutionary socio-technical system, the relationship between the positions and perspectives of stakeholders, including ourselves, and the system boundaries is no longer constant. The position/viewpoint of an observer/controller outside the system can also be transformed into an actor or a part of the system, and vice versa. As positions and perspectives on the system waver, the behavioral rules of stakeholders, such as objectives and constraints, also change in flux.

A participatory approach is necessary in the design and implementation of socio-technical systems in which the relationship between stakeholders and boundaries is fluctuating. The participatory approach refers to activities that promote understanding of both the behavior of the system and the actions of the participants through the participation of people who are potential stakeholders. Therefore, executing a human-in-a-loop social simulation or gaming simulation, both human players and computer agent players participate the simulation process at the same time. Below, we present two examples of participatory approaches: the first one is research the integration of constructivist approaches with similar business cases; and the second one is research to detect participant decision-making points in business gaming.

As novel participatory approach, Nakano and Terano (2004) proposed a case-based business gaming method by integrating real business cases and gaming simulations. First, they designed a gaming simulation system based on a real business case. The game models decision-making processes of top and middle management with the original case as the correct way of the play to the game. This enables the players as potential stakeholders to acquire perspectives as external observers and case describers in parallel, in addition to the different levels of decision-makers in various aspects of the internal context. Figure 11.9 depicts the framework of their integration method.

In a participatory business gaming context, Koshiyama et al. investigated the methods of measurement and evaluation of players' cognitions and judgments during business game playing (Koshiyama et al. 2008, 2011). They designed performance sheets to detect players' decisions during the game play. Using the performance sheet, they gathered log data of the game play game log in order to analyze the learning processes of a computer supported business game. Each player was asked to fill in the performance sheet about the information: how they perceive the target state, state variables, and control variables at each point in time and records their understanding of the changing structure of the problem from their point of view. The contents described in the performance sheet represent the same type of formalization of decision-making in the formal description of the case by MDDM.

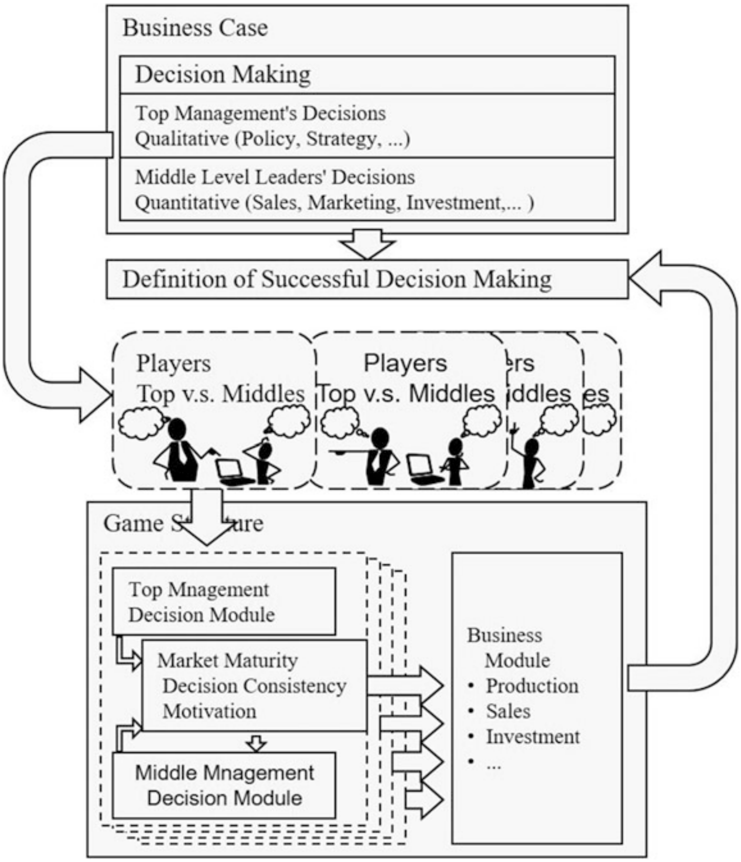

Fig. 11.9 Framework of case-based business gaming method

Therefore, based on the contents in the performance sheet, they are able to visualize players' cognition on decision-making in business gaming (Fig. 11.10).

11.7 Toward the Integration of Constructivist and Participatory Approaches

In this section, we discuss the integration of constructivist and participatory approaches. The analytical methods of agent simulation, a constructivist approach, and gaming simulation, a participatory approach, have one common feature in which they both use real and virtual cases.

As we have seen so far, in order to analyze the effects of emergent behavior and structural changes that alter the system boundaries, we are required agent simulation techniques from constructivist approach. In this process, the results of the simulation

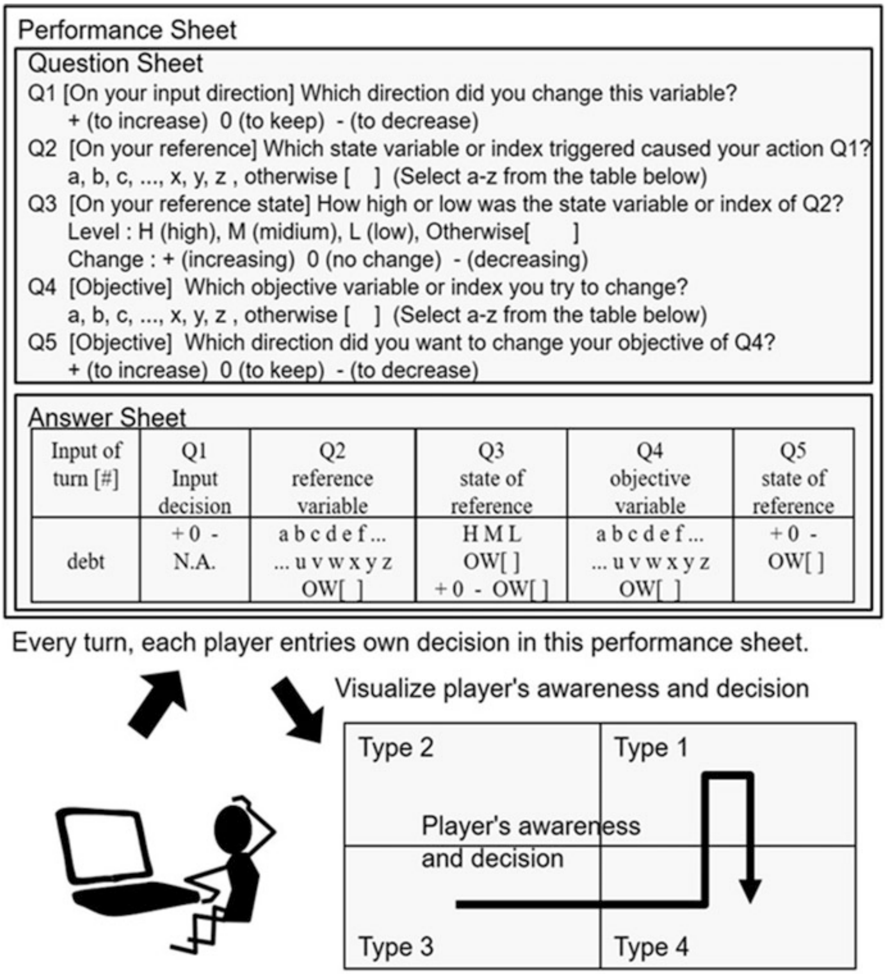

Fig. 11.10 Visualization method of players' cognition on decision-making in a business gaming

are categorized as a whole, and each categorized result should be formally described as a hypothetical case by a descriptive model. This allows us to not only ground the simulation results to the real case, but also to compare the unknown phenomena with the real or known cases.

On the other hand, participatory gaming simulation approach is necessary to analyze changes in the relationship between system boundaries and stakeholders' perspectives. The approach is also useful to promote stakeholders' understanding on targeted socio-technical systems. Such types of gaming simulation can be designed from various real or virtual cases describing specific relationships between the system and the stakeholders. We can also deal with the actions and understandings of the stakeholders who participated in this game through their decision-making and

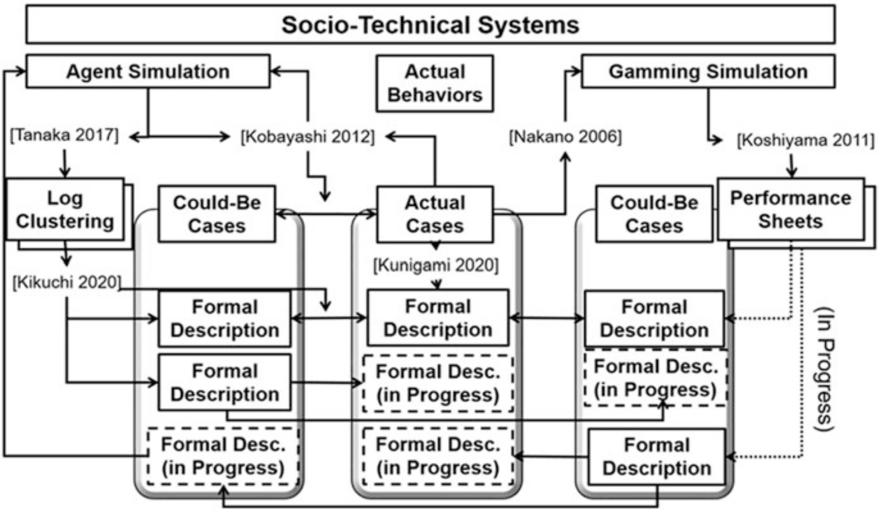

Fig. 11.11 Relationship between agent simulation and gaming simulation for understanding socio-technical systems

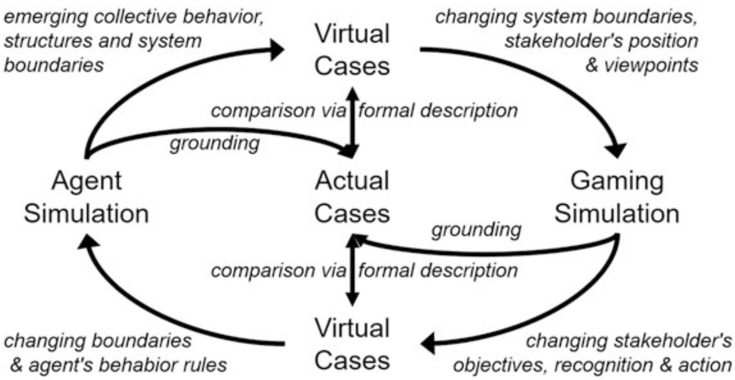

Fig. 11.12 Integration of agent- and gaming simulations with case method

their perspectives. The relationship between agent-based- and gaming simulation is summarized in Fig. 11.11.

Based on the discussion above, we can consider the following scenario for the integration of constitutive agent simulation and participatory gaming simulation (Fig. 11.12).

1. Extract and categorize fluctuations of system boundaries due to emergent behaviors and structural changes from agent simulation logs. We generate virtual cases from these types and compare them with real cases and ground them.

2. From the described hypothetical cases, we can generate gaming simulations that include changes in the participants' viewpoints and positions due to fluctuations of system boundaries.
3. From the play log of the gaming simulation, we can generate hypothetical cases, reflecting changes in stakeholder objectives, cognitions, and behaviors. Then, we can compare them with real cases and hypothetical cases generated from the agent simulation.
4. In the hypothetical cases generated from the gaming simulation, we can reflect future agent simulation systems about changes in system boundaries and stakeholders' decisions/interactions, which have not been realized in the current agent simulation.

The realization of such a scenario would yield the following new insights.

1. Reflect both explicit/potential behaviors and boundary fluctuations of socio-technical systems into novel system design and/or implementation.
2. Reflect the changing perspectives, objectives, and decisions of stakeholders in the operation of the system.
3. Promote stakeholders' understanding of and engagement with the socio-technical systems in which they are involved.

Our research to extend this scenario has been in progress on the side of the constructivist approach, inspired by the results of the participatory approach. Also, we are beginning to apply our results to the participatory approach. We believe that these new methodologies will evolve symbiotically across the boundaries of constructivist and participatory approaches. We would like to report on the results of these ongoing studies, which we have not been able to present in this paper, elsewhere.

11.8 Concluding Remarks

In this chapter, we have discussed the methodology to contribute the explicit/implicit behaviors and boundary fluctuations of socio-technical systems for novel system design and implementation principles. In addition, we have described ways to integrate stakeholders' changing perspectives, objectives, and decisions in order to promote understanding and engagement while reflecting their changing perspectives, objectives, and decisions. To work the proposed scenario, we must make progress on the side of the constructivist approach, taking cues from the results of the participatory approach and vice versa. In the future, we hope that these new methodologies will evolve as interactions to cross the boundaries of the existing strategies.

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Chapter 12
Sharing Tacit Knowledge by Playing Supply Chain Collaboration Games

Tomomi Kaneko, Ryoju Hamada, and Masahiro Hiji

Abstract Tacit knowledge, which cannot be transferred to another person through mere verbalization, plays a fundamentally important role in solving society's problems and making decisions in management. Nevertheless, earning tacit knowledge effectively and sharing tacit knowledge with other people is not easy. Learning such tacit knowledge can be achieved through experience and through learning from experience. However, only on a rare chance does one have the opportunity to experience what one wants to learn and what one should learn. The authors have created various analog business games and have used them for education to produce learning opportunities. Particularly, the authors applied Supply Chain Collaboration Games for lectures in 2014 and 2015 at Sirindhorn International Institute of Technology (SIIT) at Thammasat University. Results obtained from analyzing the students' responses to questionnaires clarified empirically that students can learn management-related tacit knowledge effectively using analog business games.

12.1 Introduction

Tacit knowledge, which is used in many activities of the society, strongly influences problem-solving and superior decision making. For instance, when servicing a car, automobile mechanics seek the cause of a malfunction. During that search, an experienced automobile mechanic can identify causes of a disorder immediately based on abundant tacit knowledge. By contrast, an inexperienced automobile

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mechanic often would take a long time to ascertain the cause. Along with progress in data analysis of defects and malfunction phenomena and causes, the sophistication of measurement technology has made it easy to identify causes by comparing a maintenance manual with measurement results. Nevertheless, that activity remains far inferior to the problem-solving capability of an experienced automobile mechanic. The same is true for management. Management's task is to achieve business objectives by making decisions continuously according to environmental changes and by putting decisions into action. A common understanding is that the management of a company aims to make a profit "by buying at a low price and selling at a high price" as a basic principle. Therefore, if one can simply learn a lot about business theory and case studies and deepen one's own knowledge, then one can manage better. However, making a profit as expected is not easy in the real business world. Few people can make appropriate business decisions to make a profit. In most cases, managers who continuously make profits cannot explain the process well even if someone asks them how to make appropriate decisions. Other managers therefore cannot make the same appropriate decisions.

Tacit knowledge is one factor that has a marked influence on problem-solving and superiority of decision making, but tacit knowledge cannot be explained in words. That knowledge which cannot be verbalized represents an important obstacle to sharing knowledge by learning from and teaching others. Transforming tacit knowledge into explicit knowledge helps to promote the inheritance of technology and tradition.

Many researchers have studied tacit knowledge for many years. It can be roughly classified as developing an effective method to formalize tacit knowledge to explicit knowledge or a case study in the Knowledge Management field. Knowledge mapping is a common technique of capturing tacit knowledge. Kunifuji (2016) reports the "KJ method" as well known in terms of sharing knowledge. Ma et al. (2007) proposes the i-system as a methodical system. The i-systems explain many applications of knowledge creation. Regarding a case study, Kohsaka et al. (2019) investigate apiculture and beekeepers in Nagoya and shiitake mushroom production in Ishikawa. Both case studies demonstrate that traditional production knowledge and experience should be transformed from tacit to explicit and should be shared. Although much research is conducted to explore tacit knowledge itself, no reported research has been undertaken to explore the teaching of tacit knowledge about management through experience to participants with little experience in the business. On the other hand, "interviews," "causal maps," and "the Q-methodology" are well known in the Simulation and Gaming field. The three are stand-alone methods. Roungas et al. (2019) proposed combining all three methods to create a more robust methodology and applied in a case study related to the railway sector. Although it is possible to transform tacit knowledge into explicit knowledge through interviews, it remains unknown whether the tacit knowledge which the interviewer finds meets the perspective of those who want to use it, or not. Markus (2001) defines reusers, a user of tacit knowledge elicited by the interviewer, of four types with different requirements for explicit knowledge. Furthermore, even if the tacit knowledge is formalized without the perspective of the reuser, it can be useless.

One of the few ways to learn such tacit knowledge is through experience and through learning from experience. Nevertheless, rare opportunities exist to experience what one wants to learn, and do so conveniently. The authors assume that games are a good way to provide such opportunities. Sato et al. (2018) introduces a milk supply chain game, which raises food waste awareness through milk waste. Suzuki et al. (2019) presents a game for teaching energy transition policies to guide society from fossil fuels to renewable resources. Many games achieve the intended educational effects by playing the game according to a scenario. The authors assume that tacit knowledge exists among a scenario. There is no example of using games that emphasize learning tacit knowledge based on experience rather than a scenario.

12.2 BASE Supply Chain Collaboration Games

12.2.1 BASE Business Games

Business games and simulations also have a long history. Walker and Eidman (1974) developed a firm management game for students to teach how to integrate concepts and information from the biological, social sciences, and so on in making decisions and how to apply modern decision-making procedures to the problems of a farm business. Keiser (1974) also developed a market management game and applied for college-level courses in a single strategy area of marketing management. Roberts (1974) introduced the Harvard Management Game at The University of West Florida in the Fall of 1971, as the primary teaching instrument in the business policy course. In this way, various types of business games have been used for more than half a century. Various games have been created according to the purposes and majors, levels, et al of the participants. 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 (Lamont et al. 2014). This game, which is accessible from all over the world, can be participated in easily. Morita et al. (2010) clarified differences in decision making between MBA students in Japan, China, and Russia using a problem-solving business game. As the times have progressed, in addition to case studies that introduced games, research that finds new findings by comparing the results has increased.

On the other hand, regardless of whether it is analog or business, trying to make a more realistic business game complicates the game itself, making it difficult to create a game without skills and experience. To solve this problem, Tanabu and Shirai (2010) developed the Yokohama Business Game (YBG), a platform for business game development created by Yokohama National University. This platform can freely be created and modified by teachers.

Since 2007, the authors have developed various original business games, called Business Accounting School for Entrepreneurs (BASE) business games, for participants to learn business management. They can experience business management virtually and can acquire tacit knowledge related to business management through experience. The authors have developed business games of 17 types, including Manufacturing (BMG), Software Kaihatsu Game (SKG), and Supply Chain Collaboration (SCC). The authors recognize that the following important policies are fundamentally important when learning tacit knowledge related to management from education using business games.

- To limit what you teach, stop what you have difficulty doing. Learn what you teach only for fundamental management knowledge.
- Enjoy playing.
- Complete the game within 10 hr.
- Motivate studies for learning management continually.

Many people, including students, tend to regard games as software games. Lean et al. (2006) conducted questionnaire-based research about business game types. The percentages of the business game type show that 35.9% of current users are using role play games, 20.5% are using non-computerized games, and 25.7% are using computer-based simulations. For example, the Beer Game, which is still commonly used to teach supply chain management, is available as a tabletop or computer-based game. The tabletop version is still popular.

The BASE business game, a board game, has participants play face-to-face in a battle format. The gameplay environment becomes an exciting place. Some mistakes and irrational decisions might occur. The accounting process using pencils and calculators might also be affected by calculation errors, entry errors, and cost accounting omissions. These actions might engender catastrophic failures such as lack of funds. The authors find it worthwhile to experience such mistakes and absurdities because such mistakes and absurdities can actually occur. Therefore, it is important to address them suitably. Facing such unexpected situations is necessary for a tacit knowledge learning process. For that reason, it is an experience that is difficult to obtain. From these viewpoints, analog business games are more useful than software games for learning tacit knowledge. Furthermore, the games request coordination of several participants as a group that shares management roles. This mechanism improves communication skills such as accommodation of conflicting opinions and persuasion when making a decision. It is one important matter that is difficult to learn in traditional lectures. Furthermore, it is useful in applying tacit knowledge. However, games have a self-contained nature. It is insufficient as an educational effect for participants to just feel “fun” at the end of the lecture. A curriculum is meaningless if one cannot learn experience and tacit knowledge or even basic knowledge. Therefore, in education using the BASE business game, the authors also give lectures to provide the necessary knowledge to management according to participants’ needs and their knowledge.

The BASE business game can incorporate what one wants to teach and what one wants to learn into the game adequately. Therefore, participants can learn the right course contents at the right time. By experiencing management through games, participants can experience and intuitively understand business-critical actions and decision making, such as collaboration and negotiation with other companies, which cannot be learned through traditional lectures.

12.2.2 Education Policy

Students study diligently and acquire great amounts of knowledge of Supply Chain Collaboration and Inventory Control through university lectures. This knowledge, which has high specialty and difficulty, is taught by teachers, in general, as a traditional lecture style. The authors assume that it is possible for students to understand Supply Chain Collaboration and Inventory Control as knowledge, but students are also assumed to have some difficulty remembering them as practical knowledge. To provide opportunities to learn them as experimental, the author created BASE business games of two types: "Supply Chain Collaboration Game (SCC game)" and "Supply Chain Collaboration 2 Game (SCC2 game)." Before developing the SCC Games, the authors defined the following educational policy.

- The target audience mainly comprises higher grade engineering students.
- Learners will be able to do the following with joy and a relaxed environment.
  - Understand basic company management, basic accounting, and basic supply chain management.
  - Importance of mutual collaboration for gaining profits.
  - Increase further motivation to study business.
- Avoid adding complicated rules or exceptions to rules.

12.2.3 SCC Games

The SCC Games represent a simple model of smartphone manufacture. They have two layers of industry, i.e. one assembler and two part suppliers, and part suppliers of two types, i.e. a Motherboard and Display. They are the simplest model of SCC. These business games require that players form teams and operate a mock-up company. Through the SCC games, they can understand and manage cash accounts, fixed costs, operations, inventory control, strategy, risks, and finally, supply chain collaboration as an extended concept of Supply Chain Management experimentally. The authors also know that understanding of multiple supply chains is necessary in the real business world, but only a few businesspersons are engaged in operation of multiple supply chain collaboration. However, almost all businesspersons must know supply chain collaboration concepts. Therefore, the authors assume that SCC games are sufficient for application to the university's lectures.

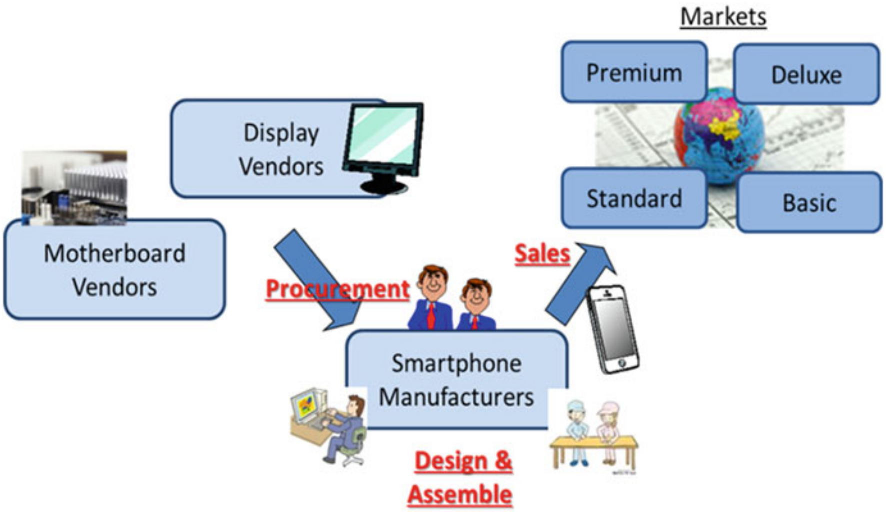


Fig. 12.1 Outline of the SCC game

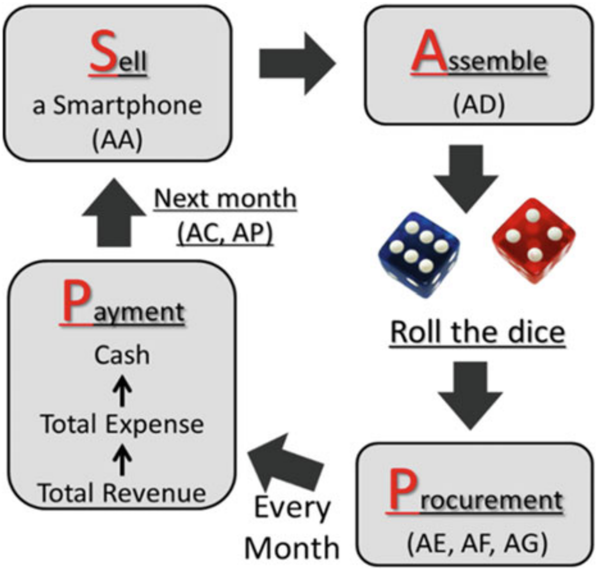


Fig. 12.2 Flow of SCC game

Figure 12.1 presents an SCC game outline. Players operate Smartphone Manufacturers and create smartphones comprising a motherboard and a display. Then they sell them on the market.

Figure 12.2 presents the SCC game flow. The game period is one year, which is divided into 12 months. One month is the minimum time scale. Players who want to sell a smartphone must make decisions about numerous actions to "Sell a

Table 12.1 Conditions of motherboard and display procurement

Spot	Quality	Max. lot	Price/lot
6	*6	3	60
5	*5	3	50
4	*4	3	40
3	*3	3	30
2	*2	3	20

Smartphone," "Assemble," "Procurement," and "Payment." They must spend three months from procurement to sales. This procedure teaches players to allow lead time for producing a product, which cannot be known to students, and prevents players from mistakes such as operating with "Procurement," "Assemble," and "Sell" for the same parts in the same month.

For the procurement process, each company purchases Motherboards and Displays every month in accordance with the conditions of procurement in Table 12.1. Each Motherboard and Display has quality stars of six levels. The price of each Motherboard and Display is fixed according to the level of quality stars. Before purchasing a Motherboard and Display, a facilitator rolls the dice, i.e. blue dice for the Motherboard and red dice for the Display, and decides conditions of procurement. For a case in which the blue dice spot 6 appears, every company can purchase only six quality stars' Motherboards within three lots. However, dice spot 1 represents an opportunity loss. In the event that a red dice spot 1 appears, no company can purchase a Display in the month. As one might expect, dice spots are controlled in accordance with market circumstances by the facilitator. Furthermore, two special rules exist in this process: a "Three month rule" and a "Discount rule."

Three month rule: The part loses one quality star if players cannot use their own parts within three months. This special rule teaches players that the quality of parts degrades with the progress of time once they are purchased.

Discount rule: Price/lot are discounted 10/lot from the price if a company buys the same quality parts in a row. This special rule teaches players the important merit that they continue purchasing the same parts from the same suppliers.

Therefore, players must devote careful consideration to which combination represents the best choice for the market situation and other companies' strategies. After the procurement, players make records of their inventories in Fig. 12.3.

Figure 12.4 presents examples of assembly processes. In case one six quality stars' motherboard and one four quality stars' display are assembled with design and assembly cost, which is calculated as total quality stars times 15, players get one

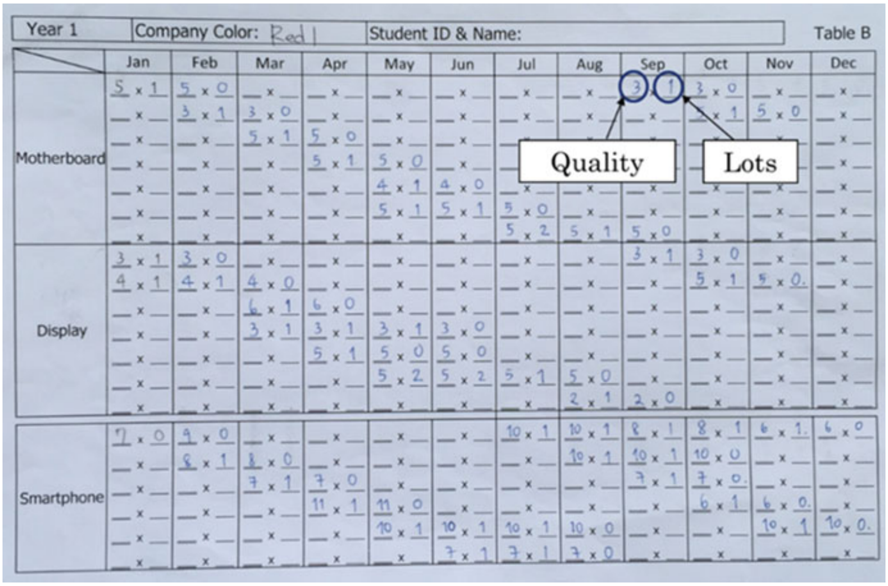


Fig. 12.3 Inventory control sheet

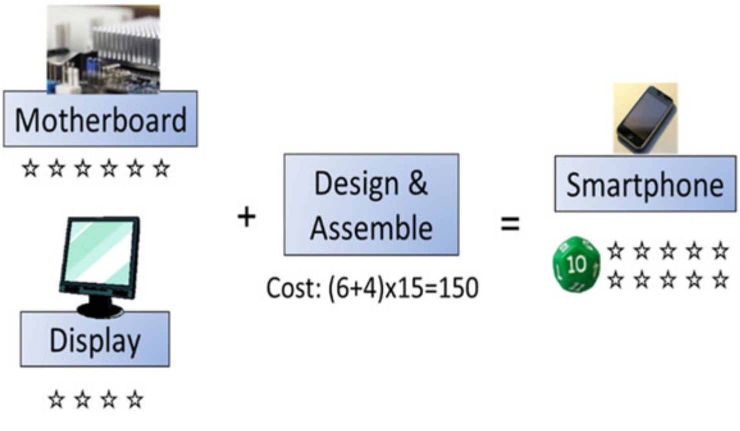


Fig. 12.4 Assembly process

smartphone, as represented by one dodecahedral die, and put it on their company sheet as shown in Fig. 12.5.

By the selling process, players can sell smartphones every month. Four markets exist: Premium, Deluxe, Standard, and Basic. Figure 12.6 shows that each market is defined as having “Acceptable Quality,” “Price Cap,” and “Market Volume.” These conditions change annually. Players must choose a market in comparison of their smartphone quality and the market’s standard of acceptable quality.

Fig. 12.5 Company sheet

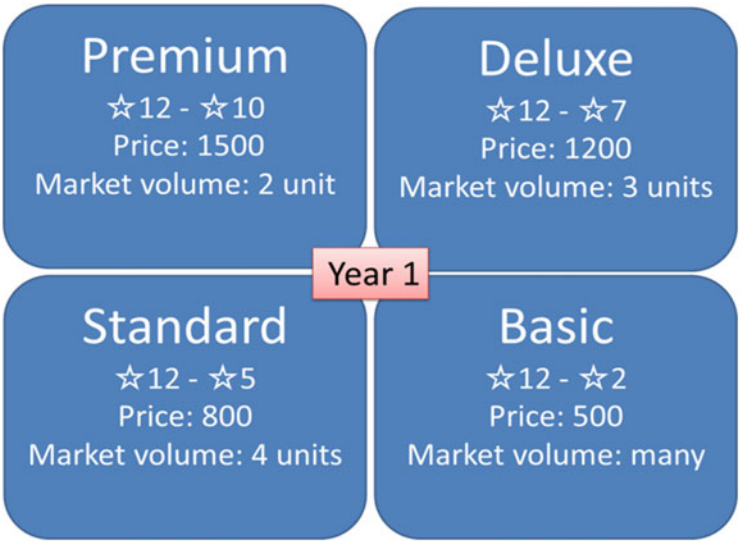


Fig. 12.6 Market sheet

When the total sales volume does not exceed market volume, players obtain maximum sales revenue, which is the same as the market price cap. However, when the total sales volumes exceed market volume, open bidding is opened. Open bidding is conducted by face-to-face bidding. Players approach the market board, by which they want to sell smartphones, and symbolically put them on the market. After they are ready, they show the price to other companies with a calculator by the

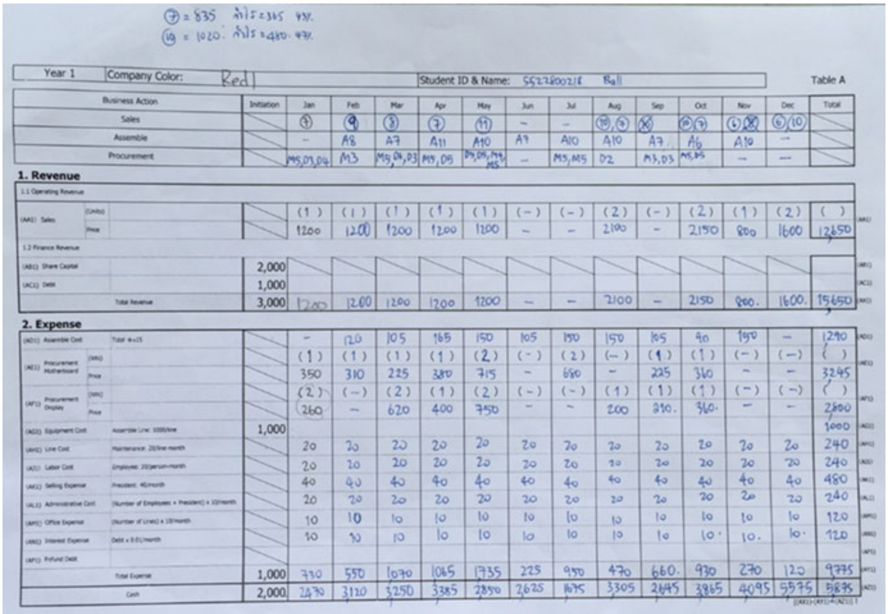
Fig. 12.7 Photograph showing open bidding

signal of the facilitator. If a player wins the bidding, then the player receives the sales revenue according to their sales price. For a loser of the bidding, one special rule exists: the "Lose quality rule." Smartphones of the loser of the bidding lose two quality stars. This special rule teaches players that the value falls once the product becomes widely known to the market. Figure 12.7 portrays a photograph of the open bidding.

During the payment process, players calculate their total revenues and total cash outlays. Then they check their cash amount every month, as presented in Fig. 12.8. At the end of the game year, they produce a basic Income Statement and Balance Sheet as shown in Fig. 12.9. In SCC games, all sheets are entirely hand-scored. Players must manage inventory, cash, and finances using pencils and a calculator. The authors do not intend to compel players to expend meaningless effort. This task is a rare chance to recognize that humans often make simple calculation mistakes and that they understand the role and value of accurate accounting through such experiences.

12.2.4 SCC2 Game

Figure 12.10 presents an SCC2 game outline. It is more complex than the SCC game. In the SCC2 game, players separate and form three companies: Motherboard Vendors, Display Vendors, and Smartphone Manufacturers. Each company

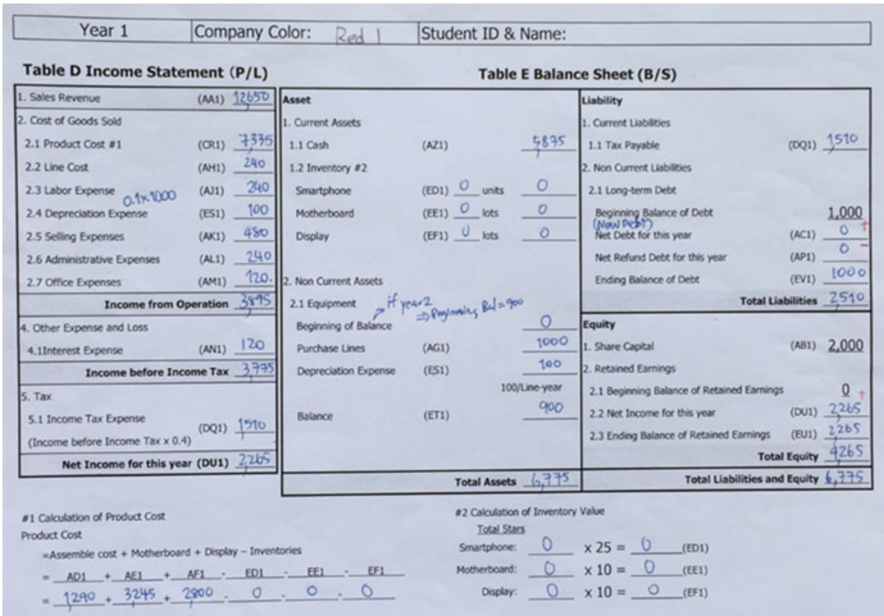


⑦ = 835 กำไร = 365 43%.
⑲ = 1020. กำไร = 480. 47%.

Year 1 | Company Color: Red | Student ID & Name: 5522800218 Ball | Table A

Business Action		Initiation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sales			7	9	8	7	11	–	–	10, 7	8	10, 7	6, 8	6, 10	
Assemble			–	A8	A7	A11	A10	A7	A10	A10	A7	A6	A10	–	
Procurement			M5,D3,D4	M3	M5,D4,D3	M5,D5	D5,D5,M4,M5	–	M5,M5	D2	M3,D3	M5,D5	–	–	
1. Revenue															
1.1 Operating Revenue															
(AA1) Sales	(Units)		(1)	(1)	(1)	(1)	(1)	(–)	(–)	(2)	(–)	(2)	(1)	(2)	( )
	Price		1200	1200	1200	1200	1200	–	–	2100	–	2150	800	1600	12650
1.2 Finance Revenue															
(AB1) Share Capital		2,000													
(AC1) Debt		1,000													
Total Revenue		3,000	1200	1200	1200	1200	1200	–	–	2100	–	2150	800.	1600.	15650
2. Expense															
(AD1) Assemble Cost	Total #×15		–	120	105	165	150	105	150	150	105	90	150	–	1290
(AE1) Procurement Motherboard	(Units)		(1)	(1)	(1)	(1)	(2)	(–)	(2)	(–)	(1)	(1)	(–)	(–)	( )
	Price		350	310	225	380	715	–	680	–	225	360	–	–	3245
(AF1) Procurement Display	(Units)		(2)	(–)	(2)	(1)	(2)	(–)	(–)	(1)	(1)	(1)	(–)	(–)	( )
	Price		260	–	620	400	750	–	–	200	210.	360.	–	–	2800
(AG1) Equipment Cost	Assemble Line: 1000/line	1,000													1000
(AH1) Line Cost	Maintenance: 20/line-month		20	20	20	20	20	20	20	20	20	20	20	20	240
(AJ1) Labor Cost	Employee: 20/person-month		20	20	20	20	20	20	20	20	20	20	20	20	240
(AK1) Selling Expense	President: 40/month		40	40	40	40	40	40	40	40	40	40	40	40	480
(AL1) Administrative Cost	(Number of Employees + President) × 10/month		20	20	20	20	20	20	20	20	20	20	20	20	240
(AM1) Office Expense	(Number of Lines) × 10/month		10	10	10	10	10	10	10	10	10	10	10	10	120
(AN1) Interest Expense	Debt × 0.01/month		10	10	10	10	10	10	10	10	10	10.	10.	10.	120
(AP1) Refund Debt															
Total Expense		1,000	730	550	1070	1065	1735	225	950	470	660.	930	270	120	9775
Cash		2,000	2470	3120	3250	3385	2850	2625	1675	3305	2645	3865	4095	5575	5875

Fig. 12.8 Cash flow sheet



Year 1 | Company Color: Red | Student ID & Name:

Table D Income Statement (P/L)

1. Sales Revenue	(AA1)	12650
2. Cost of Goods Sold		
2.1 Product Cost #1	(CR1)	7335
2.2 Line Cost	(AH1)	240
2.3 Labor Expense	(AJ1)	240
2.4 Depreciation Expense 0.1×1000	(ES1)	100
2.5 Selling Expenses	(AK1)	480
2.6 Administrative Expenses	(AL1)	240
2.7 Office Expenses	(AM1)	120.
Income from Operation		3895
4. Other Expense and Loss		
4.1 Interest Expense	(AN1)	120
Income before Income Tax		3,775
5. Tax		
5.1 Income Tax Expense (Income before Income Tax x 0.4)	(DQ1)	1510
Net Income for this year (DU1)		2,265

Table E Balance Sheet (B/S)

Asset			
1. Current Assets			
1.1 Cash	(AZ1)		5875
1.2 Inventory #2			
Smartphone	(ED1)	0 units	0
Motherboard	(EE1)	0 lots	0
Display	(EF1)	0 lots	0
2. Non Current Assets			
2.1 Equipment if year 2 ⇒ Beginning Bal = 900			
Beginning of Balance			0
Purchase Lines	(AG1)		1000
Depreciation Expense	(ES1)		100
		100/Line-year	
Balance	(ET1)		900
Total Assets			6,775

Liability		
1. Current Liabilities		
1.1 Tax Payable	(DQ1)	1510
2. Non Current Liabilities		
2.1 Long-term Debt		
Beginning Balance of Debt		1,000
(New Debt) Net Debt for this year	(AC1)	0 +
Net Refund Debt for this year	(AP1)	0 −
Ending Balance of Debt	(EV1)	1000
Total Liabilities		2510
Equity		
1. Share Capital	(AB1)	2,000
2. Retained Earnings		
2.1 Beginning Balance of Retained Earnings		0 +
2.2 Net Income for this year	(DU1)	2265
2.3 Ending Balance of Retained Earnings	(EU1)	2265
Total Equity		4265
Total Liabilities and Equity		6,775

#1 Calculation of Product Cost
Product Cost
=Assemble cost + Motherboard + Display − Inventories
= AD1 + AE1 + AF1 − ED1 − EE1 − EF1
= 1290 + 3245 + 2800 − 0 − 0 − 0

#2 Calculation of Inventory Value
Total Stars
Smartphone: 0 x 25 = 0 (ED1)
Motherboard: 0 x 10 = 0 (EE1)
Display: 0 x 10 = 0 (EF1)

Fig. 12.9 Accounting sheet (income statement and balance sheet)

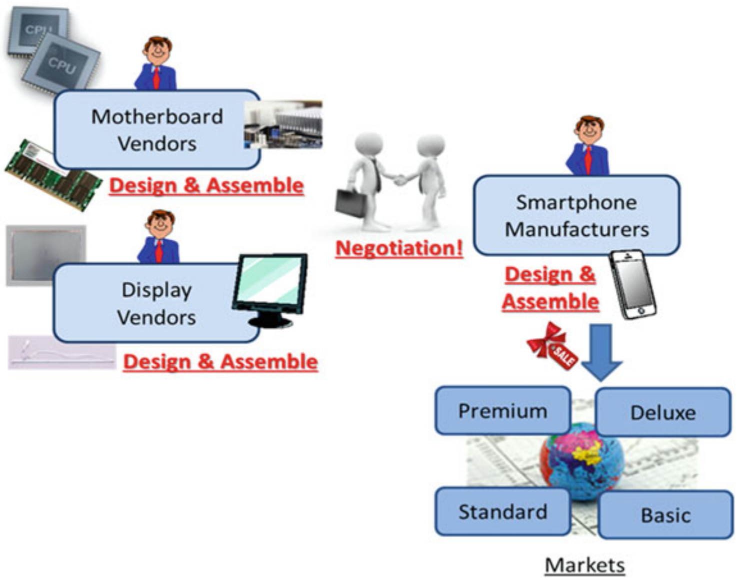


Fig. 12.10 Outline of the SCC2 game

assembles motherboards, displays, and smartphones, as in the SCC game. A salient difference between the SCC2 game and the SCC game is that Motherboard Vendors and Display Vendors are subcontractors of the Smartphone Manufacturers. Consequently, Smartphone Manufacturers must negotiate with Motherboard Vendors and Display Vendors on prices and quantities of motherboards and displays. All companies must negotiate with awareness of their own company's cash flow. Moreover, players play a role as companies of three types throughout SCC2 game. Therefore, they obtain a viewpoint from a prime contractor and subcontractor. These are outstanding features of the SCC2 game.

12.3 Discussion

12.3.1 Lectures at SIIT

The authors have collaborated with Sirindhorn International Institute of Technology (SIIT) at Thammasat University from August 2010 to assess the global and general efficiency of BASE business games. Today, SIIT provides students of the "Management Technology" with lectures related to basic accounting, finance, human resource management, supply chain management, etc. Although students study diligently, their knowledge is not meaningfully connected to real world difficulties. SIIT strives for students to unite their knowledge horizontally and to seek tools for

Fig. 12.11 Lecture photographs

Table 12.2 If you could select a traditional lecture or a business game course, which would you select?

	2014 ($n = 39$)	2015 ($n = 57$)
Traditional lecture	2	4
Business game	37	50
Both	0	1
No response	0	2

meeting SIIT's object. Therefore, BASE business games have been adopted as a conclusion of their education. From 2013, the authors conducted a lecture: "Entrepreneurship for IT Business Development." All were senior students of the undergraduate Management Technology Course and the Engineering Management Course. They already understood supply chain management to a certain degree. Nevertheless, they had no ideas related to supply chain collaboration. The authors applied the SCC game and SCC2 game for most lectures held during 2014 and 2015. At the beginning of the lecture, they were concerned about the adjunct Japanese Associate Professor and the lecture contents. However, as they came to understand the game rules, they were able to enjoy lectures better. Figure 12.11 presents photographs of the lecture.

12.3.2 Questionnaire Research

To verify the game's effectiveness, the authors conducted questionnaire research as self-evaluation using a Likert ordinal scale. Table 12.2 presents single-response

Table 12.3 Is your motivation increased?

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

Table 12.4 Do you recommend lectures using SCC games to younger students?

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

question results and confirms that our students prefer the business game to traditional lectures. The authors infer that results obtained through business game lectures are not as repetitive and tedious (boring) as traditional lectures.

Table 12.3 presents the results of the query "Was your motivation increased?" Results show that many students increased their motivation to participate in this lecture. The authors can infer that increased motivation to participate in this lecture might be equivalent to increased willingness to learn business management skills and knowledge. Business game lectures can encourage them.

Table 12.4 presents the results obtained for the query "Do you recommend the lecture using SCC games for younger students?" The authors assume that responses to this question are representative as a summary of students' satisfaction. In both years, many students might recommend that younger students take lectures that include SCC games. Results indicate that students generally enjoyed this lecture and that they were satisfied with it.

Before and after the lecture, students responded to the same questionnaire as shown in Table 12.5, assessing the understanding of management knowledge including tacit knowledge of the business. The averages of responses to the respective questions can be compared because the respondents were the same students. Comparison enabled the authors to evaluate the game effects. The response options can be represented as a five-point Likert scale for these questions.

1. Strongly do not understand
2. Do not understand
3. Neutral
4. Understand
5. Strongly understand

The average score was calculated as shown below.

Table 12.5 Questions related to management knowledge games

1.	What would a company do if 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

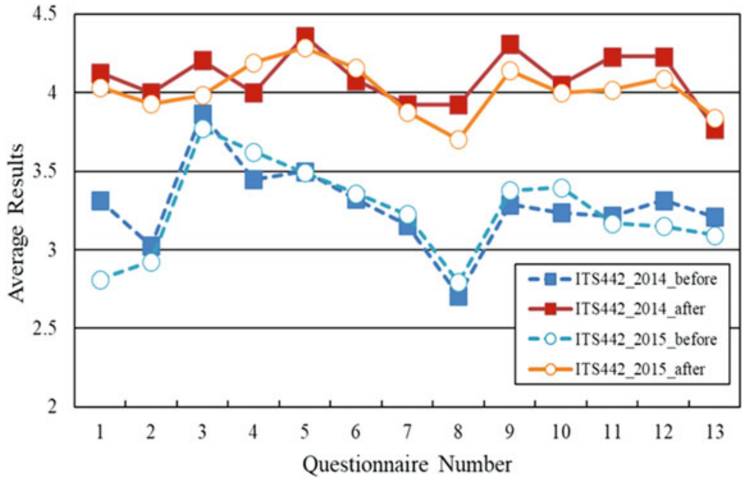


Fig. 12.12 Results obtained for 2014 and 2015

$$Average\ Score = \frac{\sum(the\ scale \times number\ of\ response)}{number\ of\ response}$$

Figure 12.12 presents results of 2014 and 2015. Overall results indicate that results of both years exhibit a similar tendency and that the understanding of management knowledge was improved. The SCC games are designed to teach the importance of continuous collaboration with suppliers and inventory control as an experience. The authors confirm that SCC games satisfy lecture course requirements. This result also demonstrates that these games yield reproducible results as educational materials. The authors assume that the responses of both are comparable. Questions 1–10 presented in Table 12.5 are related to management knowledge

Table 12.6 Do you think this knowledge and skills worked to play SCC & SCC2?

	2014 ($n = 39$)	2015 ($n = 57$)
Supply chain management	90%	95%
Accounting	97%	96%
Inventory control	97%	98%
Human resource management	67%	65%
Marketing research	85%	89%

Table 12.7 Degree of connection of their knowledge and skills horizontally in your mind

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

Table 12.8 Which game was interesting?

	2014 ($n = 39$)	2015 ($n = 57$)
SCC	33%	19%
SCC2	49%	56%
Both	10%	5%
No response	8%	19%

including tacit knowledge of the business. The results confirm that this teaching method can be effective for "tacit knowledge" acquisition.

Table 12.6 presents the results of knowledge usage in 2014 and 2015. These questions were given as a self-evaluation after the lecture. Results demonstrate that their business knowledge of "Supply Chain Management," "Accounting," "Inventory Control," and "Marketing Research," worked well in these games both years. However, the result for "Human Resource Management" was low because these games have no mechanism for teaching "Human Resource Management." The results also demonstrate that students respond to the questionnaire seriously.

Table 12.7 presents the reported degree of connection between knowledge and skills horizontally in the students' mind. The average value of the question increased 0.92 in 2014 and 0.96 in 2015. These results demonstrate that their reported knowledge and skills are well-connected horizontally. The authors confirm that this teaching method is useful for connecting their knowledge and skills horizontally.

Table 12.8 presents the result of "Which game was interesting." The result demonstrates that half of the participants reported that the SCC2 game is more interesting than the SCC game. The SCC game is useful for operating a company with the team's opinion adjustment. The SCC2 game is more challenging than the SCC game because the SCC2 game requires negotiation skills (communication

Table 12.9 What is interesting action in SCC & SCC2?

	2014 ($n = 39$)		2015 ($n = 57$)	
	Percentage (%)	Ranking	Percentage (%)	Ranking
General operation (Cash)	44	5	30	8
General operation (Inventory)	51	4	30	8
General operation (Sales)	62	2	37	5
My decision will appear in actual practice	44	5	32	7
Bid/Sales	80	1	74	1
Beat out competitors	18	9	54	3
Talk together	44	5	54	3
Talk with members	23	8	67	2
Calculation	54	3	35	6

skills) and normal company operations. Students seem to like negotiating with friends.

Table 12.9 presents answers to multiple-choice questions of interesting action for SCC game and SCC2 game. The results demonstrate that the most interesting actions of both years are "Bid/Sales," which are the favorite of approximately three quarters of students. The authors assume that they enjoyed interacting with my team and with other companies (other teams).

Table 12.10 presents responses to multiple-choice questions of difficult actions for the SCC and SCC2 games. Results show that the most difficult action of both years is "Decision making." The authors anticipated "Decision making" as the most difficult action. The best "Decision making" requires use of tacit and explicit knowledge and team discussion. However, for "Conflict of ideas in group," most students do not feel difficulty, with 5% in 2014 and 12% in 2015. This result is curious, suggesting that they felt at ease agreeing with their decisions because they knew each other well. Apparently "opinion adjustment in the group" is a serious action in these games. Presumably, they might feel more difficulty than with the process than with the result.

Regarding the "Balance sheet," 21% of the students in 2014 thought it difficult in fourth place; 37% of the students in 2015 thought it difficult and ranked it as second place. Students were accustomed to using computer-based calculations and therefore struggled to fill in the balance sheets by hand. The authors actually checked the financial statements at the end of each lecture and found numerous calculation errors and input errors. Regarding the "Bids," 36% of the students in 2014 thought it difficult as second place; 25% of the students in 2015 thought it difficult and ranked it fourth. Considering the results in Table 12.9 and the discussion presented above together, the authors infer that students were able to experience severe decisions for "Bids" even in discussions and negotiations with friends. Furthermore, they experience the use of advanced tacit knowledge depending on each counter-negotiator responding to various business agreements.

Table 12.10 What is difficult about SCC & SCC2?

	2014 ($n = 39$)		2015 ($n = 57$)	
	Percentage (%)	Ranking	Percentage (%)	Ranking
Too many tasks	15	7	16	8
Decision making	41	1	42	1
Conflict of ideas in group	5	14	12	10
General rules	8	12	4	14
Special rules (e.g. discount, lose quality)	23	3	11	12
Recording rule (Cash)	10	9	18	6
Recording rule (Inventory)	10	9	14	9
Vertical proof	0	15	4	14
Bid	36	2	25	4
Cash management	18	5	23	5
Horizontal proof	0	15	5	13
Calculation of product cost (10–25 rule)	13	8	18	6
Income statement	18	5	32	3
Depreciation	8	12	4	14
Investment	10	9	12	10
Tax	0	15	4	14
Balance sheet	21	4	37	2

12.4 Conclusions

The authors have developed SCC games and applied SCC games to students at SIIT Thammasat University in Thailand. Results obtained by analyzing student responses to questionnaires demonstrated this educational method as useful.

(1) The SCC game and SCC2 games, which were designed for learning supply chain collaboration, are useful tools for acquisition of tacit knowledge and for using advanced tacit knowledge according to various business tactics.
(2) Overall results demonstrate that the participants enjoyed the games and acquired fundamentally important business management skills and knowledge and motivation of learning the skills through game experiences.
(3) Though playing the games, students can be aware that decision making and negotiation are difficult business actions.
(4) Responses of different student groups obtained in 2014 and 2015 exhibit similar tendencies, which demonstrates that these games retain reproducibility as educational materials.

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Chapter 13
Diversity of Views on Food: A Gaming Simulation to Promote Food-Related Communication

Shin Oyamada, Takuya Wada, and Shinobu Kitani

Abstract Views on food can vary greatly from person to person. This diversity of views on food can inhibit communications among people. On the other hand, "the social functions of food," which promote the formation of relationships with others through food behavior, can have an important impact on society by rebuilding relationships based on care among people. In this chapter, we developed a gaming simulation to facilitate communications between people with different views on food and tested its effectiveness. The result shows that players became aware of the diversity of food views, and that such awareness tended to lead to meaningful consensus building on what the ideal food is.

13.1 Introduction

Views on food can vary greatly from person to person. Some see it as a mere nourishment, others see it as an opportunity to communicate with friends or relatives. Some see it as an act of gastronomic enjoyment, while others see it as an opportunity to feel sense of relationship with nature. This diversity of views on food is in some ways defined by cultural diversity. With globalization and increased opportunities for cross-cultural exchange, there are more opportunities for people with different views on food to communicate with each other. Also, as cultures change during modernization, there are differences of food views even in the same geographic area (Ishige 2009).

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This diversity of food views can make it difficult to communicate about food. For example, for those who believe that they should not eat the flesh of animals, what the food is made of is an important question. From a utilitarian standpoint, ethicist Peter Singer argues that some animals should not be consumed as food because they can feel pain (Singer 2001). However, this idea may be difficult to understand for those who see food as a mere nourishment. Or, food loss problem, which has been more and more discussed in recent years, can also be affected by the diversity of food views. Products that are unsold and thrown away, or remain unused despite being purchased, are not limited to food. For those who do not hold a special view on food, the rationale for the importance of food loss may be unclear.

On the other hand, there are some social movements based on food. The organic farming movement in Japan, for example, had the role of reexamining the relationship between city residents and country farmers (Harayama 2008). Also, in recent years in Japan, there has been a social activity called "*Kodomo Shokudo*" (children's cafeteria), which is not simply a movement to provide cheap meals to children in poor households but also to make a place for local residents to interact with each other (Yuasa 2017). These efforts are not simply a movement to improve our food situation, but rather a movement to reexamine and improve our relationships with others in our society.

These recent movements are examined by Akitsu (2010) using the concept of "food network." Food network is a movement of local production, distribution, and consumption such as farmers' markets, hands-on farming, agricultural production at community gardens, online direct sales, and partnerships between producers and consumers through CSA (Community Supported Agriculture). For example, CSA is a movement in which consumers support agriculture. It is unique in that the consumers pay a fixed amount of money in advance and receives vegetables on a regular basis during that period. In other words, rather than paying for the produce, the consumers pay in advance to support the livelihood of the producer and the continuation of agriculture. Through food network movement, these food-mediated connections can extend beyond relationship between farmers and consumers. In recent Japanese community gardens, farmers provide not only farmland, but also seeds, seedlings, and cultivation techniques, creating opportunities for communication between users. As a result, Akitsu points out that this has led to the creation of new communities within the city.

For these food network efforts to spread through society, people with different views on food need to communicate with each other. However, there has been no research that focuses on how people with different food views can communicate effectively. Therefore, no gaming has also been developed to promote such communications. There is a research on food-themed gaming (Mangnus et al. 2019), which aims to promote the players to design an ideal food system in local area. However, there is a question as to whether it is possible for players to draw ideal food visions in the first place if they have rather different views on food.

The purpose of this chapter is to develop and implement a gaming simulation for promoting communication between people with different food views and to examine its effectiveness.

13.2 Reexamining Society through Food

13.2.1 The Social Functions of Food

For humans, food is more than just nutrition. Ishige (2009) points out that cooking and "*kyoshoku* (eating together with someone)" are characteristics of human food behavior. After killing an animal, we do not eat it directly, but cut it up, bake it, boil it, or steam it (cooking). We usually do not eat the meal alone. Although things have changed in recent years, humans traditionally eat meals with family members or other people (*kyoshoku*). Ishige argues that human food behavior is characterized by the intersection of cooking culture and *kyoshoku* culture. Especially, *kyoshoku* reflects human relationships in a society. For example, before World War 2, the Japanese food behavior reflected the male-centric social relationship, with a father and the eldest son having more side dishes than the other family members. However, as democratization progressed after the war, these inequalities of meals within families disappeared.

Relationships with other creatures can also arise through food behavior. Hasebe (2007) describes relationships between human and food as a "life-giving" relationship. His philosophical discussion shows that I, as a body, eat corpses of animals or plants, and this bodily interaction is the basis of human existence. He criticizes the excessive pursuit of efficiency in food production promoted by science and technology because it is a perversion that does not consider the "life-giving" relationship with life.

As mentioned above, food reflects our relationships with others. The word "others" here means both humans and non-humans. In other words, "others" here means non-self. Food not only reflects our relationships with others, but conversely, can maintain and shape our relationships with others. As mentioned above, the organic farming movement in Japan or the "*Kodomo syokudou*" are attempts to rebuild relationships with others in society. In this study, the function of food to maintain and form relationships with others is referred to as "the social functions of food." By "social" here, we do not mean social institutions such as politics or economies. Rather, the "social" here means the way we relate to others through food or food behavior. Imamura (2016) examines the etymology of the word "social" and argues that "social" relates to fundamental human behavior that precedes the establishment of society and means treating others as fellow human beings (i.e., hospitality). Following his discussion, we use "the social functions of food" as a concept which relates to ethics or hospitality among people. Therefore, it is necessary to consider the food ethics to clarify the significance of the social functions of food.

13.2.2 A Food Ethics Based on Liberalism

An ethicist Thompson (2015) takes the folkloric proverb “You are what you eat” and argues that, from a liberalist perspective, this idea is not appropriate for food ethics.

For example, eating certain food may have any traditional value to an ethnic group. Eating such food is a way to strengthen the group members’ identity. In this sense, it can be said that “You are what you eat.” There is nothing wrong with a person who belongs to this ethnic group seeking such value. However, demanding others to eat such food violates their rights. Also, judging that a person’s fatness is due to his or her lack of temperance is based on “You are what you eat” idea, but it is also unethical to associate eating with a person’s character.

The basis of these judgments is liberalism. Thompson refers to J. S. Mill’s “the harm principle,” which is an ethical principle that if a person does not harm others, it is up to that person to decide how to live their life. According to Thompson, food ethics should be an issue only when food choices cause harm to others through the production and distribution process of food. For example, food loss can be problematic because it has a negative impact on the environment. However, you should not basically interfere with other’s food choices if such choices do not harm others. Based on this idea, Thompson argues that “You are *not* what you eat.”

It is likely that Thompson would not make a positive recommendation for the concept of “social functions of food.” Thompson considers Albert Borgmann’s idea of “focal practice.” For example, producing, preparing, and consuming food with other people are a focal practice because it generates communal projects and shared meaning among those people. In modern society, as people’s lives have become more convenient and comfortable, they do not work together as much as they used to, and they do not give meaning to their lives together. Through focal practices, we can regain the meaning of our lives that has been lost in the convenience of modern life. In other words, the focal practices of eating can promote the reconstruction of people’s identities. However, Thompson does not encourage Borgmann’s idea and just states that these focal practices are not problematic if they do not harm the rights of others. He asks himself whether we can demand others to make the food choices that encourage them to construct their identities. He writes “No, you are *not* what you eat.”

Interestingly, a recent book on food ethics published in Japan (Akitsu et al. 2018) does not refer to this “You are *not* what you eat” idea at all, despite Thompson’s food ethics book being cited several times. Instead, there are even passages that point out the importance of link between food choices and identity, referring to the phrase “You are what you eat” and asserting the need to know the history of the food we eat (i.e., where and by whom it has been produced). This argument seems to be the opposite of Thompson’s idea. But this should not be taken as a mere misunderstanding of Thompson’s argument. The discrepancy between the food ethics of Thompson and Japanese authors seems to suggest the possibility of diverse food ethics.

13.2.3 Ethics of Care

From liberalism perspective, Thompson is right. But on the other hand, Thompson's argument does not seem to consider the unique position of food in human society. In other words, Thompson's argument could be valid even if the subject is not food. For example, it is true that food loss can have a negative impact on the environment. But this is also true for other goods. Clothing, home appliances, building materials can have a negative impact on the environment if they are discarded in vain. Thompson also discusses the animal welfare of domestic animals, but animal welfare can be an issue in pet ownership, zoo, and animal testing as well.

Liberalism on which Thompson relies presupposes a symmetrical relationship between individuals. In other words, it assumes a modern view of human relationships in which individuals have equal rights to each other and make promises and contracts through dialogue and negotiation. However, in the discussion of the "ethics of care" in moral philosophy, this assumption of symmetrical relationships between individuals has been questioned (Shinagawa 2007; Takahashi 2008). For example, when we have relationships with vulnerable people such as the disabled, the elderly, children, it can be difficult to have a rational discussion with them. Rather, it is important to have an affective relationship with them, sympathizing with them, and sensing their pain and needs and caring for them. These asymmetrical relationships do not necessarily imply a one-sided relationship. For example, a person caring for an aging parent may have been cared for by them at an early age. The same argument holds true when dealing with animals. A person who cares for an animal may find a motivation in life through caring for the animal, even if he or she does not get any direct return from it (Hosaka 2013). Morioka (1994) proposes a model of human relations called "*interdependence*." This is different from the relationships of "independence" formed between independent individuals, or the relationships of "dependence" formed by people without an independent spirit. Morioka's view is that *interdependence* relationships precede independent individuals, which means that an individual is raised and established in the *interdependence* relationships.

To capture the unique position of food in our human society, it is important to introduce an ethic of care based on *interdependence* relationships. For example, as children, people need to be fed by adults to survive. They are not simply handed food by them. The adults must consider the children's needs: what kind of food they can eat, what would they like, what kind of nutrition would they need. In other words, adults care for their children through food. And the food is the corpse of some living thing. When agriculture and fisheries were the main industries, people had to kill living things by themselves to get food. In the past, in Japan, there was a culture of building graves for whales in villages where whale fishing was done (Okada 2013). This is another form of care in terms of caring for the suffering of whales. This way of caring for others through food is transmitted through cultural inheritance. Care is not something that can be made into a manual. It is learned and passed on through the practice of care in the context of relationships with others. In other words, the process of care succession itself is established through a chain of care practices.

Thus, we can view food ethics from the perspective of care. We are not claiming that care-based food ethics is better than the one based on liberalism. What we are arguing here is that food ethics can be constructed from the perspective of care and also from the perspective of liberalism. In other words, food ethics is pluralistic.

13.2.4 Ethics of Care and Ethics of Justice

The ethics of care has emerged as the antithesis to existing ethical theories. Gilligan (1993) categorized existing ethical theories as "ethics of justice" and distinguished it from ethics of care. Ethics of justice emphasizes rights and fairness, and judges things to be good or bad from some abstract principles. Liberalism, with its abstract principle of "the harm principle," can be classified as ethics of justice. Ethics of care, on the other hand, rather emphasizes empathy, each situation and context, and relationships with others. Ethics of justice and ethics of care are opposed to each other. However, Gilligan points out that the two ethics can complement each other.

Even if there are no problems from the viewpoint of ethics of justice, there may be some problems from care perspective. For example, the existence of slavery was once not seen problematic at all in society. Even Aristotle, who was a major influence on modern ethics, defended the existence of slavery. However, the content of social justice may be renewed when those who are aware of such injustice express their opposition to the existing system (Shinagawa 2007). Ethics of care can notice the overlooked injustice because it judges each concrete situation and context without being confined to existing social justice. On the other hand, ethics of care alone is limited in its impact on society. When ethics of care affects ethics of justice and improves institutions such as laws or social norms, it can have a strong impact on society.

Now back to food ethics discussion. Some of the attempts to change society through food seem to be unjustifiable from a liberalist perspective. The organic farming movement, for example, is not just about achieving a healthy diet or rebuilding new relationships between city residents and local farmers, but also about questioning the way we relate to life. Rachel Carson's *Silent Spring*, which influenced the organic farming movement, is also an interrogation of our relationship to life. In Carson's later small book, *Sense of Wonder,* she depicts her own experience of wonder of life with a four-year-old boy (her niece's son). From a liberalist perspective, we cannot demand others to think it is important to have a relationship with life. But for those who seek to care for life, a food ethics which does not care for life would not be acceptable. Of course, it is impossible to force others to "care for life." However, by reexamining the relationship with others through food from the perspective of care, people's perceptions in society may gradually change. And if it eventually becomes a common norm in society or is enacted into law, it can be said that ethics of care have renewed ethics of justice. In the book by Akitsu et al. (2018) mentioned above, the importance of moving from dialogue about food to the establishment of food-related institutions is pointed out, which is consistent with the position of this chapter, which looks forward to the renewal of existing justice from care through food.

For these different food ethics to complement each other, there must be effective communication between the two sides. This is the reason why we focus on communication between people with different views on food.

13.3 Gaming Design

13.3.1 Gaming Concept

This study focuses on communication between people who have different views on food. To reflect the interests in our gaming, the following two factors are necessary:

1. Players come to realize the diversity of views on food.
2. Players build consensus on food ideals.

Therefore, this gaming is structured in two phases in response to these factors: Phase 1 encourages players to become aware of the diversity of food perspectives, and in Phase 2 they build consensus on food ideals.

Before explaining the content of each Phase, this two-stage gaming structure should be explained in detail. In this gaming, the social functions of food should be more emphasized than other views on food because it is difficult to argue logically the importance of the social functions of food in discussion. As already mentioned, the social functions of food are based on care. However, care is based on emotional attitudes or behavior, such as empathy or awareness of others' needs, and it is difficult to argue logically for its importance. In premodern societies, the social functions of food were naturally maintained in people's practices. For example, if Japanese fishermen killed a whale, they used to build its grave. Or, it was natural for family members to eat together at the table. However, in the process of modernization, as food behavior became more convenient and more economically rational, it became difficult to support the importance of these social functions. For example, even if it is important for family members to eat together, it is difficult to do so in a situation where parents are working outside and their children are also going to cram schools. Or, even if people think it is important to know where their food is come from, they might be too busy to do so. To discuss food ideals ignoring the constraints of reality for the moment, an RPG-style gaming is an effective way. Thus, the Phase 1 is to make it possible for players to discuss diverse views on food in a virtual situation. The RPG scenarios in Phase 1 set up dilemma situations in which players can seriously consider which option should be the priority, the social functions of food or the economic rationality of food. In the next Phase 2, players are asked to discuss the realization of the ideal food in a slightly more realistic situation, considering obstacles and breakthroughs to ensure the feasibility of that ideal.

13.3.2 Phase 1: RPG-style Debate about Diverse Food Views

In Phase 1, players engage in an RPG-style debate with three agenda. They are divided into two teams which have positions corresponding to different views on food, and they debate from their assigned positions. The two positions set for debate agenda are characterized as "protecting the social functions of food" or "seeking economic rationality." These two positions are set up because many of the social functions of food are easily lost in the pursuit of economic rationality. These are competing positions and it is difficult to determine objectively which position is correct, so this is a dilemma situation. The aim of presenting the dilemma is to make players realize that there is no single correct answer to look at food. Therefore, even after they come to conclusion, some degree of dissatisfaction may remain. We hope that this dissatisfaction will motivate them to discuss more active in Phase 2 (consensus building on a food ideal). Presenting the dilemma to the players in this way is something we have done in Oyamada and Kitani (2019). The purpose of this gaming was to allow players to experience the dilemma regarding wildlife management problems and then ask them to make ideas to solve the dilemma. The gaming we constructed this time also incorporates dilemmas in Phase 1 and this is to encourage players' creativity in Phase 2.

The debate takes place in an RPG style, and its specific setting is as follows: the setting is a virtual near future, where people live in the communities which consist of members with similar ideologies and lifestyles (referred to as "Villages" in the RPG). Players play the role of an investigator who investigates the lives of the inhabitants of each village. In a village a food-related incident occurs, and the players, as members of the villagers, must take part in the discussion to address the incident. The two positions presented shown to players are those that emphasize the social functions of food or economic rationality. Players are assigned to one of the positions and debate to draw a conclusion as a village.

Each group has about 10 members, two of whom are facilitators. The remaining members are divided into two teams and each team will be assigned a position ("protecting the social functions of food" or "seeking economic rationality)." There are three "Villages," and the players swap positions each time they move to a different village. For example, in the first village the player whose position was to "emphasize the social functions of food" will change his or her position to "economic rationality" in the next village and in the last village he/she will take the position of "emphasize the social functions of food" again. The reason for taking this step is to encourage them to realize the diversity of views on food. The job of the facilitator is to read out the RPG scenario and control the players' discussions and judge the persuasiveness of each team's arguments to determine the group's conclusions. Table 13.1 below summarizes the scenarios and positions for each village.

Table 13.1 Scenarios and positions for each village

Village	Setting	Incidents	Positions (emphasis on economic rationality)	Positions (emphasis on the social functions of food)
X	An agrarian village that achieves 100% self-sufficiency within the village	They are encouraged by a merchant to install modern machinery and technology, modernizing their agriculture.	Install modern technology and machinery to sell food products outside the region.	Not sell food and will continue to live their lives as before.
Y	There are factory workers and farmers living together in the village and the traditional food passed down from generation to generation. They are proud of the food tradition.	There have been proposals to stop cooking and eating traditional food because they are too much of a burden.	No more cooking traditional food and no more festival.	Continue the tradition even if they need change their traditional ways somehow.
Z	An urban village where many villagers routinely eat purchased food alone and all food is transported by air.	After the experience of food shortages caused by a major typhoon, they discuss how to prepare for similar disasters in the future.	Make it mandatory for each resident to hold a week's worth of reserves.	Create a system that allows families and residents within the village to work together in the event of a disaster.

13.3.3 Phase 2: Consensus Building on a Food Ideal

In Phase 2, the debate teams are dissolved and all the players in the group work together. Each group is to create a single sentence to describe an "ideal food scene." The steps are as follows:

First, each group member will create a maximum of three sentences on the theme of "ideal food scene." The sentences are to be written for each of four components: "Where," "With whom," "How," and "What." The sentences created by each member are shared in the group, and each component item with similar contents is collected as a category and given a category name. The group then selects the important category for each component and combines the category names to complete a single sentence.

To create realistic sentences, group members are made to discuss what barriers exist to putting the sentences into practice in the real world and what possible breakthroughs could be made to solve those barriers. Ideas on breakthroughs are acceptable only when they have the potential to be realized soon, even if they are not feasible right now.

For the players who noticed the diversity of food views in Phase 1, it might be difficult to decide what is "ideal food scene." It is because even if awareness of different food views promotes communication about food within group, the problem of how to reconcile the diverse food views remains. However, as Weston (2010) says, a dilemma can be resolved by changing your perspective and increasing your choices. What if a new technology appears? What if a new social system is realized? What if a solution that no one else is aware of is found? In this way, promoting people's creativity in consensus building process, a dilemma can be resolved. Based on this concept, Phase 2 encourages players to creatively reconcile diverse food views by thinking about barriers and breakthroughs in realizing food ideals.

13.4 The Evaluation Framework for This Gaming

13.4.1 A Framework for Evaluating Awareness of the Diversity of Food Views

To evaluate the extent to which players notice the diversity of food views in Phase 1, we use the following two indicators.

1. The number of concepts about food that players come up with after the debate.
2. The extent to which players are unconvinced about the debate.

1 is an indicator of how diverse the players' awareness of views on food has become. However, this indicator only evaluates the degree of awareness of the way people view food. In other words, we do not know players' true views on food. Data on this indicator is obtained through a questionnaire administered before and after the debate: before the debate, players are given a 5-minute time limit to describe what they can come up with the role of food. Then they do the same after the debate is over. We compare the concepts that came before and after the debate with each player, and only count the new concepts that come up after the debate as increase. It should be noted that the players are instructed that "food" here is "everything to do with eating."

2 is an indicator of awareness of the differences between one's own view and others' views. The phase 1 debates represent the dilemmas related to the social functions of food. Because dilemmas are difficult to resolve completely, players could have some degree of dissatisfaction with the debate. The degree to which they are unconvinced of the debate could mean that they are aware of the discrepancy between their own view on food and others' views on food. In other words, they do not think their view is the only right one, or that someone else's view is the right one. We presuppose these ambiguous attitudes are reflected in the extent to which players are unconvinced of the debate. Data on this indicator is obtained through a post-debate questionnaire. The variables obtained from this questionnaire are as follows (Table 13.2).

Table 13.2 Variables related to RPG debate

Variable names	Meaning of the variables
Convinced reasonably	The degree to which the players are reasonably convinced with the debate in each village. Ordered variables from 1 to 5. The higher the value, the more convincing the debate is.
Convinced emotionally	The degree to which the players are emotionally convinced with the debate in each village. Ordered variables from 1 to 5. The higher the value, the more convincing the debate is.
Team position	Positions assigned to teams in a village debate, where 0 is the "economic rationality position" and 1 indicates the "social function position."
Group conclusion	Conclusions reached by the group, where 0 is the "economic rationality position" and 1 indicates the "social function position."

13.4.2 A Framework for Assessing Consensus Building on Food

The quality of consensus building is assessed by analyzing the sentence of ideal food scenes, and descriptions about barriers and breakthroughs in realizing the ideals. We use the following three evaluation indicators to evaluate the quality of consensus building on a four-point scale.

1. *Comprehensiveness*: Whether the sentence include diverse views on food.
2. *Consistency*: Whether the players take into account the various barriers in the real world.
3. *Creativity*: Whether the players have come up with breakthrough ideas that creatively resolve the contradictions in diverse views on food.

Consistency indicator is made to check whether the sentences deviate from the intentions of the group work or the real-world situation. It is rather comprehensiveness and creativity indicators that we focus on in this study. A high degree of comprehensiveness means that the diversity of views on food is taken into account in the phase 2 discussion and a high level of creativity is considered to mean that there is sufficient discussion on how to reflect such diverse views on food in the real world. Because the purpose of this study is to develop a gaming in which communication takes place with respect to diverse views on food, high scores on these indicators can be interpreted that a high level of consensus has been reached regarding food ideals. The judging criteria for these indicators are shown in Table 13.3.

13.4.3 The Analysis Model of This Gaming

Figures 13.1 and 13.2 show the analytical models composed of the variables obtained from the Phase 1. Figure 13.1 shows a model in which the objective

Table 13.3 Evaluation indicators for phase 2 discussion

Evaluation indicators	Judging criteria
Comprehensiveness	If the sentence contains any of the following concepts, award 1 point for each one that applies. Maximum 3 points: "relationship with family members or friends," "relationship with community or tradition," "relationship with life or nature."
Consistency	If the descriptions about barriers or breakthrough ideas for the ideal food scene contain statements about any of the following items, award 1 point for each one that applies. Maximum 3 points: "does the sentence contain references to all barriers?" "can the breakthroughs listed solve all of the barriers?" "is the breakthrough idea realistic?" The breakthrough idea that requires not only technology or social institutions, but also people's ethics or global-level social change is judged as unrealistic. "Unrealistic" here means that it is difficult to achieve without rather drastic social reform.
Creativity	If the "breakthrough ideas" include one creative idea, 1 point will be awarded. Maximum 3 points. The criterion for determining whether creative thinking is included in the breakthrough ideas is whether there is a perspective change or not. For example, the idea of "subsidizing money" in response to the "lack of funding" barrier does not include perspective changes.

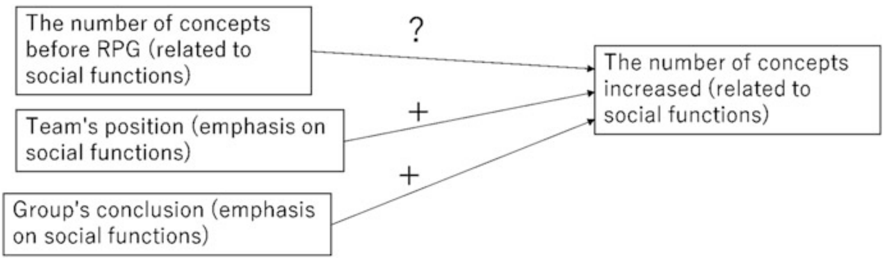

Fig. 13.1 Analytical model related to RPGs (objective variable = number of concepts increased)

Fig. 13.2 Analytical model related to RPG (objective variable = degree of conviction with the argument)

variable is "the number of concepts increased." "The number of concepts before RPG" has an unknown coefficient sign because it could be positive or negative. For those who cannot come up with food-related concepts related to relationships with others, they can learn about the social functions of food through this RPG, so the concept may increase. But on the other hand, if they originally knew the social functions of food, they could be inspired by the RPG to come up with more concepts.

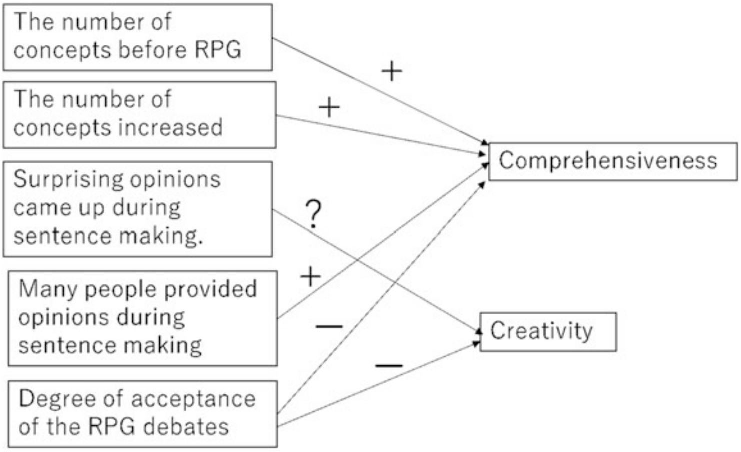

Fig. 13.3 An analytical model for sentence making

As for the team's position (emphasis on the social functions of food) and the group's conclusions (emphasis on the social functions of food), both have positive coefficient signs. This is because if the players belong to the team or group whose position is emphasizing the social functions of food, they might be influenced by the opinions of other members of the team or the group, so it would be easier for them to accept the food-related concepts which contain the social functions of food. Figure 13.2 shows a model in which the objective variable is the degree of acceptance of the debate. In this gaming, it is assumed that players encounter dilemmas that shakes their views on food and promotes their awareness of the diversity of views on food. We focus on the degree of acceptance of the debate because the degree to which they are not convinced of the debate could reflect players' serious commitment to the dilemmas. If the team's position and the group's conclusions are consistent (i.e., the team's opinion smoothly comes to the group's conclusion), players could have drawn conclusions without taking the dilemmas seriously. Therefore, if the team's position and the group's conclusions are in consistent, the degree of conviction for the argument should be high.

Figure 13.3 shows the analysis model composed of variables obtained in phase 2. Here, since the objective variable is a variable in a group unit, the analysis is performed with group as a unit of observation (1 group data as 1 sample data). If the group averages of the number of concepts prior RPG and concepts increased after RPG are high, sentences are considered to become more comprehensive because the discussion in sentence making could include various views on food. The group average of "many people provided opinions" is expected to have the same effect, so the coefficient is positive. The group average of "surprising opinions came up" could be positive or negative. If surprising opinions are used in a sentence, creativity may increase, and the coefficient may be positive. However, if the opinions are too surprising for the members, the creativity will be reduced as the discussion is hampered, and the coefficient will be negative. The group average for conviction to the RPG debate has negative coefficients for both comprehensiveness and creativity. This means that the less convinced a player is of the RPG debate, the more serious the player committed to the RPG dilemma, and they could be motivated to try to build a meaningful consensus on ideal food scenes in sentence making.

13.5 Implementing the Gaming

13.5.1 Summary of Implementation

The experiment to test the effectiveness of this gaming was conducted from December 2019 to January 2020. The schedule is shown in Table 13.4. The participants were about 300 students in the Tohoku University, taking the course for undergraduate students "Science of Decision-Making"; however, not all students participated in the experiment because some students were absent. A pre-survey was conducted to divide participants into groups. The questionnaire items are shown in Table 13.5 and ask about attitudes toward life, community, and family relationships, each of which is a four-level ordinal variable. If there is little variation in group's attitudes toward relationships with others, it is difficult to have an active discussion in this gaming session. Therefore, in grouping, we tried to reduce the bias of the members as much as possible. A cluster analysis was conducted on the results of the questionnaire and three clusters were created (see Table 13.6). The groups were

Table 13.4 Schedule for this gaming

Task	Date	Number of participants
Pre-survey	Dec. 9	286 (male = 217, female = 69)
• Questionnaire before RPG • Implementation of RPG • Questionnaire after RPG	Dec. 23	314 (male = 240, female = 74)
Sentence making	Dec. 25	272 (male = 202, female = 70)
Post-survey	Jan. 25	250 (male = 190, female = 60)

Table 13.5 Pre-survey questions

Question	Meaning
Do you like to grow plants and animals and play in the mountains and rivers?	The more positive the response, the more interested they are in the relationship with life.
Would you want to work in your hometown in the future (the place where you lived the longest)?	The more positive the response, the more interested they are in their relationship with others in the community.
Do you enjoy the time you spend with your family and relatives?	The more positive the response, the more interested they are in the relationship with their families.
Would you like to facilitate group work?	Assign a facilitator to the person who answers this question in the affirmative.

Table 13.6 Contents of each cluster

Cluster	Number of people	Interest in life	Interest in locality	Interest in family
1	94	2.49	1.21	3.00
2	105	1.87	0.58	1.65
3	87	1.95	2.53	2.29

Table 13.7 Examples of proposed sentences, barriers, and breakthrough ideas

No.	Sentences	Barriers	Breakthrough ideas
1	Eat meals cooked in cooperation with your relatives outdoors.	Difficult to cook numerous dishes, get together with relatives daily, and secure a place outdoors.	Institutionalize a day for people to get together for a meal. Accelerate the return home time. The government allocates outdoor locations to the public.
2	Eat local cuisine made with local ingredients with your loved ones in your daily life.	Some people do not have loved ones. It is difficult to realize “local production for local consumption” and “local cuisine” in our daily lives.	Create a new community by bringing lonely people together on a matching app. Promote local cuisine by selling local dishes made with locally grown ingredients at convenience stores.
3	Eat family’s favorite food with family at home.	For some people, there may be a physical or psychological distance between family members. Some people have trouble in cooking.	Coordinate meal time with family members. Improve family rapport at the mealtime. Accept the robot as family and have the robot cook for you.

made to include at least two people who wanted to be facilitators and at least two men and two women as players, while ensuring that the members’ clusters were not biased. Each group consisted of about 10 people, for a total of 33 groups. RPG and sentence making were done by dividing these groups into three classrooms. Moderators were assigned to each classroom to explain the work to the whole class. Both the RPG and sentence making were carried out in 90 minutes of class time. The examples of sentences, barriers, and breakthrough ideas in phase 2 (sentence making) are shown in Table 13.7. The January 25 post-survey was a questionnaire survey on sentence making (it asks the equivalent of the variables included in the analytical model, “Surprising opinions came up during the creation of sentences” and “Many people provided opinions during sentence making).” Because it has been a month since the sentence making, the options include “I hardly remember.”

Table 13.8 Categories of food-related concepts

Concepts	Examples
Relationship with family	a gathering, family, close friends, home, home-cooked meals, etc.
Relationship with locality	local cuisine, traditional cuisine, local production for local consumption, hometown, local, etc.
Relationship with life	appreciation for life, nature's bounty, the food chain, the seasons, etc.
Interest in personal health	Nourishment, nutrients, growth, and staying in shape, etc.

Table 13.9 Variables about concepts related to food

Variable names	Ave.	S.D.
The number of concepts before RPG (related to life)	0.13	0.405
The number of concepts before RPG (related to locality)	0.26	0.570
The number of concepts before RPG (related to family)	0.96	0.770
The number of concepts before RPG (related to health)	2.10	1.293
The number of concepts increased (related to life)	0.16	0.383
The number of concepts increased (related to locality)	0.58	0.725
The number of concepts increased (related to family)	0.51	0.619
The number of concepts increased (related to health)	0.25	0.478

$N = 243$. The RPG participants, the facilitators are excluded

Table 13.10 Variables associated with group's conclusion in RPG for each village

Variable names	Proportion of those who apply (%)
X/group's conclusion	Emphasize economic rationality = 36.2 Emphasize social functions = 63.4
Y/group's conclusion	Emphasize economic rationality = 52.3 Emphasize social functions = 47.3
Z/group's conclusion	Emphasize economic rationality = 51.4 Emphasize social functions = 45.3

$N = 243$. The RPG participants, the facilitators are excluded

13.5.2 Results

Table 13.8 categorizes the concepts that players came up with about food in the pre- and post-RPG questionnaire. We categorized the concepts into four categories: family, locality, life, and personal health. Table 13.9 shows the average and standard deviation of the number of concepts related to food. Before the RPG, the number of concepts related to health was the highest, but the concepts related to locality and family have increased throughout the RPG, while the number of concepts related to health did not increase much. This result corresponds to the lack of emphasis on the health aspects of food in the RPG scenario. Table 13.10 shows the percentage of participants whose groups' conclusion is economic rationality position or social

Table 13.11 Variables related to sentence making ($N = 33$)

Variable name	Ave.	S.D.
Comprehensiveness	1.21	0.485
Consistency	1.64	0.603
Creativity	0.52	0.566
Surprising opinions came up (group average)	3.15	0.411
Many people provided opinions (group average)	3.36	0.324
Not enough time to discuss (group average)	2.21	0.399

functions of position for each village. Basically, the value is around 50% and this result is consistent with the RPG agenda being a dilemma. However, for "Village 1," there are slightly more conclusions in favor of "social function." This might because in the scenario of "Village X" seeking economic rationality is less urgent than in those of "Village Y" and "Village Z." Table 13.11 shows the variables involved in sentence making, and the values are listed on a group basis. The largest is consistency indicator, with creativity being the smallest. All the three variables on players' impressions of the sentence making group work are listed as averages within the group, but there is no distinctive trend.

Table 13.12 shows analytical model related to RPGs (objective variable = number of concepts increased) validated by multiple regression analysis. The two models are statistically significant. Overall, the players with social-function-related positions or conclusions in RPG tend to increase social-function-related concepts (i.e., the concepts about life or locality). For the number of concepts before RPG, some coefficients are significant, but there is no clear pattern. Although the model in which the objective variable is "concepts related to health (after RPG)" is not significant, this is a natural consequence of the fact that this RPG is not intended to promote awareness of the health aspects of food. On the other hand, the model in which the objective variable is "concepts related to family (after RPG)" is not significant. The reason for this could be the fact that there were little explicit descriptions about relationship with the family through food in the three "Villages" scenarios set up in this RPG. Table 13.13 shows the results of the validation of the analytical model (objective variable = degree of satisfaction with the debate). Since there is only one explanatory variable, the partial correlation coefficients analysis is implemented rather than regression analysis (the control variables are sex and number of concepts before the RPG). Overall, those who have coherence in team's position and group's conclusion about the debate are more likely to be convinced of the debate both reasonably and emotionally. Finally, Table 13.14 shows the result of the validation of the analytical model for sentence making. Only samples with consistency indicator of more than 0 were used for validation ($N = 31$). Since no significant model was obtained when the objective variable is comprehensiveness, only the model with creativity as the objective variable is shown. Creativity, because the values are concentrated at 0 and 1, logistic regression analysis was performed by converting 1, 2, and 3 to 1 to create a dummy variable. The lower the group average of conviction with the RPG discussion, the more creative the sentences tended to

Table 13.12 Validation of analytical models related to RPGs (multiple regression analysis)

Explanatory variable	Concepts related to life (after RPG)	Concepts related to locality (after RPG)	Concepts related to family (after RPG)	Concepts related to health (after RPG)
Sex	0.002	−0.022	0.121*	0.078
Concepts related to life (before RPG)	−0.13*	−0.09	−0.083	−0.056
Concepts related to locality (before RPG)	−0.061	-−0.005	0.096	−0.025
Concepts related to family (before RPG)	0.051	0.19***	−0.112*	0.03
Concepts related to health (before RPG)	0.074	0.032	−0.019	0.007
X/team's position	0.064	0.341***	0.197	0.101
X/group's conclusion	0.21**	0.183***	−0.002	−0.008
Y/team's position	0.104	0.518***	0.173	−0.052
Y/group's conclusion	0.086	0.08	0.002	−0.029
Z/team's position	0.054	0.104	−0.041	−0.207
Z/group's conclusion	0.02	−0.011	0.079	−0.019
Coefficient of determination	0.036*	0.096***	0.021	−0.027

$*p < 0.1$, $** p < 0.05$, $*** p < 0.01$. with the objective variable as the number of concepts increased. The variables related to "position" or "conclusion" are dummy variables (social function = 1, economic rationality = 0)

be. In addition, the more group members provided opinions and the less surprising opinions came up, the more creative the sentences tend to be. A possible reason why the model with comprehensiveness as the objective variable did not reach significance may be that the distribution of comprehensiveness was somewhat skewed (about 71.9% of all groups used in the analysis had a value of 1).

13.6 Conclusion

In this chapter we assumed that the social functions of food can reshape relationships of care between people and can have an important impact on society, have developed a gaming simulation that encourages communication between people with different views on food and tested its effectiveness. The gaming consists of an RPG phase to sway participants' views on food (phase 1) and a group work phase in which

Table 13.13 Validation of analytical models related to RPGs (partial correlation coefficient)

	X/ convinced reasonably	X/ convinced emotionally	Y/ convinced reasonably	Y/ convinced emotionally	Z/ convinced reasonably	Z/ convinced emotionally
X/coherence of team's position and group's conclusion	0.173***	0.17***	0.025	−0.021	−0.129	−0.059
Y/coherence of team's position and group's conclusion	0.055	0.057	0.104	0.145**	0.037	0.029
Z/coherence of team's position and group's conclusion	0.031	−0.088	0.114	0.009	0.112*	0.111*

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Partial correlation coefficient of "coherence of position" and "the degree of conviction about RPG discussions." The variables related to coherence are dummy variables (coherent = 1, not coherent = 0)

Table 13.14 Validation of the analytical model for sentence making (logistic regression)

Explanatory variables	Creativity (as objective variable)
Surprising opinions came up (group average)	−4.74**
Many people provided opinions (group average)	3.65*
Not enough time to discuss (group average)	2.64
X/convinced reasonably	−9.84**
X/convinced emotionally	2.99
Y/convinced reasonably	2.88
Y/convinced emotionally	−4.79*
Z/convinced reasonably	4.02
Z/convinced emotionally	0.56
likelihood ratio	20.65**

* $p < 0.1$, ** $p < 0.05$. Creativity was converted to a dummy variable with 1, 2, and 3 as 1 because of the small sample size of 2 and 3. $N = 31$. Excludes samples with consistency = 0)

participants create sentences that represent their ideal food scenes (phase 2). The results of the experiment, generally in line with the analytical model, showed that awareness of the diversity of food views was generated through the gaming and such awareness leads to meaningful consensus building on food ideals. However, it is not so much clear how the RPG scenarios encourage awareness of each view on food. A more accurate understanding of the relationship between scenarios and views on food is a challenge for the future research. We also analyzed the consensus on food ideals, and when the objective variable is comprehensiveness of the sentence of ideal food scenes, we found that the model did not reach significance. This may be due to a bias in the distribution of the variable. To eliminate this bias, we need to increase the sample size or review the criteria for judging sentences.

Finally, we generalize the results of this study to clarify the findings suggested by this gaming. One of the key findings from the gaming experiment is the significance of incorporating dilemmas on diverse food views into food-related discussion. Discussions between people with different views on food can lead to the new ideas that creatively fill in the gaps between their views, rather than confrontation between the two sides. A virtual situation in the gaming would provide a safer environment in which people can creatively discuss food ideals while avoiding cultural confrontations. The application of the gaming framework in this study will provide an opportunity for people with different views on food to discuss the possibilities of how people interact in society in a meaningful way. In particular, the findings of this study could be used in the field of education. In Japan, based on the Basic Act on Food Education (Shokuiku Kihon-hou) enacted in 2005, educational activities aimed at cultivating knowledge about food and the ability to make food choices have been conducted in schools. However, the law is criticized for uncritically prescribing and glorifying "traditional Japanese food" and imposing a one-sided view on food by the government (Ikegami 2008). If this gaming can be used in these educational settings, it may help to make food-related education more democratic.

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Chapter 14
Project PAL: Development of Simulation Games for Solving Social Problems of Indigenous People

Nanako Iwasa

Abstract This study aimed to develop "Project PAL," a simulation game for solving the social problems of indigenous people, and to discuss its function and potential for social designs for the future. Many indigenous people face adversities and struggle with the hidden duality of overlapping mainstream and indigenous societies. This duality engenders difficulties when envisioning their future from both individual and indigenous perspectives. To untangle this duality, this chapter presents the development and trials of Project PAL based on the SECI model and used collaborative learning methods. The game employs case studies of indigenous people and participants role-playing as social entrepreneurs. The goal is to create solutions by developing effective strategies for social designs for the future. This chapter introduces one version of the game: "Project PAL: Hawaii," about Native Hawaiians in Oahu, Hawaii. The game in practice revealed two effects on learning: "dual function" and "multilogue" through Simulation and Gaming.

14.1 Introduction

Current societies have complex connections and virtual expansions across borders in people's minds through the Internet. People can easily share their social problems not only just globally, but also simultaneously. However, the social problems of indigenous people involve contradictions that arise from their "social contexts" in mainstream societies, which has dual layers of the meaning of land and history. The land from their ancestors has become a place/region in the mainstream social systems, and their indigenous history has replaced with a mainstream one. These two tangled issues still co-exist in mainstream societies, but in most of the cases, the indigenous sides are invisible. Therefore, many indigenous people have difficulties to share and solve their social problems with others.

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This study aimed to develop a new approach to problem solving by trying to address the social problems of indigenous people in cooperation with others. The learning process leads to solutions by imagining future visions and designing social plans that respect the knowledge of indigenous people. To achieve these goals, the author developed a simulation game called Project PAL using the SECI model (Socialization, Externalization, Internalization, Combination) developed by Nonaka and Takeuchi (1995), that deals with knowledge conversion, and incorporates collaborative learning methods (Berkley 2010; Berkley et al. 2014). This "game learning" attempts to untangle the duality of social problems by visualizing the knowledge of indigenous people, and creating new knowledge through the process of knowledge conversion using SECI. This study also applies the game frame to Native Hawaiians in Hawaii to develop "Project PAL: Hawaii," and then conducts game trials. Based on the results, the author examines the functions of the PAL game and its future potential.

Section 14.1 of the chapter presents social and psychological duality, two aspects intrinsic to the social problems of indigenous people. It is important to understand these dualities as background of this study. Section 14.2 describes development of a new learning model and its activity to try to solve the social problems. It is based on the SECI model and incorporates collaborative learning methods. Section 14.3 shows the development of a frame game of Project PAL, an educational simulation game using the learning model. Section 14.4 provides the implementation of PAL: Hawaii, a Native Hawaiian version of the PAL game. Section 14.5 examines the functions of the game and its potential for social entrepreneurship education from the trials of the game and their results. Section 14.6 concludes the chapter by outlining future potentials of the PAL games.

14.1.1 Background

In 2007, "The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)" (UN 2007) recognized the rights of indigenous peoples all over the world. It has provided international guidance on benefits of human rights, and improved living, customs, culture, traditions, and education. Indigenous people are members of the indigenous communities, but they are also citizens of the country. This means that indigenous people have been included in mainstream society, and they have been influenced by complex historical, political, and social impacts resulting from past colonization and assimilation policies. Therefore, the society that indigenous people have existed has a duality in which two societies, one indigenous and one mainstream. In addition, the social problems of indigenous people arise from that society, creating a hidden social duality. Solutions to the problems often involve ignoring indigenous knowledge systems and advocating for the rules and institutions of mainstream society. These solutions do not lead to a fundamental solution to the problem, and the same problems easily reoccur in the society.

The Ainu, the indigenous people of Japan, have faced a major turning point in history. In May 1997, the "The Law for the Promotion of Ainu Culture" was enacted, and the "Former Aborigines Protection Law (1899–1997)," which had endured for almost one hundred years, was abolished. In September 2008, the Diet passed "A resolution that recognizes the Ainu as indigenous people of Japan." Many Ainu people began to identify themselves—"We are indigenous people of Japan," and have developed their self-recognition as indigenous people since then. In April 2019, "The Act Promoting Measures to Achieve a Society in which the Pride of Ainu People is Respected" was enacted and came into effect in May 2019. It is expected to promote Ainu people who live with pride as an ethnic group in Japan, the acceptance of the Ainu by a society in which they are respected, and a mutual understanding between mainstream and Ainu people. In the Act, however, the Ainu culture is represented mainly through tourism, the most of past negative memories of the Ainu have hiddenly remained. There is almost no mention of education for the Ainu that would help address their psychological duality, essentially the contradiction of being a Japanese but also an Ainu, and of education for Ainu people to solve their social problems on their own.

In 2003, the author met Ainu people who live mainly in Hokkaido. It was clear that their problems were not only the current issues faced; many of them suffer from their historical, political, and social tendencies. Since then, I have collaborated on various projects with Ainu people, and have gradually learned and understood the complexity and depth of their problems. In 2015, I had an opportunity to visit a local community in Hawaii with the highest population of Native Hawaiians in the world. At the time, my view of Hawaii was stereotypical: it was a famous and beautiful tourist destination with great ethnic and cultural diversity. However, while visiting there I learned about the existence of social problems such as homelessness, poverty, drug abuse, high crime rates, difficult learning situations affecting the local indigenous people underneath the tourist facade.

Even though the social problems facing the Ainu today are different from the problems experienced by Native Hawaiians, the underlying nature of their problems has the similar reasons and affected the Ainu. Both groups experience psychological duality in their mainstream societies. Influenced by my experiences in Hawaii, I started this study to try to visualize the invisible social problems that were common to the indigenous people, including Ainu people. I set out to help solve these problems by developing new ways of learning that respect indigenous cultures in a virtual place.

14.1.2 Problem Solving

This subsection considers solutions to the social problems of indigenous people and focuses on characteristics of problem solving itself. Kahney notes that all problems have two things in common: "First, they all specify *a goal*, ... Secondly, in each cases the solver is not immediately able to achieve the goal because the goal is blocked either through lack of resources or knowledge. These facts can be used as a basis for a definition of the concepts of *problem and problem solving*. Whenever you have a goal which is blocked for any reason—lack of resources, lack of information, and so on—you have a problem" (Kahney 1993, p. 15). Most of the challenges faced by indigenous people do not derive from "a lack of resources or knowledge," although indigenous people are not always effective at connecting their own indigenous resources and knowledge. They have dual resources and knowledge from indigenous and mainstream societies. However, the indigenous side is typically ignored, segregated, or discriminated against, as if it did not exist.

Kahney also notes a tendency for people to use their past experiences as one of the schemas for problem solving, automatically using these to solve issues. Solutions reflect an individual's experience so that previous experience may help solve the present problem. However, relying on experience in the past could also disturb the problem-solving process (ibid., p. 75). The experiences of indigenous people show how their own language and culture are replaced by those of the mainstream society. They have been treated with discrimination and contempt for many years, both individually and collectively. It is often the case that individuals' efforts alone cannot easily change relationships in the society in which social duality is internalized. As a result, indigenous people may give up resolving issues by themselves and creating a better solution in a society. The feeling of abandonment and emptiness as a schema for problem-solving loses results in a loss of hope for the future.

The Ainu people's experience makes them act in a way that maintains a negative self-imposed status, reflected with their begging of "Please do not wake a sleeping child." (Iwasa 2018). This condition is also called "'dying people" (Smith 1999) who lost their vitality for living, seen in other indigenous groups overseas. On the case of Hawaii, it shows indigenous people gave up on thinking about their lives from their own cultural perspective, leading to a sense of self-denial, feelings of self-loss, and hopelessness for the future. This type of despair can result in health problems including alcohol/drug abuse and social problems including suicide and crime (Kaholukula et al. 2009; Look et al. 2013).

Social problems experienced by indigenous people should incorporate their knowledge systems (e.g., their knowledge, technology, wisdom) into their solutions. The incorporation of indigenous knowledge systems would be more effective than those that use past experiences or knowledge from the mainstream society. Psychological duality can be untangled by visualizing indigenous knowledge systems, and self-affirmative "conscientization" (Freire 1996) may occur. These processes of being consciousness may encourage one to become aware of social/cultural reality and capable of changing the reality. This study describes a new learning activity that helps learners to experience such process.

14.1.3 Learning Objectives

The new learning activity aimed to help for solving problems by incorporating knowledge of indigenous people and considering their problems from the viewpoint of indigenous people. The learning activity is designed for both indigenous and non-indigenous learners. The activities used a concept of "Indigenous Development: Learning Objectives for Educational Programs (IDLO)" (Mataira and Iwasa 2015). The following four goals were included: (a) Strengthening the integrity of indigenous cultural knowledge and its application to educational programs; (b) Promoting indigenous cultural knowledge as foundational to educational programs and curricula; (c) Fostering on-going indigenous community relationships and knowledge development; and (d) Situating indigenous and other local knowledge within wider regional and global perspectives.

Working towards these learning objectives, indigenous people were regarded as having a unique social system and values that differ from those of the mainstream society—rather than merely being invisible in mainstream society, as if often the case. The knowledge is incorporated into existing education, and the development of indigenous people consciously considered from a broad perspective. The existing learning and knowledge of indigenous people are not viewed as an alternative to mainstream knowledge, but rather as intrinsic for society. The relationship between the two types of knowledge is developed by creating a peaceful relationship rather than a confrontation, and in doing so, creating hope for the future. This study aims for new learning through dynamic and transformative development to solve the problems related to the social and psychological duality of indigenous people. For this purpose, the study creates a new learning to experience of consciousness with indigenous peoples' knowledge in learning activities and solving the social problems of indigenous people by addressing their future well-being and hope.

14.2 Learning Model

The previous subsection described the social duality in the overlapping relations between indigenous communities and mainstream societies. This social duality arises from the relationship of A in Fig. 14.1. Although it will take time to change this relationship, it is possible to virtually create an indigenous mainstream society that does not have social duality by using simulation, thus creating a new relationship between indigenous mainstream society and indigenous communities as represented by B in Fig. 14.1.

Aiming to solve social problems of indigenous people in this new, simulated relationship, this study intentionally makes a new learning model that is free from the social duality in the relation represented by A in Fig. 14.1. The learning activities provide new experiences for both indigenous and non-indigenous people; e.g., indigenous people could be indigenous mainstream, and non-indigenous people

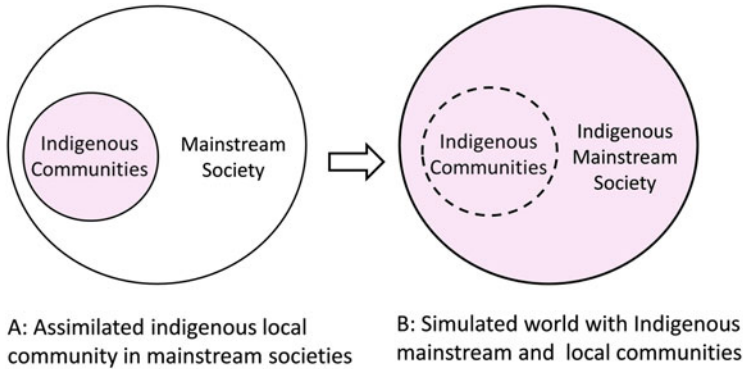

Fig. 14.1 Simulated relations in new learning (Iwasa 2019)

could be indigenous people, and use a game learning method of Simulation and Gaming (hereafter, S&G) which is referred to as "the future's language" (Duke 2014). Duke describes characteristics of the future's language as such

> Future's Languages have an ability to present a future orientation. This means the representation of any time frame other than the present (including the past, future, or any alternative to a present situation). Their purpose is to explore alternatives, to develop a sophisticated mental response to "what if" questions, and to permit the formulation of analogy for exploration of alternatives where no prior bases for analogy exists. (Duke 2014, p. 64)

Duke indicates that the future's language permits provision of alternatives, which have specific and detailed inquiries that lead to correlation with a holistic image, and opportunities to approach the topic from various perspectives that are relevant to the participants (ibid., p. 65). These characteristics show that S&G has possibilities to solve current problems with intrinsic contradiction, and to find the solutions from the future point of view and holistic perspectives. S&G affords a new experience for participants to become social entrepreneurs as social designers for future. In the next subsection, this study creates new learning activities for participants to experience future oriented approaches for solving problems by designating social plans for the future.

14.2.1 SECI Model

In solving the social problems of indigenous people by adjusting the virtual relationship of indigenous mainstream society and community (Fig. 14.1b), it is necessary for learners to respect indigenous cultural values in the learning process itself. For this reason, the author paid attention to the spiral patterns that appear in many indigenous cultures, and are found in nature and designs in the everyday life of indigenous people. They have unique symbolic meaning for each indigenous culture.

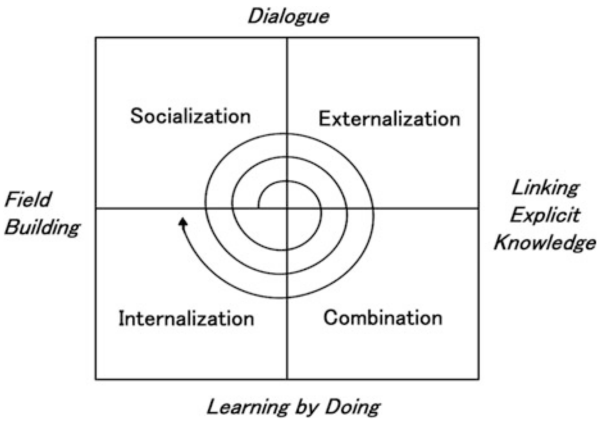

Fig. 14.2 Knowledge spiral (Nonaka and Takeuchi 1995, p. 71)

The "spiral" pattern in the Ainu culture is called "morew." "Morew Pattern" is "the spiral designs known to Ainu (. . .) the embroidered 'thorns' that protect the spiral's corners. (. . .) motifs are thought to have powers that protect one's back. They are found near openings and edges of garments and such vulnerable areas as turns in design where evil gods can gain entry." (Fitzhugh 1999, p. 22). Ainu people now engrave the patterns on wooden crafts, or embroider them on the edge of clothes and other items, and used in everyday life.

There is also a "spiral" pattern called "koru" Māori culture in Aotearoa (New Zealand). It is often used in Māori art as "a symbol of creation based on the shape of an unfurling fern frond. Its circular shape conveys the idea of perpetual movement, and its inward coil suggests a return to the point of origin. The koru therefore symbolizes the way in which life both changes and stays the same." (Royal 2005). The author found the common concepts between them and thought that it is possible to solve the problems of indigenous people by using the symbolic meaning of spiral patterns and respecting the concept of regeneration that symbolizes protection, circulation, returning to the place and change. Considering the importance of the "spiral" concept for indigenous people, this study utilizes the SECI model (Nonaka and Takeuchi 1995) that applies the spiral pattern (Fig. 14.2).

This SECI model shows two kinds of knowledge: tacit knowledge and explicit knowledge (Nonaka and Takeuchi 1995). These knowledge types move spirally in four modes of knowledge conversion, creating new knowledge and leading to innovation (Fig. 14.2). SECI is an acronym of the four initials of the modes of Socialization, Externalization, Internalization, and Combination. It is usually applied as a model of business administration and an organizational approach to corporate management reform. Nonaka and Takeuchi describe the clockwise movement from socialization to internalization incorporating tacit and explicit knowledge. This movement of modes leads to the creation of new knowledge and has each characteristic as follows (ibid., pp. 62–71).

S→Socialization (From Tacit to Tacit): A process of sharing experiences and thereby creating tacit knowledge such as shared mental models and technical skills.

The key to acquiring tacit knowledge is experience (shared experience). This mode usually starts with building a "field" of interaction.

E→Externalization (From Tacit to Explicit): A process of articulating tacit knowledge to explicit concepts. This mode is typically seen in the process of concept creation and is triggered by dialogue or collective reflection.

C→Combination (From Explicit to Explicit): A process of systemizing concepts into a knowledge system. This mode involves combining different bodies of explicit knowledge. Reconfiguration of existing information through sorting, adding, combining, and categorizing of explicit knowledge.

I→Internalization (From Explicit to Tacit): A process of embodying explicit knowledge to tacit knowledge. It is closely related to "learning by doing." When experiences through socialization, externalization, and combination are internalized into individuals' tacit knowledge bases in the form of shared mental models or technical know-how, they become valuable assets. This mode leads to starting a new spiral of knowledge creation.

Tacit and explicit knowledge exists in most societies. However, the knowledge of many indigenous people has an oral tradition with no written form. Tacit knowledge is central to many indigenous communities that pass knowledge from one generation to the next. As indigenous people today live in a mainstream society that values explicit knowledge (e.g., science, engineering, technology), it is difficult for them to prove the value of their tacit knowledge (e.g., spirituality, beliefs, mythology). People do not always understand indigenous knowledge socially and culturally, and indigenous people are often ignored or despised. This kind of treatment and negative feeling towards indigenous knowledge has led to the current social problems of indigenous people. It is important to respect indigenous knowledge and solve problems. In addition, it may also help to create a new solution. To that end, this subsection has attempted to explain how new knowledge could serve as a solution to the challenges faced by indigenous people. The learners' "conscientization" (Freire 1996) of tacit and explicit knowledge as part of the new learning process will serve as one of the triggers for new solutions. The following section develops a basic framework for the new learning activity using S&G.

Based on the knowledge conversion modes of the SECI model, a new learning process and activity were devised. The activity uses S&G that attempts to solve the problem by incorporating the indigenous knowledge as shown in Table 14.1. This learning process and activities create a new learning model.

14.2.2 Collaborative Learning Methods

To solve the social problems of indigenous people, it is necessary to consider not only their situation but also to develop collaborative relationships with others. This requires a learning activity that enables learners to create new knowledge by respecting indigenous knowledge. When learners from diverse backgrounds including indigenous students participate in collaborative learning, the learner must be:

Table 14.1 Learning model based on the SECI model

SECI		Learning process	Learning activities
Socialization	Tacit ↓ Tacit	Creating individual tacit knowledge through dialogue with empathy and understanding.	Being aware of the learner's own tacit knowledge and participants visualize it to share the tacit knowledge with others.
Externalization	Tacit ↓ Explicit	Converting individual imaged tacit knowledge into explicit knowledge as concepts.	Participants share tacit knowledge (as images) within a group by using the images that the individual created by collaboration, and creates explicit knowledge (as images) of the group.
Combination	Explicit ↓ Explicit	Learning tacit knowledge of indigenous people.	Participants learn about indigenous cultures and social issues that are inherent in indigenous knowledge.
		Creating new explicit knowledge to solve social problems of indigenous people.	Participants blend tacit knowledge of indigenous peoples with explicit knowledge of groups created by expression to create a new explicit knowledge by designing problem solving.
Internalization	Explicit ↓ Tacit	Creating new tacit knowledge from new relationships between new explicit knowledge of problem solving and tacit knowledge of indigenous people.	Participants share the new explicit knowledge created with the whole. Learn the new relationship between the new explicit knowledge and the tacit knowledge of indigenous people, leading to the next stage for the creation of new tacit knowledge.

Tacit = Tacit knowledge, Explicit = Explicit knowledge

(a) in a safe and secure environment; (b) in a new learning environment that enables learners to communicate using visualized information like images, figures, and art; and, (c) in a creative learning place ready to generate solutions to problems by creating designs using individual imagination.

To prepare situations in which learners can try to solve problems from the standpoint of indigenous people, a method that enables collaborative learning is needed. This study proposes the combination and incorporation of collaborative learning methods presented by Berkley (2010), Berkley et al. (2014). From her five collaborative learning methods, the author selected three learning methods: discussion, teaching (reciprocal peer teaching), and problem solving. Six learning techniques were then derived from these. Table 14.2 summarizes these methods and relations between them.

The learning framework in this study applied the technique called "Structured Problem-Solving" (Table 14.2), to the entire process using a structured format based on the learning framework (Table 14.1). In this format, the learning process is

Table 14.2 Collaborative learning methods/techniques for the learning model

Methods	Techniques	Overviews	Usefulness
Discussion	Think-Pair-Share	Thinking individually for a few minutes, and then discuss and compare their responses with a partner before sharing with the entire class.	Preparing students to participate more fully and effectively in whole class discussions.
	Round Robin	Generating ideas and speak in order moving from one student to the next.	Structuring brain storming sessions and ensuring that all students participate.
Reciprocal Peer Teaching	Role-Play	In a created situation, students deliberately act out or assume character or identities they would not assume to accomplish learning goals.	Through "learning by doing," students must actively apply knowledge, skills and understanding to speak and act from different assigned perspectives by their creativities.
Problem Solving	Case Study	Reviewing a written study of a real-world scenario and developing a solution to the dilemma presented in the case.	Presenting abstract principles and theories in ways that students find relevant.
	Structured Problem Solving	Following a structure format to solve problems and dividing problem-solving processes into manageable steps to reduce their feeling of difficulties.	Learning to identify, analyze, and solve problems in an organized manner.
	Group Investigation	Planning, conducting, and reporting on in-depth research projects.	Learning to research procedures and gaining in-depth knowledge about a specific area.

divided into steps called "Group Investigation," with group learning activities centered on planning, implementation, and reporting of the project. Through deep understanding of indigenous knowledge and social problems, learners plan the project, designs solutions, and share the project plan with the whole group. To effectively carry out this entire learning through each process of knowledge conversion of SECI, it is necessary to pay attention to the usefulness of each technique in Table 14.2. These techniques can be used in learning activities.

Socialization, an introductory part of learning, starts with "Imagine-Group-Share" (Imagining for a few minutes, then drawing an image individually, and then sharing drawings). This is a unique improvement on "Think-Pair-Share." The activity supports communication with visualized information, using symbols before verbalizing tacit knowledge. **Externalization** promotes brainstorming using "Round Robin." Then, **Combination** treats social problems of indigenous people as a "Case study" that includes issues of indigenous people. Learning about the dilemma of duality, and respecting indigenous knowledge when trying to find solutions, is key. Then, the "Role-play" technique is introduced to encourage learners to play the roles of social entrepreneurs and to carry out social designs that lead to the creation of new knowledge. The final technique, **Internalization**, reports learning results including new knowledge, sharing this to promote awareness and acquisition of new learning knowledge with others.

14.2.3 New Games

The learning activities developed in this study gives learners the opportunity to become virtually social entrepreneurs as social designers for creating plans for future, and solve social problems of indigenous peoples through case study and role-play. Although the activity includes elements of simulation and case studies, Leigh and Kinder (2001) indicate that games based on relationships need to be "limited by time and rules" and "competitive." Where games focus on a relationship in a non-competitive way that prioritizes "fun" rather than "win/lose" in the game, these authors define as "a new game."

In contrast, Duke (1974) positioned gaming as a new means of communication, and Greenblat (1988) argued that the difference between gaming and role-playing is the existence of rules, neither of which is an element of competitiveness. Regarding the difference between games and gaming, Duke and Greenblat considered that "gaming = gaming simulation," that is a "function" that includes the game function and the player action needed to play the game. An alternative position is that Matsuda's (2012) who regards gaming as all the activities that promote understanding of the model behind the target world of the game by briefing and debriefing before and after the game. For these reasons, the new game learning activity developed in this study could be described as "simulation games used as case studies." Leigh and Kinder (2001, p. 25) specifically referred to "simulations and games in case studies." However, as the game is a problem-solving activity that does not require a win/lose (ibid., p. 29), the new game learning in this study is best described as "a new game with the function of S&G."

S&G has many games with educational purposes for learning/training, such as Barnga (Thiagarajan 2006), Bafa'Bafa' (Shirts 2009), The Albatross (Gochenour 1993), and The Martian Anthropology Exercise (Batchekder 1993). They focus on researching/understanding different cultures, their values, and people. They also try to find effective forms of communication between/among two or three different cultural groups by using the participants' diverse perspectives, values, or skills. Most of them, however, are not for solving real social problems, and especially do not focus on indigenous issues and their real culture.

14.3 Development of Project PAL

The new game developed in this study is named Project PAL where "PAL" is an abbreviation for "Place-based Active Learning." This means active learning by collaborative learning methods in which learners participate in a virtual project, and try to solve the social problems of indigenous people by using their knowledge based on indigenous "place/land." As there is an actual project called Project PAL, the official name of the game is "Simulation Game, Project PAL" (hereinafter, "PAL game").

14.3.1 PAL Frame Game

The PAL game has the new learning model developed as a game process based on the SECI model with collaborative learning methods, and incorporates the learning process and activities (Table 14.1). This game is a "Frame Game" which Duke (2014) describes as "Frame Game: A game whose procedures are consisted from run to run, but into which new content, subject matter and data can be loaded and calibrated for a new purpose each time it is played." (ibid., p. 177). It is thus possible to make various versions of the PAL games called "Project PAL: ***" as applications based on the frame game. In this case it was necessary to collaborate with the indigenous people, and ask them to share their indigenous knowledge and social challenges as game materials. Table 14.3 shows the PAL frame game with the game stages, progress, and procedure for practicing of the game.

14.3.2 Preparations for the Game

Game materials (GMs) showed in Table 14.3 are essential tools for practicing the PAL game. The content of the materials enables versions of the game for different indigenous people, and makes the game playable. The difficulty level of the material can change depending on the ages, school grades, or purpose of the game learners. Furthermore, the materials are provided by indigenous people, and the whole process of developing the version is a collaborative work with indigenous people. This is an important preparatory process for the development and practice of creative learning that respects the knowledge of indigenous people.

For the PAL game, a specific symbol (concept) is first required to set the learning theme. The game can use symbols of peace, happiness, health, etc. Depending on the learning situation, the learning theme may already be determined. Where no learning theme is chosen, the PAL game respects the concept of "peace," aiming at the learning goal of creating a peaceful relationship (Sect. 14.1.3).

Table 14.3 PAL frame game with five game stages

Stage		Progress/Procedure of the game	GMs
S1 Individual images	Theme	Drawing an individual image of symbol	GM 1
	Time	10 to 12 min	
	Procedure	(1) Explain the outline of the game and the symbols of the learning theme. Draw an individual image of the symbol on a small piece of small paper and make the story.	
		(2) Present and share the individual images and stories within the group.	
S2 Group images	Theme	Drawing a group image using the individual images	GM 1
	Time	10 to 20 min	
	Procedure	(1) Draw a group image using the individual images in S1 on a small paper, and make the story of the group images through discussion.	
		(2) Present and share the group images and stories with all participants.	
		*This image and story will be used as the company logo and mission for the project plan of the next stage; however, a facilitator should give this announcement in the last part in S4 to respect the participants' free imaginations.	
S3 Learning	Theme	Learning about indigenous knowledge and their social issues	GM 2–7
	Time	12 to 20 min	
	Procedure	(1) Explain that the group will become a "PAL project team" and the purpose and progress of the game using GM1.	
		(2) Explain the game materials for understanding the target indigenous people's history and current geographical information using GM2, and the social issues of the indigenous people using GM3.	
		(3) Explain the values and worldviews of the indigenous culture (GM4), their art work (GM5), and use GM6 and GM7 for understanding indigenous people as appropriately.	
S4 Planning	Theme	Designing of PAL Project Plan	GM 2–7
	Time	40 to 45 min	
	Procedure	(1) "PAL Project Team" establishes a global company, creates a company name & logo, and three missions based on the group image and story created in S2, and draws the plan on a large paper.	
		(2) Choose some social problems of indigenous people that "PAL Project Team" commits to.	
		(3) Discuss "PAL Project Plan" for solving the problems respecting the company logo and three missions, consider the plan and draw the solution design using the game materials on a large paper.	
S5 Feedback	Theme	Sharing and debriefing of PAL Project Plan	N/A
	Time	12 to 20 min	
	Procedure	(1) Have the presentations of "PAL Project Plan" designed in Stage 4, and share the stories of the plan with other teams.	

(continued)

Table 14.3 (continued)

Stage		Progress/Procedure of the game	GMs
		(2) The indigenous collaborators conduct their debriefing to the participants on their plans.	
		(3) Have the time for Q&A and the discussion with the participants and the indigenous collaborators through Skype or Zoom. (*1, *2).	
		*1: The case on that collaborators cannot participate in Stage 5: It is possible to send the game results to indigenous collaborators by e-mails or other ways, and then to receive their feedbacks, and use them for additional debriefing time later. *2: The case on that an additional debriefing is not possible: the facilitator gives the participants the comments/feedbacks on behalf of the indigenous collaborators.	

Table 14.4 PAL game materials

Game Materials (GM)		Contents
GM 1	PAL game story and rules	Explanation of the purpose and progress of the game
GM 2	Map and history of indigenous people	History/records of indigenous people (use if there is a history which has the relationship with their mainstream society)
GM 3	Social problems of indigenous people	Social problems provided by indigenous collaborators and the facilitators should understand them in advance
GM 4	Five cultural values of indigenous people	At least five cultural knowledge provided by indigenous people
GM 5	Art works of indigenous people (e.g., art, poem, music, etc.)	Works that can understand indigenous culture and the feelings of indigenous people
GM 6	Information of indigenous people/the themes	Booklets, leaflets, articles, internet information, etc.
GM 7	Articles of UNDRIP (United Nations Declaration on Rights of Indigenous Peoples)	The articles to be used are selected according to the learning theme with the indigenous collaborators. *Depending on the age of the learner and the learning theme, the use of GM7 whether to be used or not, and which articles to used are decided.

14.3.2.1 Game Materials

Game materials (GMs) were developed for the target indigenous people in the game. The contents of the materials included seven kinds, classified as GM1–GM7 and shown in Table 14.3. GM2–GM5 were materials/information provided by the indigenous collaborators. To prepare the GMs, each theme was put on one page and a set of materials printed out (usually 5 or 6 pages, but in the case of GM7, 7 pages) as required for all the groups. When playing the game, facilitators of the game distribute the sets of GMs to each group. Table 14.4 shows the contents of PAL game materials (GMs) that to be prepared in advance.

14.3.2.2 Game Story

The game story (scenario) used in the PAL game is as follows.

> The United Nations requests the PAL project team (hereinafter: the PAL team) to construct a particular complex of buildings/spatial facility to ensure future well-being for indigenous people and to solve the social problems in their local communities. The PAL team establishes a global company of social entrepreneurs. To set up the company, the team creates a company name, logo, and three missions for the company using the symbols and stories in S2.
>
> The site where the facilities will be built is a local community where indigenous people live, and the area is currently facing many problems. Indigenous people revive and make efforts to establish their traditional industries (e.g., farming, fishing) in the vicinity. The PAL team must design a plan of complex of buildings/spatial facility that promote 'future well-being' and respect the five values of indigenous culture, and must help to solve the local problems. Prior to construction, "PAL project plan" as the project design will be proposed and evaluated by the indigenous people in the area. The construction cost of this PAL project will be borne by the United Nations, however if there is opposition to the construction from local indigenous people, the company will bear all the cost of it.

14.3.2.3 Game Tools

The PAL game is a simple game that can be played with "paper, drawing tools and game materials." People from children to seniors can participate by adjusting the content and difficulty level of the game material in consideration of the age, occupation, and purpose of the game learners. To practice the game, the following preparations are required by the facilitator in advance.

Table 14.5 shows the time allocation and procedure of each game stage when a PAL game is practiced, and the preparation (game materials/contents, tools) accompanying the progress of the game stages. The total time of the game varies depending

Table 14.5 Tools and preparations for PAL game items

Items	Preparations
Time	120 to 180 min: 120 min or more is desirable to achieve learning effects even with a small number of people in one game.
Learners	Total number of people: 4–45 people
Group	One group: 2–8 people (adjusted to be more than 2 groups)
Game tools	Paper: Two types of paper, large and small, are used (large: big white paper for the number of groups, small: A4/letter size paper for the number of learners)
	Stationery: felt-tip pens, markers, crayons, colored pencils, etc.)
Game devices	Using a computer: projectors, screens, monitors, wall, etc. Without a computer: Prepare printed paper material to show the game progress

on the number of learners. However, if the total number of people is in the region of 5 to 45, the time is assumed to be 120 to 180 min. The facilitator manages the whole game process.

14.3.3 PAL Version Games

Based on the PAL frame game (Table 14.3), the original versions of the PAL game have created determining which indigenous people and social problems are dealt with. Currently, three original PAL games have been created, three version games based on the PAL original games have remade, and one student version has made. Table 14.6 shows them with the year of creations and the places for the first trials.

The co-authors of the PAL original games (PAL 1–3) were indigenous people, who provided their indigenous cultural values, original arts, and current challenges/problems for the PAL games. The PAL game series include:

1. Project PAL: Hawaii (Iwasa, Kila, Oliveira 2015)

This is the first of the PAL games, and the Hawaii version focuses on solving social problems for Native Hawaiians in Oahu, Hawaii. The first trial was held at ESD Campus Asia 2015, Hokkaido University in Sapporo, Japan.

2. Project PAL: Ainumosir (Iwasa and Urespa Club 2016)

This is the Ainu version that aims to solve the social problems of Ainu people, especially focused on Ainu youth in Hokkaido, Japan. This game was made by university students of Urespa Ainu Cultural Club, Sapporo University in Sapporo, Hokkaido. The students practiced using PAL: Hawaii first, and then made PAL: Ainumosir following the PAL framework on their own. They practiced the Ainu version for the first time at ESD Campus Asia Pacific 2016, Hokkaido University.

Table 14.6 PAL original/version games

	PAL	Original/version games	Year	First trials
1	PAL 1	Project PAL: Hawaii	2015	Hokkaido University (Japan)
2	PAL 2	Project PAL: Ainumosir	2016	Hokkaido University (Japan)
3	PAL 3	Project PAL: iKoru	2018	ISAGA 2018 (Thailand)
4	PAL students ver.	PAL: People on Boarders in Thailand	2018	SIIT, Thammasat University (Thailand)
5	PAL ver. 1	Project PAL: iKoru, Future Hospital	2018	Mahidol University (Thailand)
6	PAL ver. 2	Project PAL: iKoru, TMT	2019	Hawai'i Pacific University (USA)
7	PAL ver. 3	Project PAL: Hawaii after COVID-19 [On-line & Off-line]	2020	Hokkaido University (Japan)

3. Project PAL: iKoru (Iwasa and Mataira 2018)

"iKoru" is an abbreviation for "indigenous Knowledge on returning unity." This game facilitates leadership education for young people, especially indigenous youth. The game uses Māori culture in Aotearoa, New Zealand, and provides an opportunity for youth to think about social/current problems in their local communities, and to try to solve them.

4. PAL: People on Borders in Thailand (SIIT, Iwasa 2018)

This game was the first student version of the PAL game made by university students of SIIT (Sirindhorn International Institute of Technology), Thammasat University in Thailand. After gaming experiences through practicing the PAL: Ainu version game, the students were separated two groups and made this game (Hamada et al. 2019). Using the PAL game frame, this version dealt with the social problems of people on the boarders between "Thailand & Myanmar" and "Thailand & Cambodia."

5. Project PAL: iKoru, Future Hospital (2018)

This was the first sub-version game based on the original PAL game and adapted from Project PAL: iKoru. "PAL: iKoru, Future Hospital" was conducted by university students in a nursing department in Mahidol University in Thailand. The game provided an opportunity for the students to create their expected/ideal future hospitals with the current issues of the hospitals in Thailand in mind.

6. Project PAL: iKoru, TMT (2019)

This game was based on PAL: iKoru and dealt with the topic of TMT (Thirty Meter Telescope) on (Mt.) Mauna Kea in the Big Island in Hawaii. This concerns the big issue of construction for Native Hawaiians. The game provided an opportunity for students to think about what we respected and how respect indigenous cultural values when thinking about the scientific progress of astronomy. The game was conducted by graduate students of Social Work, Hawaii Pacific University in Hawaii.

7. Project PAL: Hawaii after COVID-19 [On-line & Off-line] (Iwasa and Werner 2020)

Using the PAL Hawaii model, this game was tailored for the social situations created under the circumstances of COVID-19 in Hawaii. It was conducted by students who attended the ESD Campus Asia Pacific 2020 summer program at Hokkaido University. This was the first trial of the PAL game on-line (via Zoom), connecting three university students in Beijing China, Sakhalin Russia, and Sapporo Japan (a group of Hokkaido University played it by off-line in the classroom). The co-facilitator of Native Hawaiian provided social problems and current information about COVID-19 in Hawaii in Stage 3, and shared the debriefing/feedback from Hawaii to the students in Stage 5 through Zoom.

14.4 Implementation of Project PAL

This subsection introduces two cases of practicing “Project PAL: Hawaii” which was the first original PAL game. This Hawaii version is the only one that has two cases, which were practiced by indigenous and non-indigenous people.

14.4.1 Project PAL: Hawaii

Project PAL: Hawaii (PAL: Hawaii) deals with social problems in the west local area of Oahu in Hawaii. This part of the island has the highest population of Native Hawaiians. The game tries to find a way to enhance respect for the indigenous knowledge of Native Hawaiians. The game materials shown in Table 14.3 were modified for PAL: Hawaii: “Indigenous people”⇒“Native Hawaiians” for the Hawaiian version of the game. Native Hawaiian collaborators provided all information for the game. Game materials were prepared as one set of printed materials of six pages and distributed to each group for playing the game. Due to space limitations, full details of the game materials are not shown here. The actual game preparation follows Table 14.4, and the game process follows the game progress and procedure shown in Table 14.5.

GM1: PAL:Hawaii game story and rules
GM2: Map and history of Native Hawaiians
GM3: Social problems of Native Hawaiians (e.g., Hawaiian sovereignty, etc.)
GM4: Five cultural values of Native Hawaiians (e.g., Aloha, Pono, etc.)
GM5: Art works of Native Hawaiians (“Nation Our Own”)
GM6: Information about Native Hawaiians

The “PAL: Hawaii” study complies with research ethics for indigenous people that addresses the use of personal names, place names, Native Hawaiian culture, and social problems in the game materials. As the game uses authentic problems in the real world, it was important to protect their human rights of participants/contributors as well as copyrights. To ensure the highest ethical standards, a thorough discussion was held in advance with the Native Hawaiian collaborators. High importance was placed on understanding and respecting the indigenous people, and obtaining their approvals for all implementation.

14.4.1.1 Practice of the Games

This subsection presents two cases of the implementations of PAL: Hawaii. The cases were as follows:

Case 1: Participants were non-indigenous people who were university students from four Asian countries (China, South Korea, Thailand, and Japan) and attending

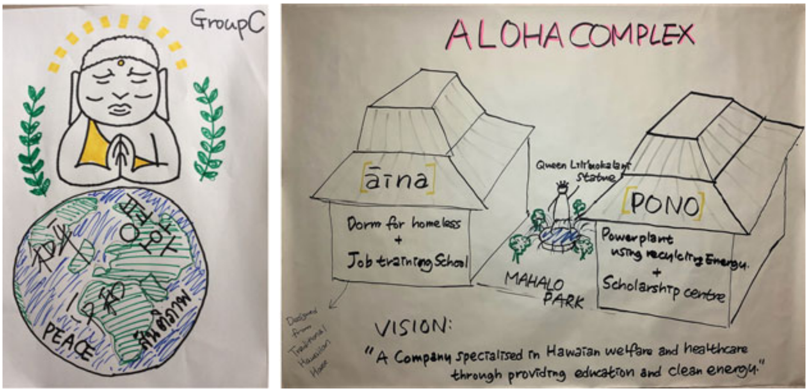

Fig 14.3 Case 1: Logo and PAL Project Plan: ESD Campus Asia 2015 (Iwasa 2019)

ESD Campus Asia as a summer program at Hokkaido University in July 2015. The 38 students were divided into 5 groups (one group: 7 to 8 people).

Case 2: Participants were indigenous people who were university students belonging to Urespa Club (the Urespa Ainu Cultural Club) at Sapporo University in November 2015. The 12 students were divided into 3 groups (one group: 4 people).

In both cases, the PAL: Hawaii game followed the outline in Table 14.5. Stage 1 started the game by drawing an individual image of "peace" and making a story about that image. The students shared their individual images with their groups. In Stage 2, the students created a peace image for the group using all individual images, and then made a story about it. They then introduced the image and story to other learners. In Stage 3 the students engaged with the game materials (GM1 to GM6); and then in Stage 4 they established their companies to solve the social problems of Native Hawaiians. They created the company logos and three missions based on the group images and stories created in Stage 2. They designed the PAL Project Plans as solutions to the problems, and drawing them on large sheets of paper. Finally, in Stage 5 each PAL team presented their PAL Project Plan sharing their design and its story. Due to time limitations, the game was divided into two parts: the first for Stages 1 to 4, and the second for Stage 5 and later.

PAL Project Plans are the results of the game. The plans in this section show that the Native Hawaiian collaborators selected, one from each of the two cases. The collaborators selected plans from their viewing that the cultural values of Native Hawaiians well incorporated, and that they hoped to use for actual community plans in the future. These plans are shown in Figs. 14.3 and 14.4 and the summaries of the students' presntaions are as follows.

Case 1 (Fig. 14.3): This logo depicts the word "peace" in four Asian languages on the earth, and the image of Buddha symbolizes prayer or peace. We chose "homelessness, employment, poverty, and health problems" from the social problems of Native Hawaiians. We established a company specializing in social welfare and

Fig. 14.4 Case 2: Logo and PAL Project Plan: Urespa Club 2015 (Iwasa 2019)

health management (our missions) under the company name "ALOHA COMPLEX" (complex facility). The "āinā" building on the left side is a housing facility that means "the land for feeding all living things" in Hawaiian. This place is for homeless people and has both a house and vocational training school in the same facility. In addition, the "PONO" (meaning "balanced and correct relationship") building on the right side symbolizes a balanced state to maintain the health of gods, spirits, people, and the earth. We also created a recycling energy center (using garbage) named "pono" and a power plant and scholarship center (which will lead to work). We built "Mahalo Park" between two buildings, "āinā" and "PONO" in a traditional Native Hawaiian style, and placed a statue of Queen Lili'uokarani, who many Hawaiians adore and respect, in the center.

Case 2 (Fig. 14.4): The logo was drawn as a symbol of the sun rising from the Hawaiian sea, and the company name is "AHUPUA'A," which refers to a traditional Hawaiian living space. We chose "homelessness and unemployment" from the social problems of Native Hawaiians. We reproduced a traditional living space centering on the river (our missions). On the left side, we built a natural regeneration area and on the right side, we built taro patches (taro: potatoes, Hawaiian staple food), a community center named AHUPUA'A, and a museum. The community center serves as a place for learning about Native Hawaiian culture and practicing cultural activities. The museum also serves as a workplace for introducing the culture. In the area above that, we built a condominium using a traditional Hawaiian house-style residence.

14.4.1.2 Debriefing after the Games

After the presentations in Stage 5, debriefing was conducted by the Native Hawaiian collaborators. Q&A took place and feedback was also exchanged. For Case 1, the collaborator 1 from Hawaii participated in Stage 5 from Hawaii through Skype, and explained and discussed the PAL project plans with the students. For Case 2, collaborator 1 responded by e-mail, and collaborator 2 gave feedback later including Q&A through Skype. Summaries of their debriefings appear below.

Case 1: This model is designed from a traditional native perspective. It encompasses the values of family and work in one complex and renewable energy and education in the other. This model creates a powerful family growth model where homeless families are close to their jobs and schools, with an open courtyard with Queen Lili'uokalani as a role model for the people. Emphasizing clean energy next to the village model also teaches traditional Hawaiian values of using the sun, wind, and organic farming for healthy living and environmental sustainability.

Case 2: This model is intended to make a Native Hawaiian community healthy by using the myriad indigenous concepts of Native Hawaiians, such as "āinā" (land), "kauhale" (village system), "ohana" (family), and "mo'omeheu" (culture). (. . .) The model also created a village as a returning place to grow indigenous food, practice traditional fishing, and learn the origins of their own culture. The designed plan is very valuable for the Ainu students themselves in recreating an indigenous revival in creating projects with village life, land management, and respecting the land and its resources. Furthermore, the plan focuses on training skills in community centers to solve social and economic challenges of indigenous people, which is very important. It has the traditional values of Native Hawaiian work with groups and families. Another significance of this project is to help each other and work with others for the good of families and other people, what is essentially called "aloha" (love).

14.4.2 Evaluation of PAL: Hawaii

14.4.2.1 Game Learnings

After implementing Case 1 and Case 2 of PAL: Hawaii, the game was evaluated with a questionnaire and free description. The questionnaire focused on: (1) understanding of peace; (2) understanding of indigenous cultures and issues; and, (3) possibility of application to their learning and work. A five-point evaluation was conducted using a scale where "5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree." Both evaluations of Case 1 and 2 showed in Table 14.7 as follows.

Table 14.7 Evaluations by questionnaires to PAL: Hawaii

	Questions		5	4	3	2	1	(%)
1	This game gave me a better understanding of the concept of "Peace."	Case 1	20	48	23	6	3	100
		Case 2	58	25	17	0	0	100
2	This game improved my understanding indigenous culture and issues.	Case 1	30	34	23	10	3	100
		Case 2	50	33	17	0	0	100
3	I plan to use some of the ideas I learned through the game on my study at school.	Case 1	34	30	27	6	3	100
		Case 2	66	17	17	0	0	100

The highest score of evaluations showed Case 1: (1) 4: 48%, (2) 4: 34%, and (3) 5: 34%; Case 2: (1) 5: 58%, (2) 5: 50%, and (3) 5: 66%. In each evaluation, Case 2 obtained higher scores than that of Case 1.

In free description, seven main themes were indicated that the game provided:

(a) opportunities to think about the effect of communication based on empathy and mutual understanding, and the position of the other party;
(b) new awareness to undertake problem solving by oneself;
(c) new methods for solving social problems of indigenous people;
(d) new awareness of the opportunity to solve problems, new initiatives for addressing them and of the impact of solutions on the local community;
(e) opportunities to recognize one's own cultural heritage as indigenous people [from indigenous students];
(f) opportunities for promoting understanding of peace through education; and
(g) significance of directly connecting to the local community through Skype.

At the same time, in both cases, three critiques were raised. Participants suggested a need for:

(h) improvement of time allocation in the game;
(i) improvement of the game progress; and
(j) prior study to know more about the target indigenous people [from Case 2].

The reasons for these suggested improvements were that the facilitator (the author) was unfamiliar with Case 1. This was the first time of trialing the game, and inevitable some unforeseeable challenges arose due to lack of experience with the first performance of the game.

Thus, in Case 2, improvements were made by considering time allocation and had been learned in Case 1, and the learners' criticisms of these matters decreased. As Duke (2014) indicates: "It is necessary to perform 10 test plays after game development." Experience with a game practice is very important as it influences the result of the game and the game evaluation. There is the possibility that some facilitators will play the PAL game for the first time without having any experience of the game, and it is likely that they will have the same experience as the author. It will be important to develop a manual that can be used for the specific purpose of facilitating the game and to understand the relationship between time allocation, game progress, and other important points about the game.

Regarding the need for prior learning about the target indigenous people [j) above], the game learners raising this point were Ainu students. They hoped to learn more about the Native Hawaiians and their social issues, to promote a greater understanding of the culture. There is a need for further learning that promotes empathy and mutual understanding, which could be evaluated in a pre- and post-study that considers mutual relationships with indigenous collaborators.

14.4.2.2 Game Activities

There are almost no criteria against which game developers can evaluate their own games at present. Therefore, this study evaluated the development of PAL games using the game evaluation items from Duke (2014, pp. 139–149). This study focuses on three items: time requirements, exercise progress, and evaluation guidelines that lead to the improvement of PAL games. This study evaluated PAL games focusing on the processes linked to knowledge conversion of the SECI model and each game stage for the improvement of PAL games.

Stage 1. Socialization (Individual images): This Stage involved a simple-learning activity in which individuals depict an image of a symbol. It is the process of creating a visual image with learners' imagination. Most learners found this embarrassing and they often made statements like: "I can't draw. I'm bad at drawing." Although there were individual differences, it took time to start drawing images from tacit knowledge. However, once the image was decided on, it became possible to draw it easily, at the same time leading to story making about the images. Learners had the experience of overcoming one barrier here. Through this simple activity, participants learned how to visualize their own knowledge. This enabled them gradually use it in more complicated learning activities by "drawing a picture and making a story" in subsequent stages.

Stage 2. Externalization (Group images): In this stage, all learners were requested to integrate their individual images, and create a group image together. Media such as pictures and images promoted the transition from tacit to explicit knowledge of individuals, and facilitated their discussions. Observing the diverse pictures and images of others, the learners become aware of the diversity of knowledge that others have, but invisible. They developed a basic stance to understand and respect others. Furthermore, through the process of using the pictures and images of all the members together and creating one group image and story, the learners had opportunities to try out different roles (often naturally decided), such as taking leaderships for the group, summarizing the story, or drawing. Some learners were hesitant to participate in the discussion and the facilitator needed to encourage them to take part or specifically promote that group members.

Stage 3. Combination 1 (Learning): In this stage, the facilitator presented information about social issues and the target indigenous culture through game materials (GMs). The materials were obtained in advance from the tacit knowledge of the indigenous people. Explanations of the game material are flexible depending on the approaches of the facilitators. However, one caution to note is that visual materials can become obstacles for learners to use their free imaginations. Providing visual information such as photos, pictures, and videos was useful for increasing indigenous knowledge, but to respect individual imagination and free thinking, the images, pictures, photos, and video as GMs should be kept to a minimum here.

Stage 4. Combination 2 (Planning): At this stage, explicit knowledge from Stage 2 and 3 was bended to solve the social problems of indigenous people. To create the relationship shown in Fig. 14.1b, the indigenous people's knowledge was used in the simulated mainstream indigenous society leading to creation of the PAL project plan in the simulated PAL learning community. These plans contained new knowledge created from the relationship shown in Fig. 14.1b, but the learners rarely notice the tacit knowledge of the plan at this stage. Indigenous collaborators drew their attention to it in their debriefing at the next stage.

Stage 4 took the longest time in the PAL game as the learners themselves read the GMs and created a design while thinking about it and discussing it. At the same time, the learning activity here became very active. Most of the learners naturally drew a new image for the logo and created a story to describe their missions. Group learning can become complicated but learners were observed to take their actions voluntarily and autonomously. This stage is the most enjoyable stage for learners. In the PAL project plans that followed, learners were observed to share roles in the group, and have great fun together with learning. The most important role of the facilitator at this stage was to manage the progress of all learning activities watching the level of accomplishment of the project plans in the overall time frame, and paying attention to the timing of the end of the game.

Stage 5. Internalization (Feedback): Here learners created new knowledge, incorporating knowledge of the indigenous people with their own knowledge, with the PAL Project Plans as the game result. Through the process of three knowledge conversions (Stages 1 to 4), learners had the experiences of sharing, creating, and presenting their various knowledge. The debriefing by indigenous collaborators provided not only evaluations of the project plans, but also awareness of the tacit knowledge of indigenous people contained in the project plans. The collaborators helped stimulate new understanding for learners through the debriefing process. In addition, the collaborators themselves sometimes acquired new knowledge from the diverse project plans by the learners. New knowledge in the project plans gained by both non-indigenous and indigenous groups might help overcome some of the current challenges faced by indigenous people. The new knowledge might be internalized as the new tacit knowledge for future learning. A game manual should be created for future use to ensure effective facilitation and possible solution to address some problems with the games.

14.5 Project PAL for the Future

This study aimed to develop a new problem-solving approach for the social problems of indigenous people. A future was imagined in which the knowledge of indigenous people is respected, and future design visions are realized through collaborative work. This chapter started by highlighting the social and psychological duality that indigenous people face in mainstream society. The study attempted to untangle the psychological duality by new learning, and intentionally using the knowledge of indigenous people to solve social problems as a form of conscientization. The new learning incorporated the knowledge of indigenous people into a future society designed to celebrate their existence and their hope. The development of the PAL game had other functions, such as learning to solve problems that give rise to new solutions. The next part of the chapter examines these new educational functions of the game.

14.5.1 Dual Function for Indigenous People

The PAL games help visualize knowledge of indigenous people through the making of game materials. They attempt to integrate new and existing knowledge through a creative learning activity called S&G. The learning process of using visual indigenous knowledge made a virtual experience so that non-indigenous learners could enter the world of indigenous people, and experience the world from another person's position. At the same time, indigenous learners could have the virtual experience of being in an indigenous main stream society without feeling psychological duality. The game creates a safe and secure learning space in a simulated community. It was a virtual experience for them to think about the problems in their own society. This new experience of conscientization is termed "indigenization" (Gray and Coats 2010; Bird 2013), and it is related to the concept of "decolonization" (Smith 1999; Smith et al. 2019).

Decolonization means to "deframe," and Smith (1999) uses this term for deframing from a frame or worldviews that based on values of the dominant group in the mainstream society. Thus, "indigenization" means to "reframe," and is a process of honoring and respecting indigenous culture and in giving it equal and critical consideration (Mataira and Iwasa 2015). This term is used for reframing by respecting the worldview, values, cultural significance, and rituals of indigenous people, and restates the society, education, and research from a standing point of indigenous people. The PAL game created opportunities for reframing, that is "indigenization" using carefully selected game material. At the same time, the game virtually created the experience of deframing or "decolonization," by using the game material to conscientize indigenous knowledge.

The synchronic occurrence of "deframe/reframe" brings about a new function called "Dual Function" (Iwasa 2019), shown in Fig. 14.5. This dual function takes place in a simulated place using S&G, and is only made possible because of the virtual place. This function helped non-indigenous learners adopt the perspective of indigenous people and respect their culture for taking action to solve the problems by

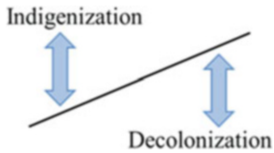

Fig. 14.5 Dual function (Iwasa 2019)

standing on the indigenous side. Indigenous learners were able to adopt the perspective of their own or other indigenous communities, thinking how their culture could take action to solve the problems of indigenous people.

Defaming helped change indigenous people's perspectives of their own culture, that is, "they dare to stand in their original position." This moving (defaming) of their viewpoints is necessary for them to create their future visions on their own, especially with feeling safe and secure. The PAL games make it possible to create such a place virtually, bringing with it socially and psychologically safe places for indigenous people. The game became a new place for creating a future.

The Dual Function shows that it is difficult to untangle from the psychological duality of indigenous people using either indigenization or decolonization. This means that public education conducted in mainstream society, or education focused on indigenous people only, is unlikely to generate the untangled function. Game learning with the function of S&G enables two such contradictory concepts to occur simultaneously even if they are virtual. Game learning can have an important role in untangling a contradictory problem by virtually creating a new relationship.

14.5.2 Multilogue for Social Designs

Indigenous people today live in societies that are developing in diverse ways. It is not realistic to plan only for mainstream society; designs must consider a future society that has diversity and uncertainty. Using IDLO goals (Sect. 14.1.3), the PAL game aimed to visualize the existence of indigenous people and to create a new society by considering the development of indigenous people from a broad perspective. Rather than treating mainstream society and indigenous people as two opposing groups or being an alternative to the existing knowledge and indigenous knowledge, the two groups should be cooperating harmoniously and build a better future through developmental synthesis.

The future designs of Case 1 and Case 2 in the PAL game showed different viewpoints of learners. In Case 1, the learners stood outside of the indigenous community; and in Case 2, the learners stood within the indigenous community. Such differences in perspective may lead to different future visions in indigenous and non-indigenous people. It is expected that differences will naturally occur and create diverse visions when designing a future society. Such different viewpoints incorporate the voices of the various people who make up the society, and the future visions of a society in which indigenous people exist. The PAL game focused on "voiceless voices" and how society can visualize the voices of indigenous people as the subjective voices making up the society. The game materials for PAL games are visualizations of the "voiceless voices" of indigenous people. The PAL project plans encompassed multiple voices in a harmonious integration: voices of the learner together with the often-unheard voices of indigenous people. These integrated chorus create a social design with a future and a new solution to the social problems.

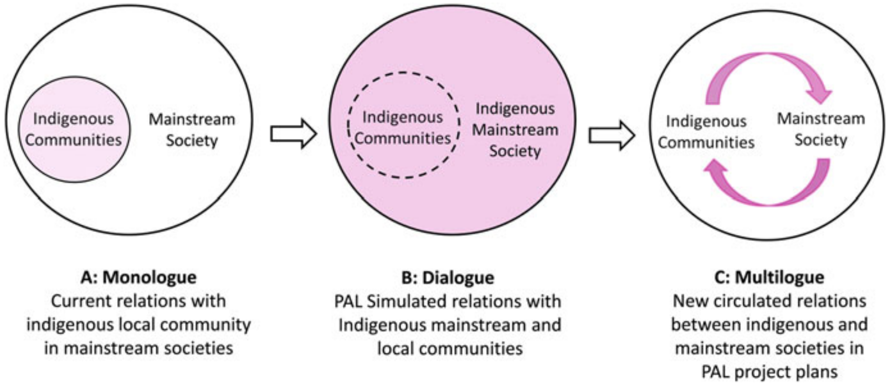

Fig. 14.6 Project PAL for problem solving with multilogue

Regarding problem-solving method, Kaneda (2005) suggested referring "multilogue" as a new mode of communication using the concept of "the future's language (Duke 2014)." Duke indicated that "Multilogue: multiple, simultaneous dialogue organized by a pulse (ibid., p. 179)," and it has multiple perceptions and mappings of one reality. Kaneda indicates that experiencing S&G helps to create a cognitive facet that is closer to the problem situation, and methods such as gaming and debriefing serve as new communication tools for promoting multiple dialogue (Kaneda 2005).

Considering the functions of PAL games from this point of view, the learning activities of S&G help create the simulated future. They make it possible to speak from the future with a voice, which has not yet spoken. This makes it possible to consider social problems in the present, and create future visions through multilogue with indigenous and non-indigenous people. Players try to find the solution to problems by uttering their own voices from the simulated future. In addition, through the debriefing process indigenous people with their past tacit knowledge become aware of their own indigenous tacit knowledge from the future. Their debriefing reminds them of the existence of their tacit knowledge in future even if two societies co-existed.

The learning function of PAL game results in multilogue and social entrepreneurship to design a future society. It had a function to virtually integrate polyphonic voices of diverse learners and indigenous people's voices contained in the game materials and debriefing. The multilogue for problem solving in the PAL game is performed through the process of moving from A to B and then to C, as shown in Fig. 14.6.

A: Monologue is at the game stage of Stage 1 and Stage 2 where tacit knowledge of indigenous and non-indigenous people is carried out through internal dialogue (individual/group) and creates explicit knowledge with visual images.

B: Dialogue occurs in Stage 3. Here learners increase their indigenous knowledge, virtually communicate with based on that knowledge, and create a virtual common field in learning (learning groups/indigenous society) to create a simulated place for indigenous people's systems.

C: Multilogue is a virtual formal indigenous society created in Stage 3, which shares indigenous knowledge and issues, and creates a new explicit knowledge 1, a logo and the missions through collaborative work and game materials in Stage 4. Then participants create further new explicit knowledge 2, the PAL project plan, which offers a solution to the problem. After that, in Stage 5, they share the explicit knowledge 1 and 2, and experience debriefing with indigenous (tacit) knowledge, and leads to the awareness and creation of further next tacit knowledge.

The PAL game created simulated experiences for social/indigenous entrepreneurship through these communications. It helped build a vision of a future society through the transformative development in mainstream and future indigenous societies constructing through multilogue. This shows that the function of multilogue in S&G has a generator for creating "future" with "hope" of indigenous and non-indigenous people.

14.6 Conclusion

During practicing the PAL: Hawaii game in Case 2, an Ainu student said "It is difficult for us to face our problems directly because of our history and actual experiences in the society. However, through the PAL: Hawaii, I learned how to look at myself and how to deal with the problem, and now I practiced them in the game. (Iwasa 2019)."The student's words demonstrate the value of simulated experience for indigenous people. As a result, the PAL: Hawaii game led to the creation of an Ainu version of the game. The university students of Urespa Club created their own Ainu version, "Project PAL: Ainumosir" based on their experience of playing the PAL: Hawaii game. To untangle the contradiction experienced by minorities such as indigenous people, it is necessary to make a buffering that serves as an "intermediate mediator" (Miyazaki 2014) in a society. In the case of practicing a PAL game, the game itself became such a mediator as a safe and secure place for indigenous people to think about themselves.

Solving the social problems of indigenous peoples is complex and time-consuming. It would be unrealistic to expect to the PAL game to solve all the challenges immediately. However, it is possible for S&G to have a role in dealing with many complicated and difficult indigenous problems in the world, and to promote learning through game experiences. S&G could be an extremely effective tool for creating a new society from the "glocal" perspective of "Think globally, Act locally" when designing future societies. This shows depending on the future development of learning, PAL project plans could serve as actual future designs for society by practicing social entrepreneurships for taking a new action "Think globally, Create virtually, and Act locally."

The PAL game needs many improvements as a simulation game; however, the existing model format became a prototype for the game. By combining collaborative learning techniques, the operability and variability of the game were brought about. It is easy and versatile to use, and can serve as a frame game with different versions based on it. The potential learning effects are great, including facilitating communication, awareness of the learner's self and others, and awareness of collaborators. Furthermore, if the social problems handled by PAL games are diverted from the problems of indigenous peoples to more wide-ranging social problems, that showed a possibility of development the Thai version created by Thai university students (Hamada et al. 2019).

"Learning by playing S&G" (learning by doing) provides a safe and secure virtual place, brings "reflection-in-action (Schon 1995)" for becoming social entrepreneurs, and facilitates "empathy and mutual understanding" among people. It creates an exchange of humanity through multilogue and encourages a first step towards action and realistic problem solving by fostering an attitude for people to work together to solve problems.

Currently, the author plan to develop differnet versions of the game as tools to design a future society that incorporates people's hopes for actual community designs. User-friendly manuals are needed to deal with the various social problems and develop entrepreneurships that create a future society with "PAL spirit," that is "Passion, Actions, and Love." This chapter will continue to the next PAL projects for designing future societies with a mind "Game is Fun!"

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