Advances in Game-Based Learning

Linda Daniela *Editor*

Smart Pedagogy of Game-based Learning

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Preface

Hopes for Game-Based Learning

To date, games have been used both to help children learn by playing, an idea that originated from Friedrich Fröbel's work, and to support adults in developing strategic skills such as through chess, bridge, Go and similar. Reiser (2001) considers that the use of games as an instructional method for educational purposes dates to after World War II, when instructional media, for example different vizualisations to let students better understand some concepts, began to be used in any sense for instructional delivery (Reiser & Gagne, 1983). It is believed that the idea of digital games originated between 1960 and 1970 (Jaiswal, 2021), and since 1971, when Intel introduced its microprocessor in Santa Clara, California (Chan et al., 2006), there has been a revolution in various digital solutions that also affected the use of games in education. During the late 1970s and early 1980s, digital educational games became an important constituent of student-centred learning (Marklund, 2015). In the research literature, the term game-based learning (GBL) is mostly referred to as digital game-based learning (DGBL) (Giannakas et al., 2018), but for simplicity the term GBL is used and digital games are proved more as motivational than educational (Chen & Hwang, 2014). Although there is potential for the use of games in education, they are still rarely used. Denham, Mayben and Boman (2016) think that the reason for this is that teachers are unprepared for using this method due to a lack of professional development in teacher training. In order for teachers to start using digital games in the teaching process, it is necessary to acquire technological, pedagogical and content knowledge on how to manage this process (Becker, 2007; Kirriemuir & McFarlane, 2004).

Kirriemuir and McFarlane (2004) have defined a game as a type of activity either where the gaming is a central element of the activity or where there are stimulating elements for other activities and where learning is a planned or accidental outcome of that activity.

Currently, the use of games can be divided into two large categories: entertainment games where accidental learning can take place and a purposefully organized game-based learning process that focuses on learning. In this book, we focus more on the fact that a game or elements of a game are purposefully used to strengthen one of the dimensions of knowledge – (i) the perspective of knowledge growth; (ii) the perspective of knowledge acquisition and use; (iii) perspectives on knowledge accumulation; and (iv) perspectives of knowledge access (Daniela, 2020). If we look at these dimensions of knowledge from the perspective of game-based learning, different elements of the game come to the fore in each of them that combine with each other, but in the use of games, one must take into account not only the motivation of students, which can be promoted by games (Chen & Hwang, 2014; Burgos et al., 2013), but also what the digital game helps to achieve and where the teacher orchestrates all the elements of the games:

(i) The perspective of knowledge growth – in this case, when planning the game-based learning process, the focus should be on the fact that the main outcomes of using the game are an increase in students' knowledge and the construction of new knowledge. If these are the main goals of game-based learning, then it is necessary to make sure that knowledge increases either by incorporating an assessment algorithm in the game itself that can provide teachers with information about the increase in knowledge or after the games to test knowledge using other assessment methods.
(ii) The perspective of knowledge acquisition and use – this is when the student acquires different types of knowledge during the game, but the main goal is not to prove the increase of knowledge but instead to use this knowledge both to analyse information differently and to use knowledge in different contexts. In this case, games can be used as a way for a student to acquire information, knowledge and competence in the use of knowledge. If this dimension is at the forefront of the educational process, then while the game may not include knowledge assessment elements, learning happens as a side effect of the game, which can be through either accidental learning or an intentionally set process, to gain a different perspective of thinking, for example to understand the historical or religious contexts that influenced the progress of certain processes.
(iii) Perspectives on knowledge accumulation – games can also be used as a learning method when knowledge accumulated in world history is included in them, for example about historical events that can no longer be repeated, knowledge of galaxies, which the student cannot access, or knowledge of objects that cannot be considered in detail. This may be a game about building the Great Wall of China or a game about the structure of a spaceship in which the student accumulates new knowledge in their existing knowledge schemes.
(iv) Perspectives of knowledge access – this is where digital games are used to provide access to knowledge that is available to students in traditional learning settings (books, laboratories, classrooms) but which they are not using because they have lost interest in reading or in cases when it is impossible to reach the laboratory or classroom due to restrictions. Games can be used to simulate practical activities, to provide information that can be found in books, or to

force students to look for information in books or other sources to play the escape room.

Very often, games which are commercially developed may seem to be more readily available because no pedagogical resources are required to develop these games; however, their pedagogical value is often questionable because they are inadequately designed and do not achieve any of the learning objectives (Ioannou, 2021). For teachers to start using digital games in the teaching process, it is necessary to acquire technological, pedagogical and content knowledge on how to manage this process (Becker, 2007). Teachers should not only assume that games raise the motivation to learn just because learning content will be included in the context of the game. One should keep in mind the pedagogical perspective (Daniela, 2019; Chen & Hwang, 2014), where innovative technologies or innovative instructional strategies are used in line with the principles of cognitive development, cognitive load theory (Sweller et al., 1998) and the principles of knowledge construction for the curriculum students have to learn. Their interests should be augmented and enhanced with Internet tools, mobile environments and popular communication services to ensure that both gaming and appropriate (learning) strategies have significantly positive effects on both students' learning achievements and their motivation (Chen et al., 2015).

Thinking of games that are played anywhere and anytime, and we hope that students will also be eager to play educational games, developers of such games should strongly rely on smart pedagogical aspects and understand that if learning happens without the supervision of teachers, and students use self-regulation strategies to choose particular educational games, they should include not only learning aspects but also entertainment aspects to merge together the aims we have as teachers and the aims students have. In a real learning environment, it is the teacher who orchestrates the various variables that affect whether higher levels of knowledge can be achieved or whether the use of the game achieves the intended learning objectives, but using the possibilities of digital games, it is clear that the orchestration of this pedagogical process must be included in the essence of the game.

Organization of the Book

This book consists of 13 chapters which all, in different ways, try to explore the possibilities of game-based learning.

In Chap. 1, Ignacio López-Forniés presents three learning experiences of creativity based on the design and construction of artefacts used as tools or devices for competition, which were the means to demonstrate the creative solution. Two types of metrics are presented, based on conditions and on goals, which allow scores to be compared to cases in which games are involved or to those that attempt to exceed certain goals.

In Chap. 2, Kirsi Syynimaa, Kirsi Lainema, Raija Hämäläinen, Timo Lainema and Tiina Lämsä examine the role of instructional activities facilitating collaboration in GBL and discuss the role of instructional activities promoting collaboration in the context of simulation-based game environments. In collaborative learning settings, such as GBL, the teacher's role is associated with planning and organizing the learning circumstances in which collaborative and inspiring group work may arise. The study at hand presents analyses of real-time audio and video data collected in an authentic GBL setting.

In Chap. 3, Janna Kellinger examines game-based learning approaches to teaching. She begins with an analysis of educational games and concludes that curricular games are goal-driven simulations where players can experiment in a risk-free environment. The author then pulls out the essential elements of game-based learning and examines ways in which free and/or ubiquitous technology tools can be used to design curricular games.

In Chap. 4, Efi Paparistodemou, Maria Meletiou-Mavrotheris and Christina Vasou explore the capabilities of a learning environment that uses programming logic in a game setting. Based on challenging students (aged 8–13) to create their own games, they attempt to explore and enhance their reasoning about probabilistic ideas. Children were introduced to the block-based programming language Scratch 2.0 and used it to create their own games. The findings show that the idea of chance has an important role in their games and that they expressed probabilistic ideas while designing and playing their game.

In Chap. 5, Bassam Hussein provides a thorough description of a project management game that is used in an introductory course in project management. The game was developed to demonstrate the scope and impact of assumptions and biases on the early phases of project development. The game provides the course participants with an opportunity to comprehend the importance of reflecting holistically before taking decisions.

In Chap. 6, Nicholas Zaranis and Fotini Alexandraki assess the effect of the use of game-based learning with tablet computers in teaching multiplication and division to kindergarten students. Their research compares the level of mathematical competence of the students taught using their tablet-oriented game-based learning method, which specifically takes advantage of 'Realistic Mathematics Education' for the concepts of multiplication and division, as opposed to traditional teaching methodology.

In Chap. 7, Mariano Sanz-Prieto and Gema de Pablo González discuss their experience of developing digital escape rooms (created with Genial.ly) with students. They believe that the results obtained and the response of the students to the activity encourage the incorporation of new tools to create pedagogical proposals using gamification and learning by doing as the main basis and, in this way, continue to deepen the options offered by gamification in learning and challenge-based learning.

In Chap. 8, Elīna Grāvelsiņa and Linda Daniela discuss the possibilities that an escape room can provide in a remote learning environment. The benefits and the downsides are explored to understand the design process and the results from the different mechanisms used. The results can give an insight into future possibilities for making escape rooms for classes or for using this format as a prototype for an escape room application.

In Chap. 9, Emmanuel Fokides, Penelope Atsikpasi, Polyxeni Kaimara and Ioannis Deliyannis present the results of a study in which the users' experience when playing serious games (in terms of gaming and learning) was examined in an effort to determine which factors contribute significantly to the above and how they are related. Two serious games were used (one 2D and one 3D), and the target group was 384 university students. The findings highlight the need for further research in this field, but they can also serve as the basis for the development of more comprehensive serious games evaluation methods.

In Chap. 10, Santa Dreimane explores quiz apps as game-based learning tools for the repetition and mastery of a subject and for enhancing students' learning motivation in higher education. This study uses a survey as its research method and gathers students' opinions on quiz apps, their application in lessons, what the most common quiz apps are, as well as which elements students find engaging and motivational.

In Chap. 11, Efi A. Nisiforou and Charalambos Vrasidas shed light on the design and development of a smart learning environment in the context of digital citizenship to promote smart pedagogy. A compendium of terms, definitions and key concepts is provided. It aims to reflect on the potential of the DRC Heroes application to cultivate young learners' digital competencies through an attractive educational setting. The five digital competencies of the European Digital Competence Framework (DigComp) were gamified to develop the proposed game, including essential gamification elements.

In Chap. 12, Andrea Filatro and Marilene Santana dos Santos Garcia present a space for reflection on games in adult education and their potential for developing a smart andragogy. The applied methodology covers an analysis of publications registered by Google Scholar between 2018 and 2020, and the authors find some important factors in the adoption of games in adult education in the learning process, among which are that games open opportunities for the use of cognitive skills with playful support.

In Chap. 13, Agnes Papadopoulou, Emmanouel Rovithis and Iakovos Panagopoulos establish the theoretical framework for the design of the interactive narration game 'Just ahead of me'. Through this fusion of narration and game-based learning, they aim to enhance learners' script-writing skills and guide them to explore their imagination and openness. At the core of the game's learning mechanics lies the card selection system, which trains learners to distinguish between desire and necessity and benefit from adjusting their creative thought to the challenge of the unexpected.

Riga, Latvia Linda Daniela

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Contents

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Fotini Alexandraki graduated from the Department of Preschool Education of the University of Crete. Also she received her Master of Science in School Psychology and her PhD in ICT and Mathematics from the Department of Preschool Education of the University of Crete. She worked for many years in kindergartens with children of typical classes and children with special needs. Currently, she works in a counseling center. She is a member of the interdisciplinary team. Her interests include assessment of children with special needs, integration, ICT, and Mathematics.

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She is author of publication about gamification for education, its historical development, intersection of serious games and learning motivation, game-based learning tools and technology-enhanced learning for the development of learning motivation, augmented reality mobile application for learning the anatomy, and about children's social adaptation in a mixed-age group at Montessori preschool.

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Raija Hämäläinen, (PhD) has contributed to top-level international research on technology-enhanced learning and game-based learning and is an expert in mixed-methods research. She has wide international networks. Recently, Hämäläinen was invited to give a keynote lecture in the EARLI 2021 Conference (see https://www.earli.org/EARLI2021). Hämäläinen is an associate editor of *Educational Research Review* (impact factor 6.962). She is a community committee member of CSCL and a board member of the Finnish Multidisciplinary Doctoral Training Network on Educational Sciences (FinEd). Hämäläinen has led and is currently leading several research projects (e.g., for the Academy of Finland and H2020).

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Timo Lainema, PhD (Econ) has applied simulation games in business education, in university teaching, executive education, and in in-house management training programs. His research interests are learning through gaming, conceptual change, knowledge sharing in virtual working contexts, and dynamic decision-making in time-intensive environments. He has published in various journals in the fields of Higher Education, Management Studies, Gaming, and Information Systems. He holds an adjunct professorship in Education in the University of Turku, and in Information Research and Interactive Media at the University of Tampere. He is a senior fellow in Turku School of Economics and Business Administration (University of Turku), and he presently works as CEO in RealGame Business Training, a company whose expertise is virtual business simulation training environments for business and higher education.

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Chapter 1
Game-Based Learning and Assessment of Creative Challenges Through Artefact Development

Ignacio López-Forniés

Introduction

The future of quality education with a high skills training value must be student-centred with an intelligent and multidisciplinary educational system supported by adaptive learning programmes, collaborative methodologies, digital learning resources and STEAM technology training and adapted to Industry 4.0 (Uskov et al., 2018). It must also improve creativity, the visibility of learning outcomes and communication, motivation and interest in learning. The educational environment applied by smart pedagogy must develop skills of a technological-pedagogical nature and predictive analytical skills to develop an educational environment and an intelligent society (Daniela, 2020). These educational environments must be flexible and capable of integrating new forms of learning, such as learning by doing, project-based learning, module-based learning (López-Forniés et al., 2012) or others that promote "active learning" and focus on experiments carried out by students, whose results indicate their learning (BenMahmoud-Jouini & Midler, 2020).

The game-learning relation, and the use of games as a vehicle for learning, has long since been of interest for educators (Chmiel, 2019). Learning theories of socio-cultural cognition or learning theories indicate that potential games have to motivate, engage and provide real learning experiences. The integration of game into learning is justified by it involving game elements, such as incentive systems, to motivate players to engage in tasks that they otherwise would not find (Plass et al., 2015). In addition, the learning experience with game favours knowledge retention as emotion is an element that favours cognitive processes, such as memory. Wouters

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et al. (2013) show that, according to a set of reviewed studies, games are more effective in learning and retention terms than conventional instructional methods.

Playful and creative activities share certain characteristics that remind us of a direct relation, which are often intrinsically motivated and almost never occur when participants are anxious or they focus on achieving a specific goal (Dansky, 2011). Both involve transformations, possibilities and unusual combinations of ideas, actions and situations.

Integrating games into product design and creativity activities requires a specific definition of learning objectives and custom design because the design process of games for learning involves balancing the need to cover the subject matter and the desire to prioritise game play (Plass et al., 2015). Play in learning also develops twenty-first-century skills, which are very valuable in future designers, such as teamwork, collaboration, co-creation, problem-solving, creativity or communication (Plass et al., 2014). Design challenges as games can be played in groups and involve meeting and coordinating with one another and competing as teams. Product design also involves creative problem-solving work and sometimes the construction of a prototype that effectively represents and communicates the solution designed to compete in the game.

By separating assessments from learning, fun leads to a free-thinking situation, and the academic result objective becomes a new objective as points, best times, best performance, a record to beat, etc. The legislative thinking style (Sternberg, 2010), oriented to tasks, projects and situations that require creation, formulation and planning ideas, strategies, products and the like (Sternberg, 2020), positively and directly influences metacognitive strategies that impact creative production (Gutierrez-Braojos et al., 2013) and can be considered an intellectual style that facilitates the definition and redefinition of problems. Achieving this free thinking is possible, thanks to the integration of legislative thinking and game elements into creative thinking. Game elements can be affectively related to interest, motivation and training in values or to elements of character that promote discipline, tenacity and audacity (Burgos et al., 2010).

Tim Brown (2008), designer and CEO of the IDEO company, expresses the idea that design, game and prototyping are related. He believes that play helps to come up with more creative solutions and make a better design and helps to feel better when working. Prototypes allow you to play and "think with your hands" so you can quickly perform many tests with low-fidelity prototypes.

A proof of concept (POC) shows that a product or feature can be developed, while a prototype reveals how it is developed. A POC is designed purely to verify the functionality of either a single concept or set of concepts to be unified in other systems (Singaram & Prathistha, 2018). The POC is a way to move away from uncertainty. Although it does not offer a final solution, it demonstrates that the idea works, and the first results confer us confidence in knowing what the final design process requires (Cohen et al., 2015). Sometimes the word prototype is more colloquial and easier to understand by nonexperts, although the term artefact is used in this chapter to refer to the presented cases that came closer to a POC.

The artefact or prototype is a learning tool and represents an idea through which concepts can be discussed, changed and negotiated (Rodriguez-Calero et al., 2020). It implies players designing and building their game tools, which also happens in fighting robot competitions for learning robotic vision (Culler & Long, 2016), in truck design challenges to apply physics concepts while testing the use of bearings (Aguilar Martín & Santo Domingo, 2018), in paper plane competitions to learn statistics (Ruiz Sánchez, 2020) or for understanding fluid dynamics processes (RedBull, 2018). In contests, the artefact acts as an editable model (Lennings et al., 2000) that is iteratively adjusted and leads to learning about optimisation and improved performance.

To win or lose, which fall in line with follower robot races (OSHWDem, 2019), depends on the effectiveness of the prototype, the improvement and the adjustment based on the tests carried out and also the participants' training and skills. The starting conditions are the same for everyone and what is shared is an open-source code for learning to programme. Game-based learning provides a safe place in which to fail and learn, challenges students and provides immediate feedback, including socialisation as an additional stimulus (Hertz, 2013).

In creativity assessments, several metrics are used and refer to generic dimensions, such as novelty, usefulness, feasibility and the like (Shah et al., 2003; Dean et al., 2006; Kudrowitz & Wallace, 2013). However in game-based learning, it is more logical to assess creativity by evidence-centred design (Mislevy et al., 2003; Zhao et al., 2015) and to validate the creative solution. The dimensions measured by the metrics allow game results to be compared and goal achievement to be evaluated.

As some terms are confused, such as gamification, game-based learning and serious games, we point out that gamification refers to the use of game elements and serious games use games to motivate learning (Tecnológico de Monterrey, 2016). The choice of game-based learning for the experiments presented in this chapter is linked with the objectives of the learning outcomes in creativity, problem-solving by applying creativity to interpret the problem and to generate solutions, learning through construction, improvement and adjustment of an artefact and competition according to rules and limitations, to verify the effectiveness of the design in relation to other similar or different solutions.

Creativity Challenges: Three Experiments for Applying Creativity and Artefact Building

According to the definition of Chmiel (2019), game is a form of entertainment that is limited by rules, often competitive ones, and is based on some kind of skill. In games, participants can propose strategies and tactics that adjust to the mechanics of the game, and rule-based systems are designed to govern the mechanics and limit actions in a game. Two of the experiments we present herein are based on competitive game activity using an artefact as a game tool to achieve certain goals that conform to rules, the challenge and learning feedback (Roungas & Dalpiaz, 2015). The third one includes neither a game nor competition, but involves the same learning objectives as the picking up balls (PUB) one and serves as a reference for comparison purposes. The experiments involved different groups of students according to the number of components and the required design.

Three experiments are presented, each with a challenge to overcome that involves learning creativity being applied to product design as part of the Degree of Engineering in Industrial Design and Product Development. This creativity is expressed by constructing an artefact that solves a problem or meets set goals. Experiments were similar for integrating the following factors, creativity, problem-solving and constructing an artefact, but had different goals and conditions. To integrate game and the playful aspect, two of the cases are presented as competitions to engage all the participants in the shared fun and in observing work and the other participants' achievements. The third experiment proposes a challenge based on goals to compare the results.

The participants must face challenges as a creative process applied to a design problem by fully defining their own objectives, difficulties and limitations. They also generate ideas and seek solutions to the problem by sketching representations before moving on to construct an artefact and its test operation to achieve goals, and all this during an iterative process of optimisation cycles (Lennings et al., 2000).

The first experiment forms part of the optional bio-inspired design subject with 22 participants. The initiative came about at the students' request who, after completing the teaching activities, asked to undertake a quick competition project on 1 day for the sheer fun of it and to have a good time with their classmates by applying the knowledge they had acquired. Participation was open to the other students who do not study this subject to form groups made up of up to four people. Figure 1.1 shows the poster announcing the bionic design challenge (BDC) with the contest

Fig. 1.1 The bionic design challenge poster

bases, which stressed that the brief project was a surprise. The goal was to design a helmet or protective headpiece with no specific application, but it had to withstand heavy blows, and involved holding a fragile object to be protected, simulated with a balloon filled with water that weighed 1 kg. The impact test was carried out by throwing the helmet with the balloon inside from a tower with a free 12-meter fall. Several designs were assessed, such as inspiration in nature, feasibility, aesthetics or the fun aspects of the design and presentation. With this exercise, concepts about energy absorption and dissipation, damping, programmed breakage, light structures, resistance of materials, etc. are learned. On the Biomimicry Institute website (AskNature.org, 2017), the participants can consult the functional taxonomy, where they can search for functions and references in nature to find solutions by analogy.

During the second experiment, called picking up balls (PUB), an artefact had to be designed to collect balls during a time trial competition. Before the participants started their project, a series of YouTube videos were shown about how to make homemade traps to catch rats with recycled materials by applying very basic principles of physics, but filled with creative thinking. These videos (Imaginative Guy, 2018) aim to stimulate creativity and ingenuity and to help students to perceive how easy it is to make an effective trap with very few recycled materials by simply applying creative thinking. Another objective was for them to perceive the potential of constructing and testing artefacts so they could start the trial-and-error methodology by making improvements to their artefacts and correcting both experimentation and observation (Brown, 2008). The challenge lies in designing and building an artefact that allows balls or marbles to be collected to simulate a particle system in a limited space. Students practice with physical concepts and material characteristics, such as stiffness, flexibility, deformation, thrust, friction, etc. They must also develop a certain skill in handling artefacts, which means that the design is conditioned by the effective and efficient use in relation to a given time.

The goal of the third experiment is to design and build a tape dispenser (TD) and includes the function of measuring the amount of cut tape. A series of limitations is included in the brief design that corresponds to the objectives to be academically evaluated, e.g. ease of use, measurement accuracy, a clean safe cut and the number of pieces or quantity of materials used. The design must also present some improvement to existing dispensers on the market to evidence the application of creativity to the design process. During this exercise, creativity concepts are learned about generating functional alternatives in both cut and size, optimising resources and adaptation to use. Establishing each goal is a problem to be solved and must be integrated into a single device. As some goals can be antagonistic, students must apply their ingenuity to integrate and overcome them in a balanced manner. They also learn by building; by observing the viability, feasibility and operability of their prototype; and by correcting concepts or construction errors. This type of project has been proposed in other academic years given the learning objective of maximising or minimising a function, as in building toothpaste dispensers to regulating doses, citrus fruit squeezers to facilitate cleaning, rice dispensers to measure doses within a variable range, etc.

With learning experiences through play, a series of essential components is structured (Fullerton, 2014), such as players, goals, rules, resources, conflicts, limitations and results. Table 1.1 shows these essential components for each challenge, which make competition fair under equal conditions. All the experiences were designed for learning and difficulty levels according to everyone's knowledge and skills. They required a medium level of active participation and the time spent was quantified.

The objectives of each challenge were adapted to the knowledge type that had to be learned with the subject, but by highlighting some points that made participation more challenging and fun. Rules were defined to confer the group homogeneity and equality, as were available resources to avoid external advantages to creative contribution and the participants' skills.

In both BDC (helmet) and PUB, which involve play and competition, conflict and rivalry to help to obtain the best mark, there were no winners or losers. However, rivalry was generated at the time of participation given the desire to win or exceed a partner's mark. The game limitations were, on the one hand, physical, namely, the structure where balls were collected, the collection area, height of walls, etc., and, on the other hand, they involved material resources and time which, for the participants, were their own design space limits (López-Forniés, 2021). The results were uncertain and uneven. With BDC, players only had one chance because there was no time or materials to carry out previous tests, and a second try would generate uncertainty as to whether the design would withstand impacts. Moreover, the chosen design and its construction marked differences in the participants. Success or failure in achieving the goal was the proposed challenge, instead of winning or losing, and the results were unknown when the game began. Uncertainty generated some stress in those who had still not participated given the possibility of losing a mark or having the chance to do better than those who had already burst their water balloon. It was only at the end of challenges when results were clarified and stress disappeared.

The first two experiments took game into account, and both included an element of challenge, fun and playful learning. Game mechanics differed because, when collecting balls, solutions could be established tactically to obtain a better result. For example, differences are marked between designs to collect balls one by one, done in small groups, large groups or all at once. It is even than game sport played in a field because it had rules and scoring linked with the number of collected balls and spent time. However, there were no defined game mechanics in BDC and only one chance, namely, a single launch, because no previous launches from the tower were allowed. The helmet design included two intermediate presentations: the concept to be developed and prototype construction. In both cases, corrections and suggestions were made by the teacher to reinforce ideas and to learn from them.

Another difference lays in incentive, and the only motivational element in BDC was the prestige of passing the test as rewards only took a symbolic value. PUB included a score and a classification, which form parted of the final course mark. Training and practicing the test beforehand were allowed to determine which of the two components of the pair was more skilful or faster and to choose the participants for the day of the competition.

The reward in the first experiment was participating, although some trophies were designed and six categories were established. Trophies were made from recycled material and were distinguished by colours (see Fig. 1.2). Each colour corresponded to a category, the most resistant one to pass the balloon breakage test, the

Table 1.1 Challenges for experimenting with artefacts through creative design-based games

Game element	Bionic design challenge (BDC)	Picking up balls (PUB)	Tape dispenser (TD)
GBL	Yes	Yes	No
Participants	22 participants from years 3 and 4 of the Degree in Design Engineering. Seven groups with up to four members are formed	73 students of year 2 of the Degree in Industrial Design Engineering. Participation is in pairs or as individual, as preferred. There is only one try	79 students in year 2 of the Degree in Industrial Design Engineering. Participation is individual
Goals Objectives	Prevent water balloon from (1) coming out of the helmet while falling and after impact and (2) breaking after hitting the ground. (3) Minimise the use of material. (4) Aesthetics and constructive evaluations	Collect as many balls as possible with diameters of 16 and 25 mm. Collect all 50 balls in the shortest time possible (15 large, 35 small). Minimise parts and material usage	There are four goals (measure, cut, facilitate, economise). Dispense masking tape by measuring the length before making a clean safe cut, easy to use with the fewest pieces or the least material
Rules	The biomimetic relation must be justified. Manufacturing the prototype must be done manually or with hand tools. Launching from a tower at a height of 12 m	First round limited to 30″ to count the number of balls. Second round continues to 5′. Balls must be collected in a defined area inside a square ring in order to be valid	The prototype must be built manually or with hand tools. 3D printing or rapid prototyping machines are not allowed. A fail mark or a zero score is allowed only in one goal
Resources	Limited to the materials delivered to teams. All the materials are waste that have been recycled and cost €0. Time is limited to the competition time, from 9 am to 3 pm	Limited to recycled and recovered materials. All the materials are waste that have been recycled and cost €0. The project time for designs and prototypes is 4 weeks	Save the number of parts and material used. Use materials recycled or recovered from other products. The whole exercise lasts 4 weeks
Conflict Rivalry	There is no direct rivalry, but is a matter of achieving goals. There is no conflict, and a good atmosphere must be perceived during the competition	There is no direct rivalry while designing and constructing the artefact. There is rivalry at the time of the competition. There is no conflict	There is no direct rivalry with other participants, because it is about overcoming the goal individually. There is no conflict

(continued)

Table 1.1 (continued)

Game element	Bionic design challenge (BDC)	Picking up balls (PUB)	Tape dispenser (TD)
Limitations	Time and materials are limited. Purchasing parts or materials is not allowed. Recycled materials found in the university can be used	The operation must be exclusively manual and mechanical. Motors or electrical devices are not allowed. Suction systems cannot be used. The device can only be operated by one person and by one hand	There is only one limitation with materials. Buying or using parts or components from other dispensers is not allowed. The students are allowed enough time for their design and construction
Results Rewards	Launches are video-recorded and photographed. A poll is taken by the participants to deliver different prizes. The reward is fun and learning	According to the results, a table will be drawn with the distribution of times and the obtained mark. All the designs that collect balls in less than 5 minutes will pass the test and obtain a mark	Part of the mark is given depending on whether the learning objectives are achieved

Fig. 1.2 Symbolic awards and categories for the bionic design challenge

best design, the most viable design, the most aesthetic design and the most entertaining one, and, finally, there was a wooden spoon as a booby prize. Classifications were done by the participants voting. The organisers' opinions did not affect the results, which meant that selection was also a playful part of the game because organisers appreciated funny comments and jokes about designs and designers.

Assessing Creativity and Meeting Objectives

By taking a group of people and giving them a sheet of paper to make a paper plane with and offering them several launch opportunities to improve design and to verify which one flew the best, we establish competition, and we can subjectively state who the winner is. However, in order to be fair and be able to make a correct statement of who the winner is and to even make a classification, we must introduce some objective indicators, e.g. distance travelled, gliding time, height reached, not leaving the flight path, etc. With all these indicators, we can take accurate measurements to assess competitors' achievements by establishing categories by achievement, or using a combined classification of several indicators, which makes assessments a determining element of learning. So the participants must bear in mind that the assessment begins before the game, is applied while the game is underway and continues when the game has ended (Michael & Chen, 2005).

In order to compare the results of the three experiments, setting mechanisms for assessing or measuring the creative result formed part of the game design and served to check whether competing actually stimulated creativity. Fair play and equality had to be guaranteed with the game conditions, such as resources or time, so that the assessment only depended on the participants' learning, experimentation and the ability to combine knowledge, creativity and resources. The assessment also allowed to see if the construction of prototypes helped to improve or achieve better designs and if performance in the game was affected. During the game, obtaining a better result meant exceeding a minimum threshold and approaching the optimum of the set goals.

Classic metrics to assess creativity usually include the following dimensions: novel, useful and feasible (NUF) (Kudrowitz & Wallace, 2013). Other metrics were designed to measure and assess dimensions based on goal achievement (López-Forniés et al., 2017; Shute & Rahimi, 2021). In the three presented experiments, the creativity assessment was linked with the novel dimension, and the prototype assessment was linked with the useful and feasible dimensions, but goal-based metrics were also needed. Both kinds of metrics allowed the experiments in which the game forms part of the learning activity to be compared, for example, between the first and second experiments and the experiments that valued meeting certain goals thanks to prototype performance, as between the second and third experiments.

The basis for both metrics (NUF and goal-based) applied to the three experiments, as seen in Table 1.2, was the metric by (Kudrowitz & Wallace, 2013), in which each dimension was rated on a 3-point Likert scale (2 = yes, 1 = somewhat, 0 = no). Designs were independently assessed by teachers. The same range was used with a 3-point scale, but avoided the vague *somewhat* score, and each

Table 1.2 Creativity scoring rules (NUF and goal-based). Assessment conditions for each experiment

Dimension	Bionic design challenge (BDC)	Picking up balls (PUB)	Tape dispenser (TD)
(N) Novel	The concept is novel 1C and/or inspired in nature 2C	Original idea in group 1C and/or market 2C	Original idea in group 1C and/or market 2C
(U) Useful	After the integrity of balloon 1C and/or structure 2C remains	The artefact proves utility 1C and functionality 2C	The artefact proves utility 1C and functionality 2C
(F) Feasible	The artefact proves feasibility 1C and/or viability 2C	The artefact proves feasibility 1C and/or viability 2C	The artefact proves feasibility 1C and/or viability 2C
Goal 1	The artefact integrity remains #1, and the balloon is safe #2 after falling	The artefact picks up all the balls #1, and in less than 30 seconds #2	The artefact can measure #1 and is precise #2
Goal 2	The artefact is inspired in nature #1 and is well-founded #2	The artefact picks more than Qb_3 balls in 30 seconds #2, less than Qb_3 but more than Qb_1 #1, less than Qb_1 #0	The artefact can cut #1 and safety #2
Goal 3	The artefact is feasible #1 in a simple manner #2	The artefact picks the whole lot in less than Qs_1 seconds #2, more than Qs_1 but more than Qs_3 #1, more than Qs_1 #0	The artefact is easy #1 and intuitive #2 to operate (video evidence for number of operations)
Goal 4	The artefact is aesthetically pleasing #1 and related to nature #2	The artefact uses fewer than three components #2, uses three or four components #1, more than four #0	The artefact uses fewer than three components #1, and materials are recycled #2
Goal 5	The artefact #1 and the presentations #2 are humorous		

dimension was conditioned in such a way that if two conditions were met (in Tables 1.2 and 1.4 → 2C), the score was 2; if only one was met (in Tables 1.2 and 1.4 → 1C), the score was 1; and if none was met (in Tables 1.2 and 1.4 → 0C), there was no score. If the goal assessment met the main condition, it scored 1 (in Table 1.2 → #1); if it fulfilled it outstandingly compared to the other designs, it scored 2 (in Table 1.2 → #2); otherwise the score was 0.

From the novel dimension, two conditions were applied if it was more original than the participants' designs, and also in relation to the market or existing products, when it scored 2 points. If it only met one of the two conditions, it was scored 1 point, and 0 if it did not meet the two. The useful and feasible dimensions scored in the same way, with two conditions proven by prototype performance according to its operation and construction.

In the goal-based assessment applied in PUB, ranges were obtained thanks to quartiles, with a score of 2 when the assessed dimension was maximised Q_3 or minimised Q_1, with a score of 1 when it was halfway between quartiles Q_1 and Q_3 and with a score of 0 when the dimension to maximise was below Q_1 or above

Table 1.3 Polling by participants for the bionic design challenge

	Concept	Resistance	Bionics	Viability	Aesthetics	Fun	Total	%	Rank
G1 Herizont	Suricata	Fail	13	4	13	10	40	14,3	3
G2 Kiwi Peace	Cefalosaurus	Fail	–	–	14	23	37	13,2	4
G3 Rumanian	Armadillo	Fail	2	14	2	5	23	8,2	7
G4 Pulling Point	Armadillo	Pass	8	15	5	–	28	10,0	5
G5 Bushteam	Baby skull	Fail	25	26	1	2	54	19,3	2
G6 *Stegosaurus*	Kingfisher	Fail	7	3	5	12	27	9,6	6
G7 Bionic State	Grapefruit	Fail	15	8	30	18	71	25,4	1

Q_3 in the dimension to minimise. The goal-based assessment for the TD experiment was somewhat more subjective because it included no precise measures.

Only in the BDC experiment was the assessment open to the participants to encourage play and fun because it involved no evaluation or academic reward. Peer assessment-based game development also helped them to improve their in-depth thinking, creativity and learning motivation (Hwang et al., 2014). However, the organiser acted as an impartial judge to avoid irregularities that could favour or harm a group. Each group had 50 points, 10 points for each of the five categories. During the categories polling, each group had to distribute 10 points among the other groups and was able to award 10 points to one group and none to the rest. Polling was done secretly and then read aloud category by category. This polling system, like Eurovision (DitzyNizzy, 2021), means that the final part of the challenge is great fun and participants attempt to condition polling by showing certain dispute and ironical arguments. The summary of the votes from the seven groups is shown in Table 1.3.

Achievements and Interpreting Them

Artefact-based learning is a way to defend an idea and demonstrate how it works, which allows students and the teacher to discuss the design by reinforcement learning and improving the design from errors in the finished tests. The game also allows the inclusion of two factors of interest; the first is the stress or pressure generated by having to compete; even in challenges in which a record is set by an attempt (distance, time, tokens, points, etc.) for each artefact, in the end, a classification is generated in which the participants can see their rank, which shows the validity of their design, the success of the design decisions made in conceptual phases and their participation performance, which are transformed into academic marks. Secondly, there is the ludic and playful factor, which camouflages learning in the game. During the challenge, the participants forget about the academic component and focus on

Table 1.4 Summary of the results for the three experiments

	Bionic design challenge (BDC) (22 people, 7 cases)						Picking up balls (PUB) (73 people, 37 cases)						Tape dispenser (TD) (79 people/cases)					
	2C	%	1C	%	0C	%	2C	%	1C	%	0C	%	2C	%	1C	%	0C	%
Novel	Novel idea and based on nature						Original idea in the group and/or market						Original idea in the group and/or market					
	3	43	4	57	0	0	3	8	8	22	26	70	6	8	55	70	18	22
Useful	Balloon and structure integrity remain after impact						Artefact has proven utility and functionality						Artefact has proven utility and functionality					
	1	14	5	71	1	14	15	41	20	54	2	5	17	21	52	66	10	13
Feasible	Artefact has proven feasibility and concept viability						Artefact has proven feasibility and concept viability						Artefact has proven feasibility and concept viability					
	3	43	1	14	3	43	7	19	30	81	0	0	13	16	66	84	0	0
Goal 1	Higher impact resistance						Pick up the whole lot						Measure and/or precision					
	1	14	5	71	1	14	5	14	29	78	3	8	60	76	18	23	1	1
Goal 2	Best bionic design						Number of balls in 30”						Cut and/or safety					
	3	42	2	29	2	29	10	27	19	51	8	22	23	29	56	71	0	0
Goal 3	Most feasible						Time to pick up the whole lot						Easy and/or intuitive					
	3	42	1	16	3	42	9	24	19	51	9	24	44	56	35	44	0	0
Goal 4	Most aesthetic						Number of components						Minimum components and/or material					
	3	42	2	29	2	29	13	35	22	59	2	5	19	24	53	67	7	9
Goal 5	Offers the most fun																	
	3	42	2	29	2	29												

participating. This comes over more evidently in the BDC experiment than in the PUB competition where no academic assessment is linked with an academic mark, and the game is played on 1 day when everyone applies prior learning about design bionic, enjoys a good working environment and shares fun time.

One inconclusive aspect is that the process leads to artefact construction and its validation. In both the PUB competition and the TD experiment, the time allowed to build the artefact was about 4 weeks, during which time the participants had to propose conceptual solutions, make design decisions, build previous artefacts for testing, edit their designs to improve them and construct the artefact with which they had to achieve academic objectives and competition goals. Some of the participants made decisions quickly and failed, but had more options to learn from their mistakes and to stimulate creativity (Tahirsylaj, 2012). Others attempted different conceptual solutions to compare performance and to make decisions based on results and not on intuition. Artefacts helped to convert intuitive creative thinking into rational creative thinking so that imagined ideas could be validated by transforming them into something physical to be tested. The recommendation for the participants in the different experiments was to always seek alternatives and validate them with artefact tests. However, some participants risked everything with a single option. If the intuitive idea worked, they took it as being valid without further exploring it. So they opted for the first idea and ignored the critical learning process through failed attempts (Matson, 1996), which means that they had stopped learning this lesson.

From a qualitative perspective, it can be stated that the construction of artefacts was an academic objective achieved by all the participants and materialising the idea was, therefore, an achieved learning outcome. The level of finish, functionality and precision in performance vastly varied, but they were able to demonstrate what the presented idea contributed, its operation and feasibility, its number of components and its easy use.

Twenty-two students in seven groups participated in BDC, where the diversity of ideas and concepts was high, and were all inspired in nature. Only two groups chose the same living being to solve the helmet problem, but with different applications. However, their ideas were not entirely original as some concepts were based on precedents and application cases in marketed products or the scientific literature. All except one maintained helmet integrity after impact, and only one managed to prevent the balloon from bursting. The fact that there was only one attempt made it impossible to correct errors and improve artefacts, which rendered it very limiting in design improvement terms, but responded to limitations in a 6-hour competition. Three of the proposals could feasibly become products. However, three other proposals would prove very hard to develop due to lack of current technology. The learning achieved with these three proposals lay in the fact that, despite being able to build a prototype in an artisanal manner, reality ruled out its industrialisation potential. Figure 1.3 shows the artefacts made for launches. Pictures were taken during the second round, during a presentation before the final vote and the stress test.

Seventy-three people participated in PUB and made 37 artefacts. To analyse the creative dimension of novelty, 12 conceptual groups participated, of which 3 were unique in the group and presented state-of-the-art novelty. Eight of the other artefacts included in three conceptual groups presented minimum repetition, and two or three cases demonstrated novelty but were similar to one another. Finally for 26 cases in 6 conceptual groups, the creative contribution was poor because artefacts were similar and they repeated ideas that already exist in the state of the art, such as excavator shovels, norias, draft or drag shovels, fishing nets, pincers, tweezers, etc. Regarding usefulness and functionality, all the artefacts displayed the operation that was conceptually proposed, and only two artefacts broke during the competition from lack of trials. The participants had the opportunity to repair their artefact to compete again and obtain their mark. More doubts about feasibility arose, but the possibility of making the artefact was demonstrated, and only part of the artefacts made sense as products for collecting particles in a real environment. Those who thought about specific device applications came closer to viable products. Some applications had to do with rubbish collection on beaches and seabeds, games or toys with balls or sports applications. Other ideas about the collecting balls application were not developed to become a real product or an application for the market. Figure 1.4 shows the built artefacts. Models a, b, c and d operated similarly as they

Fig. 1.3 Presentation of helmets that participated in the challenge

were based on the deformation and plastic recovery of material, albeit in different configurations: mesh, in a point like a sphincter, aligned on a plane or aligned around an axis. Others were based on pushing, dragging, pinching or sliding (examples e–k).

The competition rules allowed varied concepts and different collection strategies, with a balance between speed and the amount of balls collected in each attempt. If winners achieved both goals, e.g. collect all the balls at once and in a record time of 13 seconds, it showed that the proposed creative solution enabled both goals to be achieved. In other cases, e.g. collecting in small groups, or one by one, had to be compensated by performing very fast actions during each attempt to prolong the total time. Figure 1.5 shows a design with a centrifugal operating principle that collected a few balls and the competition ring and the collection mark with the remaining balls after the first 30 seconds. Quick actions did not compensate the collection strategy in small groups.

Seventy-nine people participated in TD, each with their artefact. When analysing the creative dimension of novelty, only a few offered a differentiated contribution to the group and the market. Despite the fact that the added function of measuring was already something new, the presented measurement systems were not very original, but based on other measurement systems, such as tape measures, rulers, modules of pre-established distances, lap counters or cylinders with marks or numbers. Figure 1.6 depicts some examples. For utility and functionality, all the artefacts demonstrated the conceptually proposed operation. Artefacts' finish is an important

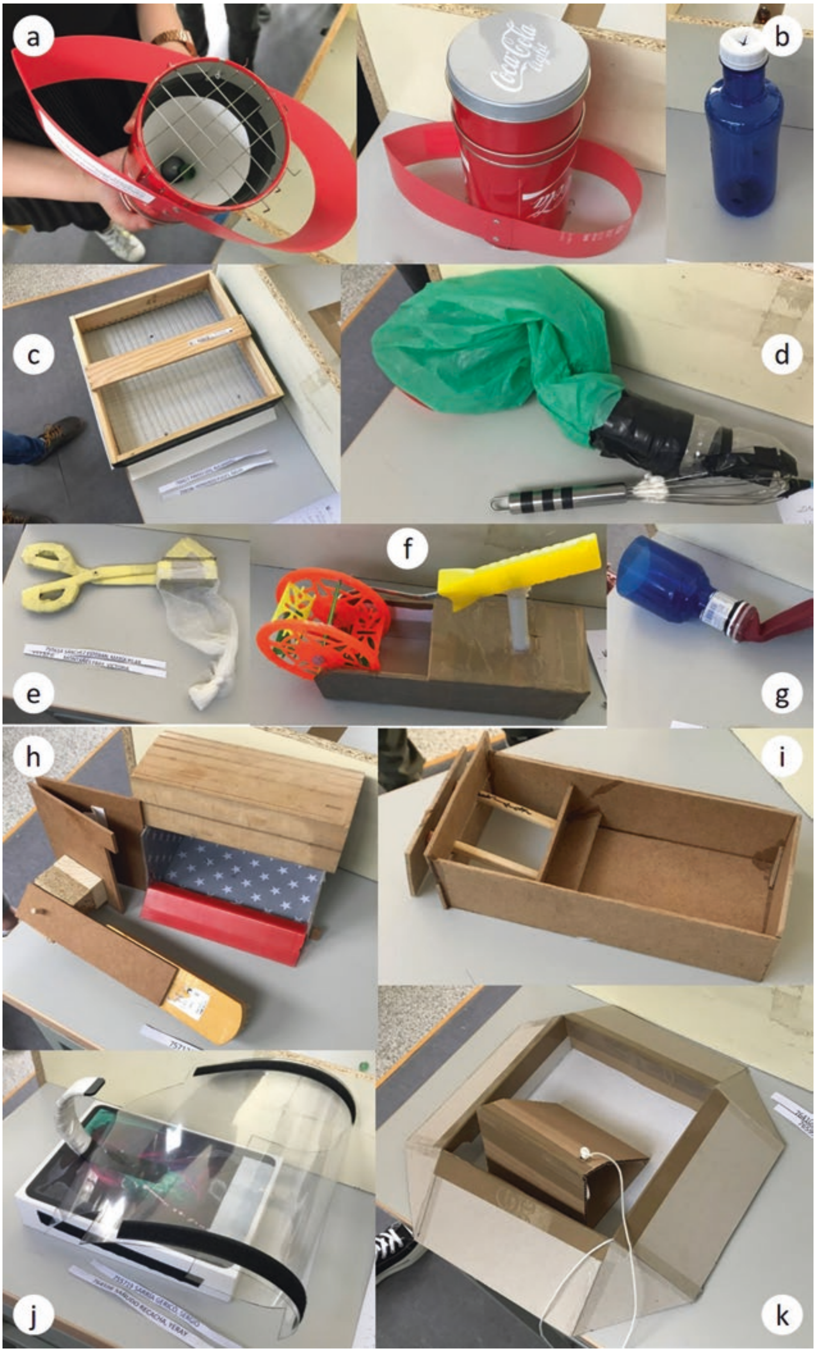

Fig. 1.4 Examples of artefacts built for the PUB competition

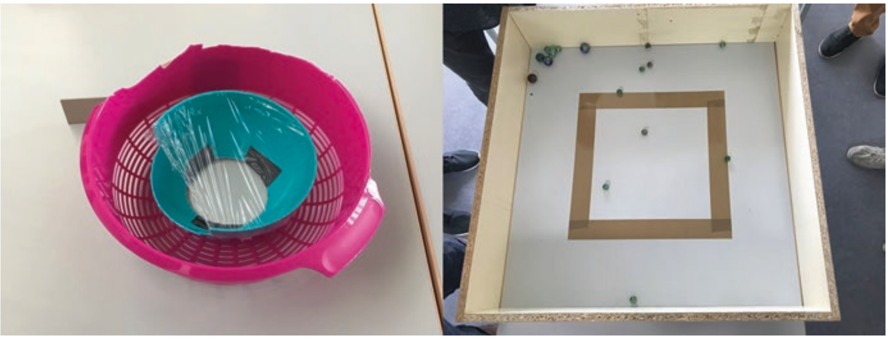

Fig. 1.5 Example of an artefact with centrifugal action and a competition ring with the collection area limits (brown lines)

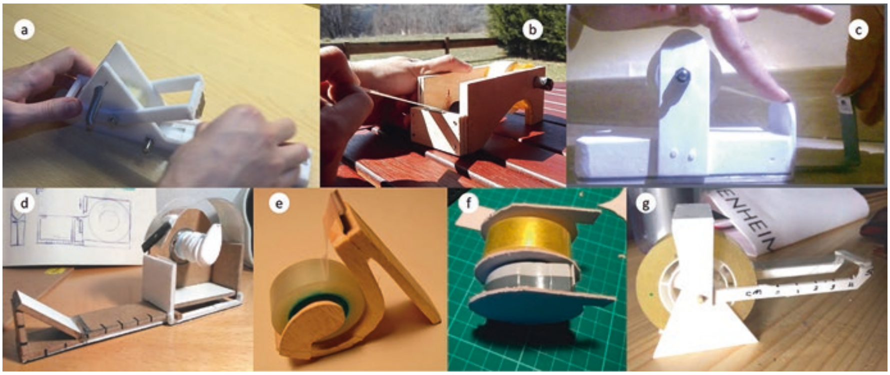

Fig. 1.6 Examples of TD artefacts showing hand use and different cutting systems

factor in the operation and there were problems while using some. Some designs were difficult to use because they required two-handed use or could be dangerous because of a cutting element being exposed. These factors were related to the goals of a second condition: obtain better results and provide feedback to the participants about improving their designs to develop real products. Regarding feasibility, once again they all demonstrated the possibility of building an artefact that worked, but only some could become viable products for the real market.

From a quantitative perspective, the following differences were observed in the experiments carried out, which are reflected in Table 1.4. Comparing the NUF metric to the goal-based one allowed a better assessment because goals were the determining factors of design or the game itself. The NUF dimensions should be restrictive and mandatory, at least for one of the conditions: assessing by means of the game's goals with measurable and quantifiable dimensions. Failure to meet at least one condition was a fail, the exercise had to be repeated and the participants learned from their mistakes. In PUB and TD, 70% and 22%, respectively, did not meet either of the two conditions for the novel dimension. This confirmed that only some solutions were genuinely original, 8% in both cases. For the useful and feasible dimensions, the compliance values were acceptable, but with low values for noncompliance under both conditions. These data indicate the need to make assessments according to the goals achieved in the game or competition, as long as the NUF minimums are met. This assessment would be fairer and allow a broader and more differentiated distribution of marks between the best and worst results.

The goal-based assessment carried out by the teacher in BDC was fairer than groups of students voting (Table 1.3). Some concepts were not scored on any dimension, and the difference between the best and worst was large and did not correspond to reality. Peer voting can be interesting to assess part of the project and to acknowledge classmates' work. Dialogue can also be established with which to make corrections that reinforce learning.

When comparing the PUB and TD experiments by goal achievement, it clearly came over that the results in TD were better because it was a matter of meeting a condition or not. So 0C percentages were very low, or even zero. However in PUB, the conditions that were more closely related to precise measurements (number of balls in 30″ and time to pick up the whole lot) led to higher 0C percentages compared to those dimensions with more elementary conditions (pick up the whole lot or the number of components). Using mathematical functions, such as quartiles, implied that the assessments with precise measurements better represented reality and allowed to adjust student assessments in an objective and measurable way. The only objection was where to set the threshold for each dimension to decide whether or not students had passed. It is also necessary to create custom metrics as each experiment differs and the metric to validate the metric's effectiveness must also be different (Takai et al., 2015).

Regarding students' academic results, there was no difference in the marks obtained in similar exercises performed in previous academic years, when game-based learning was not included. By comparing the PUB and TD marks, the average ones were 7.0 and 7.3, with maximums of 8.8 and 9.3 and minimums of 5.2 and 5.4, all respectively. Marks were slightly lower in PUB than in TD because the assessment was based on measurable and precisely quantifiable dimensions in relation to the condition-based assessment.

In other similar experiments to TD, more precise measurements, use and toothpaste or rice dose were tested, with similar results to PUB and the only difference lying in including competition or games. So it would seem that game-based learning does not vary or limit learning outcomes and assessments. It is necessary to collect data from the TD experiment to make the conditions of the precision, security or usability measurement goals comparable to PUB, run experiments in PUB without competition and draw conclusions about whether game improves results and assessments.

Conclusions

Our experiments of creative challenges applied to design artefacts showed that creativity was stimulated without affecting the learning outcome, which was successfully achieved. Neither were academic results markedly affected, with minimum variations in grades. More motivation was detected in most of those students who took a positive attitude and shared a good environment with their classmates. Some students showed disinterest, usually with difficulties in constructing artefacts, and they habitually took the first valid option and settled for a pass mark. However, these data were not quantified.

Proofs of concept were not definitive, but should be taken as evidence for performance, which will improve when a larger number of experiments and tests are performed to set learning. The development of artefacts that can be improved and updated allows escape from intuitive thinking, which is supported by paper to error-based learning to do more tests to improve records and optimise artefacts.

The assessment with NUF metrics is less important for assessing concepts than goal-based metrics, but they must be applied as game and design project conditions to exceed the state of the art. Those based on goals are more precise but involve a more accurate definition and applying some kind of mathematical function to establish the final student ranking.

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Chapter 2
The Role of Instructional Activities for Collaboration in Simulation-Based Games

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Introduction

Success in life and work in today's knowledge society calls for novel approaches to support workplace learning. Technology, together with social networks, provides different levels of interactivity during the learning process, increasing the participation of learners and resulting in more active learning (Lytras et al., 2018). Autonomous and socially actionable competence and resources deriving from belongingness to a sociocultural community can also be seen as outcomes of learning processes (Kira et al., 2010). The use of technologies in the learning process not only supports students' and workers' learning processes but also the development of values, which are important for a sustainable society (Daniela et al., 2018). While technology-enhanced learning can be designed or reimagined and delivered based on principles, values and aspirations of sustainability, the promotion of sustainability in the community requires socially inclusive participation (see Hays & Reinders, 2020; Lytras et al., 2018, 16). Game-based learning (GBL) environments can be employed as pedagogical contexts for fostering sustainability.

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In recent years, GBL environments have been discussed extensively as pedagogically sound contexts for providing unique learning experiences in various school and work life contexts (e.g. Amory et al., 1999; Barab et al., 2005; Ravenscroft & Matheson, 2002; Prensky, 2003; Rieber & Noah, 2008; Kiili, 2005; Tynjälä et al., 2014). Against this background, we introduce GBL environments as fruitful settings for collaboration. However, despite this potential, there seems to be a lack of research-based knowledge concerning if, how and under which circumstances instructional activities are beneficial to collaboration in the context of simulation-based game environments. Therefore, in our empirical study, we set out to probe into how pre-game and during-game instructional activities contribute to collaboration in a simulation-based learning game.

Collaboration in GBL and Simulation-Based Games

GBL refers to a learning approach that involves a game environment with components of learning operations (e.g. practising, inspecting, communicating) to improve particular domain-related knowledge (e.g. English, business) and obtain expertise, where operations regularly deal with problem-solving and aim to enhance participants' experience of their achievement (Emerson et al., 2020). The literature on GBL has highlighted several positive educational outcomes of the application of educational games, such as providing the opportunity to offer learning experiences that are inspiring and effective (e.g. Yang, 2012) or practising skills and competences that are difficult to learn/understand (e.g. Ronimus et al., 2014; Koskimaa & Fenyvesi, 2015) and/or dangerous to do in real life (e.g. construction safety, Hämäläinen, 2008; aviation games, Proctor et al., 2007).

In accordance with these investigations, simulation-based games for educational purposes have demonstrated their potential for, for example, improving the participants' knowledge, skills and motivation regarding instruction (Papastergiou, 2009). In contrast, researchers have also raised a concern that in addition to individual learning, educational learning games could exploit the full potential of the social aspects of playing, as is often done in entertainment games (Hämäläinen, 2008). Next, we will discuss how games are beneficial for collaborative learning (see Lainema 2014; Lainema and Nurmi 2006; Lämsä et al., 2018; Oksanen et al., 2017).

Papastergiou (2009) postulated that educational game environments provide a fruitful context for collaborative learning and shared knowledge construction via social interaction, which is a pivotal attribute of online environments. Under the circumstances, the success of learning in GBL environments is dependent upon the quality and effectiveness of the interaction between participants. Thus, learning games involving multiple participants can serve as contexts for interactive and collaborative learning and provide social experiences that may promote high-level knowledge construction and learning (De Freitas & Oliver, 2006; Bluemink et al., 2010). Furthermore, novel technological advances enable the design of increasingly delicate and pedagogically accurate GBL environments (Rieber & Noah, 2008;

Lainema, 2004). In sum, GBL seems to offer vast opportunities to learn and to contribute to the process of knowledge construction (see also Daniela et al., 2018).

Related to this potential, studies have increasingly focused on developing a better understanding of the various collaboration processes that take place during simulation- and/or game-based environments. For example, according to Andrews et al. (2017), different interaction patterns can be identified in simulation-based games. Andrews-Todd and Forsyth (2020) explored different social and cognitive dimensions of collaboration in the context of simulation-based tasks. Furthermore, Hao et al. (2015) assessed collaborative problem-solving in simulation-based tasks, and Martínez-Cerdá et al. (2018) investigated the effects of games and other technologies on collaboration skills. Additionally, decision-making processes have been in the focus of GBL. For example, Linehan et al. (2009) found that the game environment offers possibilities to rehearse, enhance and assess participants' decision-making processes. Studies have also emphasised that simulation-based games can be utilised to develop the reflective and interpretative skills of learners (Harviainen et al., 2014) as well as competencies needed particularly in twenty-first-century digital work, such as the ability to use technology and to evaluate information, flexibility and self-direction. While all these approaches are vital for the development of high-level simulation-based games, less is known about instructional activities in these contexts. Therefore, we will next discuss the role of instructional activities in the context of simulation-based games.

Instructional Activities to Trigger Collaboration

The challenges of creating high-level collaboration include not only the design of high-level simulation-based games (Buchinger & da Silva, 2018; Andreoli et al., 2017) but also the instructor's ability to inspire and engage learners towards collaboration (Ingulfsen et al., 2018). Typically, instructional activities combine design and improvisation in that the curriculum frames the starting points for learning, the learning environment affords collaboration and the instructor's pre-design structures the learning process while leaving space for real-time flexibility (Hämäläinen & Vähäsantanen, 2011). Therefore, we need to understand if, how and under which circumstances the instructor's instructional activities are helpful for triggering and supporting students with the game content or problem-solving (Molin, 2017; Vangsnes & Økland, 2015). In relation to the temporal dimension, these instructional activities have been categorised into three main groups of pre-game, during-game and post-game phases of the learning process (Bado, 2019) (see Methods section Fig. 2.2).

There are divergent methods to execute pre-game, during-game and post-game instructional activities. The instructional activities before the actual game session may involve instructions and training (e.g. Kangas et al., 2017) and may primarily aim at preparing participants with the technology, content (Bado, 2019), game rules and the overall aim of the game. These instructional activities executed by instructors before actual gameplay may ensure that participants reach joint orientation for completing game-related tasks and objectives. Moreover, pre-game instruction may entail collaboration scripting (Hämäläinen, 2008; Van der Meij et al., 2020), handouts and readings (Zold, 2014; Bawa et al., 2018; Maguth et al., 2015), game manuals (Jong and Shang, 2015), instructional videos (Bado, 2019), lectures (Panoutsopoulos & Sampson, 2012; Poli et al., 2012; Liu, 2016) and a schedule for the learning event (Meluso et al., 2012). There is still uncertainty, however, how pre-game instructional activities contribute to collaboration amongst the participants.

During-game instructional activities can be applied in GBL environments and may entail providing technical support to the students (Vangsnes & Økland, 2015; Vasalou et al., 2017; Whalen et al., 2018), controlling the time and progress of the task (Tüzün et al., 2009) and managing the student teams' divisions of labour, such as in regard to who controls the keyboard and ensuring that team members are contributing equally to the mutual task (Bado, 2019). Haruehansawasin and Kiattikomol (2018) found that in successful GBL settings, the instructor's role as the facilitator of learning and the gameplaying process is to trigger the players' learning with the help of particular activities, such as offering timely assistance that originates from the students' needs, encouraging participants to contribute to discussions, offering instructional materials and giving instant feedback. Moreover, during-game instruction is implemented to help students experiencing difficulties with the game content or problem-solving (Liu et al., 2011; Hämäläinen & Oksanen, 2014). An additional aim of during-game instruction is to ensure an enjoyable and productive experience for the students during gameplay, and therefore these activities are frequently employed particularly in simulation-based games (Bado, 2019).

The post-game instructional activities usually involve debriefing after the game session to reinforce and build upon the knowledge acquired during gameplay (Lederman, 1992; Kangas et al., 2017). Debriefing can be executed as discussions amongst teams (Franciosi, 2017), as discussions between teacher and students (Jong & Shang, 2015), as homework in class with the instructor or as reflection texts written by the students after the gaming session.

While simulation-based games create fruitful contexts for collaborative learning, there seems to be a lack of research-based knowledge concerning how instructional activities are beneficial to collaboration in the context of simulation-based game environments. This study grounds the notion that a more in-depth examination of instructional activities is needed in order to better understand the relationships between the instructional activities (Bado, 2019) and the shared learning process in a multiplayer GBL environment. Therefore, we set out to probe into *how pre-game and during-game instructional activities contribute to collaboration in a simulation-based learning game*.

Methods

RealGame Simulation-Based Business Game Environment

RealGame is a dynamic, clock-driven simulation-based business game which represents the supply chain and the order-delivery processes of a manufacturing company (Lainema, 2003). Effectively, RealGame depicts an enterprise resource planning (ERP) system. The purpose of the game is to manage the simulated company and its supply chain in the game environment. Participants work in teams and purchase raw materials from the simulated raw material markets, manage their manufacturing and warehousing processes and deliver their products to simulated customer markets, meaning that teams compete for the same customer orders (see Romero et al., 2012). The aim is to streamline the company's operations and supply chain and to improve the company's performance in light of selected key performance indicators (KPIs).

In RealGame, the participants continuously make decisions on purchases, warehousing, production, deliveries and invoicing and can follow the operations and material flows of their (simulated) company in real time on their computer screens (see Fig. 2.1). This means that all operations taking place in the game are immediately visible to the participants. Events in the game proceed continuously, which demands that participants work in close collaboration and pay attention to several operational and strategic decision-making areas simultaneously. These decisions comprise, for example, which components to order, at what price and terms of delivery, which manufacturing lines to run and on how many shifts and which markets and customers to serve, amongst others. The performance of each company is assessed based on different KPIs, such as profitability, market share, production and raw material costs and inventory level.

Fig. 2.1 RealGame user interface

The transparency of operations and the cause-effects of decisions taken provide a dynamic view of how a business organisation functions. Consequently, RealGame provides an authentic learning experience illustrating the complexity of real-world business operations in a realistic manner (Lainema, 2004).

Instructional Activities in the Simulation-Based Game Session

A few days before the simulation game, session participants were divided into teams of two to three. The participants were experienced specialists and middle managers representing ten organisations from various industries ranging from steel, chemical and forest industries to education, media, wholesale and IT. The participants had diverse backgrounds and, thus, different types of knowledge.

One of the authors ran the simulation game and performed as a tutor the simulation game session. Before the actual game session, the tutor provided the teams with a game manual as a PDF file and a web link to a self-learning video by email. In the email, the participants also received information about their teammates as well as the timetable for the gaming session. The participants were encouraged to familiarise themselves with the instruction. However, as this was not controlled by the tutor, it was left to the participants' own initiative to prepare for the game.

Instructions before the game were delivered by email to the participants a week in advance. Links to Microsoft's *Teams* meeting software and the RealGame simulation game were emailed to the participants the day before. On the simulation day, the tutor first summoned all the participants in a joint *Teams* meeting to welcome everyone and to go through the timetable and practicalities regarding the gaming session. Specific organisational roles were not assigned to the participants. Instead of scripting the participant roles in the teams (Kobbe et al., 2007; Heinonen et al., 2020), the teams were allowed to spontaneously and autonomously organise their collaboration (Stahl, 2010).

During the game, the tutor provided two types of instruction. First, the tutor provided the teams with instruction through the game's own communication channel. The tutor sent pop-up instructions to the teams so that the instructions appeared as messages on the simulation users' game user interface. Second, halfway through the simulation session, the tutor summoned the teams to the joint *Teams* meeting to go through interim results and receive feedback on the teams' performance in the game. Additional pedagogical elements in the game included the tutor's written feedback via email after the game. Feedback after the game, however, remains outside scope of our treatment. Instead, we focus on examining the following pedagogical elements: instruction before the game, pop-up instruction during the game and the interim results session during the game (Fig. 2.2).

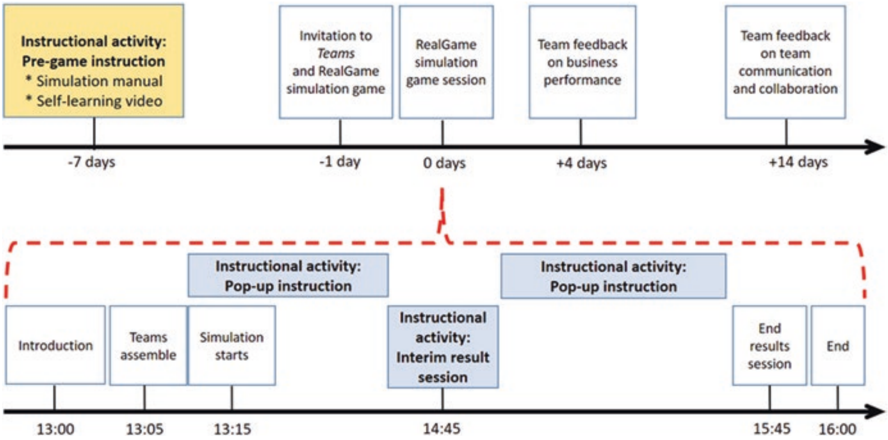

Fig. 2.2 Instructional activities in a RealGame session

Participants, Data Collection and Analysis

In this study, we focused on examining the role of instructional activities in regard to collaboration in the simulation-based game environment of RealGame. In our research setting, ten teams with two to three participants on each team took part in the simulation game in altogether three gaming sessions, with three to four teams in each session. All teams were geographically dispersed, meaning that the participants joined the game from their own locations with their PCs via Internet and communicated using Microsoft's *Teams* meeting software, enabling synchronous communication within the team.

Data collection was part of a larger research project targeting digital work, digital skills and wellbeing in digital work. Three of the authors were involved in designing the gaming event as well as collecting the data, which was organised and analysed by two of the authors.

During the simulation game, we collected screen capture data and audio materials from the teams, which allowed for tracing the role and influence of the pedagogical elements in regard to collaboration and teamwork. The data corpus comprised over 30 hours of recordings. The screen capture data were stored according to the university's data handling policies and could be accessed only by designated researchers. All participants were informed of the study and gave their written consent to participate in the study.

Data analysis was conducted by two of the authors. In particular, the analysis focused on examining the role and influence of the three selected pedagogical elements in the simulation game – instruction before the game, pop-up instruction during the game and the tutor's feedback in the interim session. While post-game activities, such as debriefing, have been found beneficial for learning (Lederman, 1992; Garris et al., 2002), they are omitted from our analysis as we concentrate on looking at those instructional activities that have importance for teamwork and collaboration. Our analysis thus focused on detailing how pre-game and during-game instructional activities were reflected in the teams' communication and collaboration while engaged in the simulation-based business game.

In the analysis, we employed a qualitative content analysis (Patton, 2015; Krippendorff, 2004) through three main phases of preparing, organising and reporting data (Elo & Kyngäs, 2008). Two researchers participated in this iterative analysis process by coding manually entire data set. First, in the preparation phase, all ten screen capture recordings were viewed several times by the researchers to obtain an understanding of the data as a whole. The unit of analysis for the current investigation was the entire dialogical episodes between participants in the multiplayer gaming situation. Based on the focus of this study, specific episodes were marked in the data to be examined in more detail. These episodes comprised the instances of teamwork at the beginning of the game, events after the pop-up instruction in the game and events after the tutor-led feedback session halfway through the game.

Next, in the organising phase, subsequent rounds of analysis were executed, and marked episodes were allocated into condensed units of meanings and compared with each other in light of their content and context. After various iterative rounds of scrutinising the screen capture data, we selected specific samples of the data for a more detailed analysis. Based on this progressive process, we aimed to understand these arrested samples from the view of the participants' collaborative simulation-based game session and in the context in which the dialogical episodes emerged. Afterwards, we juxtaposed interdependent aspects of various meanings and grouped similar meanings alongside each other. Finally, in the reporting phase, two main categories and nine subcategories were composed through careful discussions and close collaboration with two of the authors.

Researcher triangulation and data extracts demonstrating the results of the analyses were employed to support the trustworthiness of the analytical process. The analysis was conducted in the original language, Finnish, with a shift to English to produce the report. Illustrative data extracts were translated, and the translations were double-checked in collaboration of two researchers. Moreover, in order to protect participants' privacy, all participants' names were pseudonymised at this stage.

Findings

In this study, from the qualitative content analysis, two main categories emerged, as follows: (1) pre-game instructional activities that consist of five subcategories of *accelerating roles and responsibilities*, *building a common understanding*, *expediting the decision-making process*, *initiating meaningful communication* and *increasing knowledge sharing and co-creation* and (2) during-game instructional activities that consist of three subcategories of *directing the participants' attention to important aspects*, *advancing equal participation* and *fostering rich and dialogical communication* (see Table 2.1). These two main categories with their subcategories are

Table 2.1 Temporal and pedagogical dimensions of instructional activities for simulation-based game collaboration

Main categories Temporal dimension of instructional activity	Instructional activities	Subcategories Role of instructional activities in simulation-based game collaboration
1. Pre-game	Game manual Self-learning video	1.1 Accelerating adopting roles and responsibilities 1.2 Supporting building a common understanding 1.3 Expediting decision-making process 1.4 Initiating meaningful communication 1.5 Increasing knowledge sharing and co-creation
2. During-game	Pop-up instructions Interim results session	2.1 Directing the participants' attention to important aspects 2.2 Promoting team members' equal participation 2.3 Fostering and maintaining rich and dialogical communication 2.4 Supporting reflecting on team performance in comparison to other teams

described below together with extracts to further illustrate the qualitative data, hence illuminating the role of instructional activities for collaboration in a GBL setting.

Pre-game Instructional Activities

In general, our results indicate that implementing pre-game instructional activities, such as the game manual and the self-learning video, promoted the participants' teamwork and collaboration at the early phase of the simulation-based business game. First, the results show that these pre-game instructional activities triggered teamwork in relation to group dynamics and processes by *accelerating adopting roles and responsibilities* within teams. For example, participants who had gone through the instructional materials before the game session were more knowledgeable on the game content than the less-prepared team members. Hence, these participants were also keener to take an organiser or initiator role within their team. These roles were self-organised and emerged at a very early stage of the GBL process.

Second, it seemed that the pre-game instructional activities supported participants in *building a common understanding* with their team members. The following extract illustrates how one well-prepared participant actively checked her team members' prior knowledge by asking questions and guiding and sharing information with the others to ensure that they reached a consensus concerning the game content, rules and the overall aim. By advising others how to play the game, the participants aimed to confirm that they have shared goal orientation in order to work together and proceed in the game as a uniform group:

Tuulikki	Erm, there was that instructional video and a document, and I viewed them kinda, what was in them and (.) Did you have a chance to take a look at what kinda is the purpose (*of the game*)?
Iivari	For my part I can say (.) I'm a tourist here, sort of (.)
Tuulikki	Okay. If I shortly repeat and summarise so that we can proceed in the game (---) Yea, so I browsed through the instruction, so as a summary, this firm manufactures an end product called BioCounter. And to manufacture this end product we need one Processor and one Scanner (---) So that was kinda the basic idea of what we'll be trying to do there (*in the game*).
Iivari	Mmmhy.

Furthermore, our findings indicate that pre-game instructional activities *advanced* particular game actions, such as the *decision-making process*. Hence, in teams in which all participants had acquainted themselves with the pre-game instruction, the participants were able to promptly proceed to the task at hand by first discussing the specific decision-making areas in the game and, after that, sharing knowledge for the basis of making decisions. Activity roles and responsibilities were shared amongst the participants through open negotiation. The next data extract illustrates how equally prepared participants shared their newly acquired knowledge from the pre-game instruction and how they used this information as a basis for making assessments and decisions on next actions for the gameplay, such as raw material needs in their game-simulated company:

Petteri	In the hint (instruction) they said 6900 devices in a month (---)
Jouko	Yea so it was, it was yea.
Liisa	Yea, exactly!
Petteri	So if we produce on this volume, then we get the quantities per day, what we need in terms of raw material.
Liisa	Yea.
Jouko	Yea it seems to have been 230 BioCounters, ja 170 Scanners. (---). And it looks like BioCounter is the main product. (---)

The above data extract shows how the pre-game instruction accelerated the team's game actions and fostered a levelled decision-making process within the team. In addition, teams with equal pre-game preparation could build their *knowledge sharing and knowledge co-creation* on a firmer ground than teams with only one well-prepared participant.

Furthermore, teams with equal preparation were also quick to identify areas that needed clarification. In the previous extract, Jouko mistakenly referred to 'Scanner' as a finished product that could be sold to external customers ('And it looks like BioCounter is the **main product**'). However, as explained in the pre-game instruction, Scanner was a semifinished product that would be used in production on the BioCounter production line. The next extract illustrates a discussion taking place approximately 1.5 minutes after the interaction sequence in the previous extract:

Liisa	Sorry but now I have to clarify: do we sell both BioCounter and Scanner, or both or how did this go again?
Petteri	No, no there is one and only one product to be sold.
Jouko	Oh, I see, I see, so that's how it was.

Liisa is confused by the comment made by Jouko in the previous extract ('And it looks like BioCounter is the **main product**') as she, too, has read the pre-game instruction where it is stated that the game company has only one end product. Therefore, Liisa seeks clarification on the issue by asking if there are two end products. Petteri assertively responds to Liisa's question, correcting the false claim made by Jouko (No, no there is **one and only one** product to be sold out). Jouko accepts Petteri's viewpoint and more or less admits his mistake.

Thus, equal preparation for the game by studying the pre-game instruction *initiated meaningful team communication* and provided the participants with a solid shared basis to collectively debate and contemplate the available information. Having a comparable level of prior knowledge of the game also provided the participants better opportunities for identifying misinterpretations and for correcting them in order to reach common understanding within their team.

Alternatively, teams with inadequate pre-game preparation suffered from the inability to grasp the essential elements in the game. This hampered the participants' possibilities to identify relevant aspects in the game and diffused their attention. As a consequence, the participants would be absorbed in discussions about the basics of the game, which, in turn, would restrain the team's decision-making. When the whole team was involved in discussing the same issue, decision-making was slow, and other equally important areas would be left out of scope.

At the same time, insufficiently prepared participants were at risk of being dropped out of the discussions and the joint decision-making processes as the better-prepared participants were considered more trustworthy. For example, when the team leader noticed that one participant did not have prior knowledge concerning the game content, she focused her discourse only towards the third team member, who expressed her knowledge and ideas. It seems that trust was established between team members who were able to communicate about the task on a similar level.

During-Game Instructional Activities

Pop-Up Instruction

Instruction through the game's own communication channel entailed pop-up instruction that appeared on the game user interface. The purpose of this instruction was to provide expedient and timely information about the game's functionalities and to focus the teams' attention on relevant decision-making areas in the game.

The next data extract illustrates how pop-up instruction is reflected in team communication and collaboration:

Jouko Here's a message 'Result of your company can be found under the clock (*on the computer screen*). All teams seem to have negative result, as the market is not yet properly awake' (--)
Liisa Yea here is the income statement.
Jouko I wonder if there was a kinda hidden message in that suggesting that if the market is not yet awake, so =
Petteri =should we manufacture goods to stock=
Jouko =to stock, so could we dare erm to run the machinery (*on the production line*) at a bit brisker pace (.)
Petteri [yea]
Liisa [do] it all right, and now an offer with lower price got sent, and more of these could be made.

The above extract illustrates how during-game instruction in the form of pop-up notifications helped in directing the participants' attention to the aspects of the game that were relevant in each phase of the game. As the game events were continuously unfolding on the participants' computer screens, there was little time to get familiar with all the features of the game during gaming. Instead, decisions needed to be made promptly and frequently. The pop-up instruction pointed out important areas to consider and fostered rich and dialogical team communication during which conclusions could be drawn and action plans developed.

The next extract illustrates how pop-up instruction helped a less meticulously prepared participant to assume a constructive and active role in the team:

Anni It says here now: 'Scanner production is first run in three shifts, the end product only in the morning shift'.
Mika We get Scanners (.) we have too many in stock (1)
Kalle [So we must stop them yea]
Anni [So we must stop the night shift] (.) Let's do it, shall we now send this order is everything ok with it.

As shown in the above data extract, the pop-up instruction paved the way for Anni to have the attention of her teammates. By reading the instruction in the pop-up window, Anni could initiate a discussion on a current issue regarding the management of the game company's supply chain. Anni's initiative immediately ignited a discussion, during which a problem was identified by Mika ('We get Scanners (.) we have too many in stock'), and relevant solutions were immediately suggested by Kalle and Anni. Concluding the discussion, Anni announced the decision ('Let's do it') and proceeded to deal with the next tasks in the game.

Pop-up instruction thus provided opportunities for the less-prepared participants to also focus the teams' attention to timely issues and to initiate knowledge-building activities as well as to assume a central role in drawing conclusions and taking part in decision-making sequences.

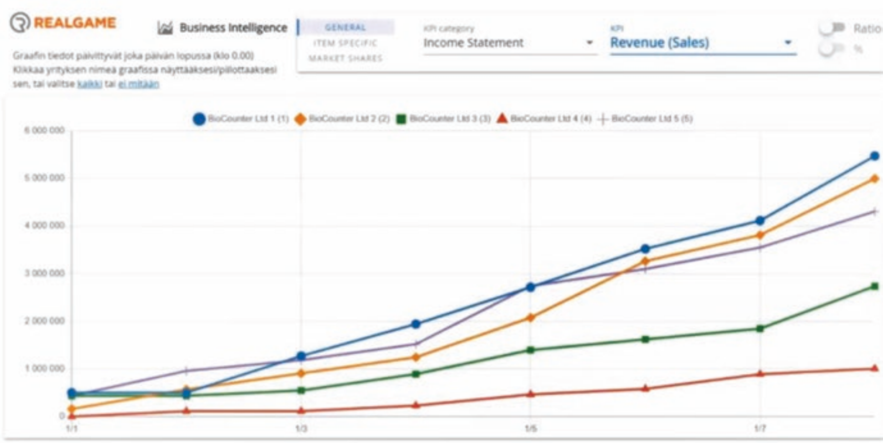

Fig. 2.3 Screenshot from interim results session. KPI: result (profit)

Feedback in the Interim Results Session

The interim results session was held by the tutor in the general *Teams* room and lasted about 15 minutes. The KPIs of all game companies reflecting the efficiency and fluency of managing the supply chain were displayed by sharing the tutor's screen with all participants in a graphical form, allowing comparison between the game companies (see Fig. 2.3). The KPIs were selected from the income statement (e.g. revenue/sales, gross margin, cash) and from the material process (e.g. inventory, delivery accuracy, manufacturing costs, waste). While going through the KPIs, the tutor pointed out differences in the game companies' performance and explained the factors affecting each KPI as well as potential reasons for good/poor performance.

After the interim results session, all teams returned to their designated *Teams* spaces and continued their team collaboration in the simulation-based game. The next data extract illustrates how participants utilised the content of the feedback session to analyse their team performance and to discuss potential areas for development:

Juha	Observations did you go through our KPI slash operations (gives a laugh)
Kaisa	Well not actually, I also only just returned online so that (.)
Juha	Okay (.) It seems though that they are going in the right direction, our KPI, almost [everywhere] that delivery accuracy must be grasped (gives a laugh) in kinda control.
Kaisa	[Yea, yea] Yea but I was wondering a bit about where it (.) and of course these (.) production costs.
Juha	Yea that is another one, yea (1) There is also a lot of waste.
Kaisa	I've kinda not noticed that deliveries would've been (delayed), but maybe there has been something (.) Delays on the way.
Juha	Yea yea, there's been something.

As shown in the data extracts, the feedback received in the interim results session could be used by the teams to discuss game strategy and to adjust their actions in various decision-making areas. The interim results session provided the teams with opportunities to *reflect on their performance in comparison to other teams* and to identify areas of good performance as well as areas for improvement. At the same time, the feedback helped to build connections between events by explicating the causal relationships between different areas in the game company, such as sales and results, and the feedback allowed for learning the generic business dynamics present in real-life commercial organisations. This way, the during-game instruction in the form of interim feedback fostered the teams' learning and knowledge building by showing how different functions and areas of a company affect each other.

In addition, the feedback during the interim results session triggered the identification of causalities between actions taken in the game and the outcomes in light of the KPI analysis:

Laura	(---) Yea we've actually been forced to buy them Processors with such a high price (.)
Iisa	Yea them we should actually not buy at all anymore.
Laura	[No no]
Iisa	[No] (2) And then also our average price in them is quite high (gives a laugh)
Laura	(.) Yea, it is.
Iisa	Now that we went through that (interim feedback session) one can read this (the game) again a bit better.
Laura	Yea (2) But waste we do not have. (---)

The above extract illustrates how participants were able to employ the instruction and feedback provided in the interim results session to analyse the performance of their simulation company and the consequences of their team's previous actions in the game. Also, participants made conclusions based on the information shown in the interim results and their own prior actions in the game. Clearly, during-game instruction in the form of interim results was beneficial for mutual reflection on cause-effect dynamics regarding the teams' actions and helped the participants to plan for future decision-making in the game.

Furthermore, the feedback helped to highlight the fact that since all areas in the game company are connected, the contribution of each participant in the team is much needed and valuable.

Concluding Discussion

Our study contributes to a discussion about how pre-game and during-game instructional activities fostered the collaboration in teams engaged in a simulation-based business game. The most interesting finding was that the instructor's instructional activities in different phases of the simulation-based game played a significant role in how the participants positioned themselves regarding the mutual learning task and how they took responsibility and assumed accountability for collaboration and guided their teammates' activities. Moreover, pre-game instructional activities advanced particular game actions, such as the decision-making process, team communication and the organisation and management of activities.

The findings of our study corroborate that, at best, GBL environments create opportunities to enhance active self-directed learning and encourage complex collaborative problem-solving in authentic settings (Lainema, 2009; Harviainen et al., 2014). The instructor's role in GBL is associated with planning and organising learning circumstances in which collaborative and inspiring teamwork may arise. Thus, the instructor's role is facilitative and accommodating, supporting and assisting the learners' collaborative learning process and encouraging their contribution to collaboration (Haruehansawasin & Kiattikomol, 2018; Bado, 2019). In our case, pre-game instructional activities were implemented to prepare the students for the use of technology (Vasalou et al., 2017; Whalen et al., 2018) and to enable pre-game orientation (Tüzün et al., 2009). Knowledge of the game environment, the game dynamics and decision-making in the game allow for a speedy start to the game. Furthermore, investing in studying the pre-game instruction may increase the participants' commitment to the game as well as strengthen the participants' impetus to invest in the gaming activities.

Instructional activities during the simulation-based game, in turn, aimed at helping the participants with the game content and problem-solving (Molin, 2017; Vangsnes & Økland, 2015; Liu et al., 2011; Hämäläinen & Oksanen, 2014). In addition, instruction during the game aimed at fostering collaboration and communication within teams and focusing the participants' attention towards timely and relevant aspects of the game. Our findings are in line with previous studies in that instructional activities especially during the learning event support the participants' own initiatives (see also Lytras et al., 2018). Our study also revealed an additional important aspect regarding instructional activities, namely, that with the help of instruction, the participants were able to proceed from making simple decisions (e.g. making raw material orders) to tactical decisions (e.g. ordering raw materials with optimal price/delivery time ratio) and further to strategic decision-making and planning, such as focusing on specific market areas or customers. In other words, the instruction guided the participants to first make a decision and, after that, to understand the outcome of their decision and, finally, to grasp the complex dynamics and causal relations affecting decisions. Thus, at best, instructional activities help the participants to develop from a novice to a competent decision-maker able to analyse the consequences of their actions.

Consequently, our empirical results illustrate that the participants' collaboration is related to the quality and timing of the pedagogical activities as well as to how the instructional activities are implemented and to what kind of feedback the instructor provides to the participants in guiding their journey from novice to expert (see also Fuller & Unwin, 2003). Levelling the amount, degree and type of instruction in GBL environments requires careful consideration and balancing between instruction and the learners' intrinsic learning activities. Therefore, more research on the pedagogic aspects regarding GBL is needed in order to better understand how instruction can be designed and timed to best support collaboration in simulation-based game environments.

The challenges of earlier workplace learning research call for a better understanding of the forms of collaboration in game-based environments. Namely, the criticality of collaboration is emphasised in contemporary work life, where digital teamwork and dispersed teams have become commonplace (Ferrari, 2012), and the latest views of learning also stress the social and collaborative aspects in facilitating workplace learning (see Tynjälä et al., 2014). GBL environments, such as RealGame, can provide a levelled and accessible platform for collaboration amongst participants in different phases of work life. Thus, GBL has the potential of illustrating the concept of sustainable learning and education as a possibility to create and proliferate sustainable approaches to workplace learning (Lytras et al., 2018; Daniela et al., 2018; Hays & Reinders, 2020). As has been shown, having a sense of belonging and receiving continuous positive feedback from the instructor can, at best, slow down or even halt the process of social exclusion (Määttä, 2014). Enthusiasm, interest, motivation, autonomy and a sense of belonging support and predict good learning outcomes throughout life (see Eccles & Roeser 2011). Thus, future studies need to investigate how collaboration experiences in game-based settings can contribute to public health and work-life balance. Furthermore, we need a better understanding regarding if and under which circumstances GBL can offer long-term adaptive and proactive possibilities for workplaces to create sustainable work in which existing personal resources are benefited from, developed further through learning or translated into novel resources (Kira et al., 2010).

The intention behind sustainable learning and education is to instil in people the skills and dispositions to thrive in complicated, challenging and ever-changing circumstances and contribute to making the world a better place in which to live (Hays & Reinders, 2020). These elements of sustainable learning are also important in technology-enhanced learning, such as games, when aiming at inclusive and equitable quality education that promotes lifelong learning opportunities in all age groups. Sustainability is also a fundamental element in workplace learning and applicable in the context of GBL. Initiating meaningful communication, increasing knowledge sharing and co-creation, promoting team members' equal participation and fostering and maintaining rich and dialogical communication are valuable competencies in work life and therefore important elements for creating a sustainable work culture and skills that can be honed with the assistance of real-time instruction and feedback in GBL.

At its best, simulation-based games can help to achieve the goals of sustainable workplace learning – the more fully we accept and appreciate our co-workers, organisations and societies as important, interdependent and deserving of a viable future, and the more we engage with them towards positive ends, the more universally accepted the importance of sustainability will be, and the more likely we are to attain it (Hays & Reinders, 2020). Future studies should focus on developing a better understanding on experiences of belonging, ability, autonomy, meaning, responsibility, identity and commitment in the context of simulation-based games as these can reasonably be viewed as central motivators of human activity (see Eccles & Roeser 2011). Crafting sustainable work is particularly relevant in post-industrial work and workplaces, and we need novel research-based ways to facilitate sustainable and technology-enhanced learning and to promote the development of personal resources leading to sustainable work ability (see Kira et al., 2010). The methods that support learning, collaboration and interaction in GBL may be used to obtain these objectives.

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Chapter 3
Repurposing Tech Tools for Game-Based Learning

Janna Kellinger

When I first started exploring game-based learning, I found that there are many different definitions and conceptions of what exactly that meant. For some, it means having students play video games in the classroom that either taught the content directly or could be used by teachers to teach the content. This ranged from using commercial off-the-shelf (COTS) video games such as *Minecraft* or *World of Warcraft* to educational content delivered in a video game like format, or edutainment, such as *Duolingo*, to video games that truly "find the game in the content" (Klopfer et al., 2009, p. 31) such as *Lure of the Labyrinth* where players complete math quests that are part and parcel of the game story. For others it means "gamification," adding the trappings of video games such as badges and leaderboards to traditionally taught courses and calling grades "experience points," assignments "quests," and groups "guilds." And, for many, it means doing what many teachers have been doing for years, playing one-shot recall games like *Jeopardy* in class. However, after much exploration and reflection, for me, it means designing and teaching with my own curricular games.

This may sound daunting at first; after all, if you look at the credits of video games, you will see they rival the credits of major motion pictures. But, as Kurt Squire reminds us, students will not be comparing your classroom games to *Grand Theft Auto*, but rather to traditionally taught classes: "Kids compared [*Supercharged*—the educational game Squire helped create] to 'what they did at school' rather than 'the games they played at home'" (2011, p. 96). In my own use

"Students frequently walk away from homework when it is too difficult, but difficult games are another matter–kids walk away from games when they're too easy."—Devaney (2014)

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of self-designed curricular games, I have found over and over again that students enjoy learning in this fashion, engage with the material more, and remember their learning for longer.

However, I have found that students will be critical of worksheets or tests dressed up as games, what Laurel (2001) calls "chocolate-covered broccoli games" where students have to eat the broccoli first (complete worksheet-type problems) in order to eat the chocolate (play the game). As Klopfer et al. (2009) point out, "If your spaceship requires you to answer a math problem before you can use your blasters, chances are you'll hate the game and the math" (p. 25). The key to avoiding this pitfall is to embed the learning in a game story.

There are more and more technological tools out there to design all different types of games—from narrative branching platforms such as *Twine* to block-based programming such as *Scratch* to full-blown programming tools such as *Unity*. All of these tools have relatively low floors and high ceilings; in other words they are pretty easy to start using, but also allow users to do a lot with them. I know, though, that even walking up the front steps and knocking on the front door of technology can be intimidating, not to mention time-consuming, for teachers, instructors, and professors who already have their hands full teaching classes full of students.

What I propose as an on-ramp to creating curricular games is for teachers to use software tools that they already use, but use them to create games. By repurposing common applications like PowerPoint, Google Slides, Excel, and Google Forms, teachers can create dynamic and immersive curricular games that move beyond the recall games of the past to curricular games that teach instead of test, that derive from the content instead of being divorced from it, and that allow the learner to engage deeply in the learning process instead of being a one-shot competitive recall game like *Jeopardy*.

Methods

In order to boil down exactly which elements of video games should be replicated to maximize game-based learning and to study the best ways of doing so, this chapter takes an autoethnographic and self-study approach (Hamilton & Pinnegar, 2000). This requires vulnerability and, by its very nature, involves risk: "Looking at ourselves up close, we risk exposing our insecurities, revealing bad habits and dangerous biases, recognizing our own mediocrity, immaturity, or obsessive need to control" (Nielson, 1994, quoted in Samaras et al., 2004, p. 911). However, taking risks through an honest examination of your own teaching is essential to making progress: "Self-exploration is challenging because we rarely want to face the parts of ourselves that are in conflict or that do not satisfy us. But it is exactly these parts that can act as catalysts for meaningful change" (Arhar et al., 2001, p. 61). For example, in my first article on game-based learning published under my former name, I write about how an honest appraisal of my teaching led me to completely transform my teaching (Jackson, 2009). It is important to make these epiphanies public because "when we write vulnerably, we invite others to respond vulnerably" (Tierney, 2000, p. 549). Most importantly, modeling this vulnerability invites others not just to respond, but also to use critical reflection in their own development as teachers.

What Is a Curricular Game?

Before we get into the details about repurposing software tools as game creation tools, it is important to establish what I mean by a game. If I were to take out a beach ball and ask questions about beach balls, that clearly would be a test. If I were to ask questions about beach balls in a *Jeopardy*-like format, it would still be a test, just dressed up as a game. If I were to throw out the beach ball into an audience and have them hit it around, that would be play. If I challenge the audience to keep the ball from hitting the floor, now we have a game. Play + goal = a game. If I throw out a second beach ball and ask to see which side of the room could keep the ball afloat the longest, then we would have a competition.

If I then introduced tennis balls and asked the audience to play around to see which was easier to keep afloat, the tennis balls or the beach balls, we would have an experiment. If I said the balls are low-density lipoproteins (LDL), the molecules that carry cholesterol in the body, with the beach balls representing large LDL and the tennis balls representing small LDL, and that the floor is the arterial wall and the people arterial plaque, we would have a simulation. If I then said, "Let's find out how long we can keep our human alive by varying factors such as diet, stress levels, and exercise and see their effects on the beach balls/large LDL and tennis balls/small LDL", we would have a curricular game. Simulation + goal = curricular game. Another way to put this is that a curricular game is a goal-driven simulation where players can experiment in a risk-free environment. If we move this into the realm of real life, how long can we keep Uncle Harry alive considering his high cholesterol, then we have a medical situation that is high-risk and becomes no fun. By keeping it low-risk, giving actions a goal, and making it playful, i.e., able to manipulate different factors to see what happens, teachers can create curricular games that entertain and educate.

Game Stories: Plausibility and Messaging

I argue in my chapter "Gaming and College Reading" (2018) that a curricular game is not a game unless it has a story. Now, you might protest, there are plenty of games that do not have a story. For many of us, *Tetris*, where players try to fit falling blocks of different shapes together, is probably a game without a story that comes to mind. To this, I would agree. Many casual games, games that you can play when you have a free moment such as waiting on a bus, do not have game stories. You could even argue that *Tetris* is a teaching game—after all, the longer you play, the better your mind gets at mentally rotating two-dimensional figures. I would agree with this as well. However, I would argue that including a game story makes it not only more compelling, but more likely students will play the game longer than it takes to wait on a bus. For example, here is a game story for Tetris that I just made up:

> You proceed cautiously through the underground tunnel towards the cavern containing the treasure. You find yourself in a room full of falling oddly-shaped bricks. You realize they are all coming down from a horizontal slit in the roof of the cavern. On the other side is a pit of snakes. You frantically rearrange them to fit together to form a wall without any holes between you and the snakes so the snakes cannot get through. As you work, you grow more and more frustrated because the bricks explode into dust once a full row is completely solid with bricks. You then realize that is a blessing in disguise when you notice that the bricks are falling onto a scale that lowers when more bricks are stacked on it. Your obsession with watching Indiana Jones' movies pays off because you recognize that, if the scale goes too low, something catastrophic will happen. While you still have the same goal of fitting bricks together, you now have a different reason for doing so. Snakes you can deal with. Triggering a booby-trap with unknown consequences, that's another story.

Stories provide context. Stories provide goals. Stories provide reasons to persist. Stories provide motivation.

I would argue, however, that stories provide more than just motivation. Stories also provide learning. Brown (2000) illustrates this with a story of Xerox technicians who ignored the set of detailed instructions given to them and instead relied on swapping stories to figure out fixes. While many curricular theorists, from Dewey to Bruner, argue for experiential learning (Bransford, et al., 2000), I maintain that it is organizing experiences into stories that leads to deep and lasting learning.

To tell a good story, you want your readers to suspend their disbelief. If you do not have internal consistency, however, that spell will be broken. The long-running television series *Happy Days* featured Fonzie, a character so cool he did not have to impress others. When the writers had him waterski over a shark, however, that did it for viewers. The Fonzie they knew would never try to impress others like that. That episode spawned the term "jumping the shark." To "jump the shark" means that your story does something so out of line that readers become too aware that it is just a story created by humans that they can no longer suspend their disbelief. In games, this "spell" is called "the magic circle" (Huizinga, 1955). Players know that a game is just a game—rules and goals made up by humans for fun—but they buy into the rules and agree to being in this "magic circle" for the time they are playing the game. For your game story, make sure that it makes sense. This often means running it by others, or promotyping, your game story before creating your game.

You also want to be aware of the messaging of your game. What moral lesson does it teach? I had a student who wanted to create a "Race to the Atomic Bomb" game where each student was from a different country trying to get the atomic bomb so they could deploy the bomb and win the war. I asked her what kind of message did that send. I suggested revising the game so the goal was to make sure that bad actors did not get the atomic bomb in order to keep peace in the world. Another approach would be to keep the same game but debrief with students after the game is over. During this “After Action Review,” students could then discuss the ramifications of deploying an atomic bomb.

Now, you may be saying, “But I’m a teacher! Not an author! I don’t have a creative bone in my body!” One of my students in response to taking my Introduction to Game-based Teaching class had this to say afterwards:

> This class was such an amazing experience for me! I never thought I would have the creativity to create my own video game, and understand the time, effort and process that goes into creating video game. I’m just used to grabbing a controller and playing, that’s it.

If you are struggling to come up with a game story, I recommend starting with the skill you want students to learn. This will become the “core game mechanic”—the game play of the game that will increase in difficulty as students “level up.” Then, think about what problem can be solved or obstacles that can be overcome by using that skill. These will become your “quests.” Determine what goal those problems or obstacles are blocking; that will become your “winstate.” Finally, determine who, or what, would make sense to be trying to achieve that goal; that will become your protagonist, the game player. Papert (1980) describes a type of learning he calls “syntonic learning” where the learner identifies with the object and the task. To enact syntonic learning, then, the player should be referred to in the second person. It is not the main character, whether that be a scientist or a water molecule, that is playing the game; it is “you”—the game player—embodying the game.

Storytelling: Words, Images, and Actions

Repurposing common software tools to tell stories is not a stretch. PowerPoint offers many options for storytelling—text on slides, visual images, recorded narration, and even the ability to include an embedded video of the narrator talking (under Record Slideshow) which can be resized and moved to anywhere on the screen. PowerPoint now even includes the ability to have subtitles to make slideshows more accessible to all users, particularly those who are hearing impaired. While Google Slides is often just one step behind PowerPoint in terms of capabilities, you can record yourself in external video recorders and import it into Google Slides. Google Slides also has a screen reader option to make it more accessible to all users, particularly those who are visually impaired. While often stilted and perhaps not so compelling, you could argue that the typical lecture with bullet points on a PowerPoint slideshow tells a story or at least demonstrates the potential for PowerPoint to tell stories.

In addition to text and narration, PowerPoint and Google Slides are intended to be visual. PowerPoint in particular can even be used to create “sprites” and “objects,” characters and items in video games, by inserting images or drawing them yourself and saving a slide as a picture. By using options under “Format Shape,” you can crop a picture, resize it, remove the background, change the color, use artistic effects, and so forth. The eyedropper tool can be particularly useful when manipulating images to make sure the colors are the same when "photoshopping." When you remove the background of an image, I have found that saving it as a .png preserves that transparency better than a .jpeg does. I often find myself using two PowerPoints during game creation —one for the game itself and one to create sprites and objects for the game which I then save as .png's and insert into the PowerPoint I am using to create the game.

One advantage of PowerPoint and Google Slides is that images can be animated to help tell a story. For example, I had one student use animation to depict a character jumping into a lake. He drew a motion path for the character and, using animation timings, had the splash appear right after the character landed in the water by using the animation pane to designate that it would appear after the previous animation ended. He did not have to say or write that this character jumped into a lake; he literally did what English teachers implore their students to do, "Show, don't tell." In PowerPoint, this is under the Animations menu item. In Google Slides, you can right-click an object and select "animate." By programming a presentation tool to move images around on slides, you can tell your story through action.

Transitions in PowerPoint and Google Slides can also help tell the story. For example, one transition in PowerPoint makes it look like you are turning a page and another like you are opening blinds. One of the transitions folds the image up in the shape of an origami bird that flies away, a transition I used to convey a sense of magic in a game I created about Harry Potter. In that game I used transitions to fold up the Marauder's map and to make it look like doors were opening and closing. Special effects using animation and transitions can help you "show" your story.

Even something as simple as an image can help introduce something so that you do not have to explain it later. For example, I designed a game that featured zombies. When I animated the zombie hands to do different things like play whack-a-brain, I realized they were disembodied as they moved around. I added an image at the beginning of the game of a zombie holding his own disembodied arm so players would recognize this was possible. This idea originated from a story I read in Jesse Schell's (2008) book *The Art of Game Design* where video game designers had hamster cannons in the game. Earlier in the game when the player passed a pet store, they included a poster in the window advertising hamster cannons. That way, when the hamster cannons came into play later on in the game story, the player accepted the idea of hamster cannons without an explanation needed. Like movies and television shows, game stories employ images and animations to help tell the story.

However, you can also make items in your images do complex actions depending on what is clicked, turning your passive story into an interactive one. To do this, use "triggers" in the animation pane. For example, in the Harry Potter game, in the potions classroom, I set certain items to be triggered by clicking on other items so that different ingredients could be mixed to create a Polyjuice potion, which then allowed the player to go into the Slytherin's common room, a link that only worked after being triggered by the creation of the Polyjuice potion. Not only can you make items appear or move when something else is clicked, but you can also make them disappear as well. Using effect options in PowerPoint allows you to play a sound, control why something happens (triggers), when something happens (delay), how long it happens (duration), and whether or not it keeps happening (repeat). Using these effects can transform PowerPoint from a presentation tool to a game creator.

Surprisingly, spreadsheets can be used to tell stories as well. While Excel is designed for numbers, it does support text. One advantage of Excel is that it can manipulate text by sorting, comparing, and filtering. For example, you can use Excel to create a mad libs game by prompting players to write in nouns, adjectives, etc. into cells on the first worksheet and choose "paste link" under Paste to link the cells to the cells in the next worksheet where they fall in the story. When you paste link, any changes made to the original cell are reflected in the second cell. The formula in the second cell looks like this: =Sheet1!A1, meaning paste the contents of cell A1 from the first worksheet into this cell. While spreadsheets also are not thought of as very visual, beyond the charts and graphs they can generate, it is possible to import images, including animated GIFs. Excel now even has a background option where you can choose a background for your spreadsheet. You can turn off the gridlines to make it appear you are not using a spreadsheet at all. In addition to using Excel to tell a story, you can use Excel to create interactive stories where the user becomes a co-author.

Combining paste linking and image inserting, I used Excel to create a game of Jotto. I created an image of an attic with a trunk where you had to enter a three-letter code to open it. Off to the side, the player can enter letters which then appear on the trunk. I used a formula to calculate how many letters matched the code to unlock the trunk and programed it to display the result. I did this by using a formula that would put a 1 or a 0 in a hidden cell if it matched any of the letters, which looked like this = IF(OR(N1 = "F", N1 = "O", N1 = "R"), 1, 0) and reads "if the contents of N1 equals F, O, or R, insert a 1 into this cell, otherwise enter a zero." I then copied this formula for the two other inputs into their associated hidden cells. I then had a cell that added up the ones and zeroes and displayed the results that looked like this = IF(AND(N1 = "F", N2 = "O", N3 = "R"), "Congrats!", SUM(Q1:Q3)). In other words, if the first cell has an F and the next cell has an O and the next cell has an R, display "Congrats!"; otherwise display the sum of the hidden cells. The picture told the story—an old attic with a trunk with a keycode that needs to be deciphered to open it—and the formulas in Excel allowed the player to take action in the story to move the storyline along.

When telling a game story, think beyond written and spoken words to the images seen and actions that players can take. In an escape room-type game I created as a take on *Romeo and Juliet*, players discover it's about Romeo and Juliet not by being told, but by reading "Juliet" on the headboard above the bed where the two of them lay. When players look in the pocket of the jeans Romeo has flung on the floor, they see that he has a locket with the name "Rosaline" on it, his first love in *Romeo and Juliet*, indicating that he is not as dedicated to Juliet as you might think. This, along with other clues such as Juliet's diary hidden under the bed, leads the player to realize the theme of this version of *Romeo and Juliet* is that love is fickle, which they need for Romeo to realize in order for him to escape from the room before he gets caught by Juliet's mother. When creating a curricular game, think about how you can use images and actions to advance the story line.

Decision-Making: Linking

Clearly, a linear story does not make a game. In order for a story to become a game and the reader to turn into a player, the reader has to be able to take actions in the story that impact the storyline. In other words, the reader becomes a co-author. Sid Meier, creator of *Civilization*, famously said, "Games are a series of interesting decisions" (quoted by Prensky, 2011, p. 272). In order to make decisions in a story, the players need to be able to make choices, and those choices need to lead to different story paths. While in *Choose Your Own Adventure* books this is accomplished by flipping to different pages depending on your decision, you can repurpose common software tools to link to different story paths.

If I had 5 minutes to teach all teachers one skill, it would be how to link, specifically how to create internal links in PowerPoint. Most PowerPoint and Google Slides users create slideshows that only link linearly; they just do not think of it as linking to the next slide because it is the default. However, your slideshows do not have to automatically go to the next slide. Instead, you can create links to any other slide in the slideshow. This is what allows users to repurpose PowerPoint and Google Slides from presentation tools to game creation tools. When you highlight and choose text or an image and go to insert a link in PowerPoint, instead of using the default "Existing File or Webpage," select "Place in this Document." You will see all the slides listed and you can select which slide to link to. You can also use the "Screentip" button to have text appear when users mouseover that link. In Google Slides, whenever you select link, it gives you the option of linking to another slide in the presentation. To link a shape in Google Slides, right-click on the shape and choose link. By putting two or more links on a slide, your users, or rather players, can select which path to choose, changing your PowerPoint presentation to a *Choose Your Own Adventure* game.

PowerPoint has a feature that gives designers even more linking options called action buttons. To do this in PowerPoint, insert a shape and scroll to the bottom of the window. You will see a series of squares labeled "Action Buttons." Choosing the empty square gives you the most possibilities because you can either use it as a shape with colors, special effects, text, and so forth or make it transparent by selecting "Format Shape" and moving the slider to full transparency. This allows you to hide the action button and create Easter eggs, or hidden areas you can click to reveal something. Users can find these Easter eggs by moving the mouse around until it turns into the finger-pointing hand that indicates something is a link, but if you really want to hide it, you can first create a transparent action button that covers the whole slide and link the action button to the current slide and put the Easter egg action button on top by using "Arrange" to bring that action button to the front. After you draw your action button by clicking and dragging diagonally, you will be given the choice to choose which slide to go to, including ending the slideshow—very useful to create game-over "dead ends"—and you have the option of playing sound effects when the button is clicked. I had one student do this so that her students could explore life on a coral reef by clicking different areas to link to slides that showed what lives there such as a clown fish in an anemone or a shark in the distance. It is this internal linking capability that turns these presentation tools into game creators.

Other common technological tools also offer linking capabilities. In the Excel Jotto game I described above, unlocking the trunk allowed the player to unlock the door in the attic and escape to the bedroom below. To do this, I created a link that only worked when the player discovered the keycode. The formula looked like this: =IF(T4 = “Congrats!”, HYPERLINK(“level2.xls”),“”). In other words, if cell T4 had the contents Congrats! which, remember, only happened when the player typed in the correct keycode, then that cell operated as a hyperlink to the next level in the game, another Excel workbook named level2, which I had already created as a bedroom where a five-letter code was needed to escape, thus allowing the player to “level up,” or move on to a harder challenge. Notice that I have the player link to a new Excel file instead of a different worksheet. I did this so players could not peek ahead.

One thing I have learned over the years of creating games is that it is often easier and cleaner to create a whole new file, whether it be a presentation file or a spreadsheet, to link to the next level. Using “Save As” allows you to save a copy, name it something different like “Level 2,” and make changes from there so you do not have to recreate everything. Cloud storage allows you to create a shareable link (make sure it is not editable and that anyone with the link can use it). By forcing users to go to another file, you create gateways to the next level. For example, maybe you want students to do something in real life (IRL) like perform a skill or write something to be evaluated by the teacher before they move on. You can control whether or not they move on to the next level by providing them with the URL to the next level file only when they have succeeded.

Using a combination of Google Slides and Google Forms can be an effective way to do this, particularly if you want to create an escape room-type game. You can actually just use Google Forms to create an escape room or even choose your own adventure-type game; however, doing so in combination with Google Slides or PowerPoint allows you to use their interactive features. The text fields for the question prompts in Google Forms support inserting images, including animated GIFs, so you can make it more visual. You can branch Google Forms by using multiple-choice questions and clicking on the “kebab” (three vertical dots) in the lower right-hand corner and selecting “Go to section based on answer.” This then gives you a dropdown menu for each multiple-choice option, and you can choose where the user goes based on their answer, including ended it by choosing “submit form.” When the player chooses the correct path, or the “golden spine,” you can enter the URL for the next level, whether it be a Google Form or Google slideshow, under settings (the gear symbol), presentation, and confirmation message. You can also set it to quiz mode under settings and make it so users cannot move forward until they get the correct answer by making a question required and using the answer key, which will now appear under question items, to “grade” each question on the spot. If you want to make it more visual and interactive, you can use Google slideshow and create links to Google Forms from the slideshow, including links from images.

One problem I had with Google Slides was that linking to a new slideshow would take you to edit mode so students could then see all the slides. I solved this by googling my problem and discovering that if you replace the end of the URL "edit?usp=sharing" with "preview?rm=minimal," then it shows up only in presentation mode. The corollary in PowerPoint is to save a PowerPoint presentation as a PowerPoint Show.

One note of caution about escape rooms is that they often tend to be just tests in disguise as players have to recall something to unlock a lock. I solved this problem when I created a *Romeo and Juliet* escape room by hiding the information needed in the room so instead of recalling the information, the players have to figure out how to apply that information. To do this in keeping with the game story, which involved Romeo waking up in bed with Juliet and thinking, when you click on him, "What have I done?," I have dresser drawers that players can click on to link to slides that show books that contain more information than needed. One drawer contains a bird book which they would have to first unlock in order to find it so they can use it later in the game to identify that the bird at the window was a lark heralding the breaking dawn, thus giving Romeo an excuse to escape. The other drawer contains a book of poetry with different types of poems labeled (think of it as a textbook students have to study, or rather pull information from, to solve the game instead of typical textbooks which push information onto students). Players have to figure out the rhyme scheme of Shakespearean sonnets to unlock the lock on the wardrobe which then links to the next level where players can open the drapes to the balcony. Players can use that first book to identify the scansion of Shakespearean sonnets to unlock the drawer containing the bird book. These locks in Google Slides "when clicked" link to Google Forms where the same lock was pictured in the question prompt section. Players can only get to the next level by getting the answer right because, when they submit the form, they get the confirmation message with the link to the next level. I will confess that my students, when I assigned them to create escape rooms of their own, did me one better by creating a game story where a detective is trying to figure out how a character in a story died and, along with finding clues, also has to learn about various psychological theories to understand the clues. There are many ways to avoid the "test in disguise" or even "worksheets in disguise" game, but first you need to be aware that danger exists in order to recognize when it happens.

Educational escape rooms derive from breakout games where you have to unlock a series of locks to break out of a room. The original *Can You Escape?* games and their derivatives such as *Tiny Spy* involve finding Easter eggs and solving puzzles. I used PowerPoint to create a mini chemistry escape room by having the key to unlock the room in the middle of a block of ice. When users clicked on the image of the block of ice which was on a stand underneath a series of beakers, that linked players to a slide with that image enlarged (PowerPoint now has a Zoom feature that does this for you). On that slide, the beakers are labeled O_2, H_2O, and acid. Clicking on the oxygen just makes the sound of escaping air, clicking on the water uses a motion path to show the water pouring over the block of ice, and clicking on the acid pours it onto the block of ice which dissolves not only the ice, but the key as well. It's only when the player discovers that clicking on the Bunsen burners underneath each beaker lights a flame that the player then can light the burner beneath the water. Bubbles then appear by using the "after previous" animation control, and those bubbles then follow looped motion paths that make it appear as though the water is boiling. The player can then click on the beaker to pour to boiling water over the ice which then melts the ice but not the key, and the player can use the key to escape. Instead of figuring out a code to unlock a lock, in this escape room, you have to know your chemistry and perform a skill to get the key to escape.

No matter what tool you use to create your links, you need to keep a couple of things in mind. In order to link, you must first create what the link is linking to. This seems obvious, but you will be surprised at how many times you go to create a link and remember you have not created anything to link to yet. Second, you don't want to orphan your user. That means, you don't want to link them somewhere where they have nowhere to go to after that. Sometimes this means creating a return link to the original slide, sometimes it means creating another internal link, and sometimes it means allowing them to go to the next slide. Remember, the default is linking to the next slide so if you don't want them to go there, create a transparent action button that covers the whole slide and links them to where you want them to go. Branching like this can expand the number of slides you have to create exponentially. Having more than one choice link to a common slide and/or having dead ends by choosing "end slideshow" for game-over situations helps limit the number of branches.

Linking in this way also provides replayability—users can replay your game over and over again and get a different story every time. When I presented the results of my dissertation which was about how queer teachers navigated their careers, I got bored with the standard linear presentation so I changed it up so the audience could decide how they wanted to navigate through the data by majority vote. They could choose at which age they wanted to come out to themselves and then to others, whether or not they had a different career before becoming a teacher, what grade level they taught, and which subject area. For each choice, they got a quote or two from one of my participants who fell in that category. Now, I know what you are thinking. How can it be fair if each student gets a different set of information? And how in the world can you test them if they do? At the end of each section, I would summarize the results about the differences coming out age, first or second career, grade level, subject taught, etc. made. When your students play a game in the classroom, build in these moments of reflection and have a debriefing session, or "After Action Review" to use gamer language, to weave all those experiences into overarching lessons. Taking these steps can bring it all together, creating a shared experience out of many different experiences.

Immediate Feedback: Responses and Fail States

One big advantage of video games is that players get immediate feedback on their actions, unlike students in school who have to wait to get a paper or a test returned. In the chemistry escape room described above, turning on the Bunsen burner under the vial of oxygen causes an explosion, and the player has to start all over again. Now, I know what you are thinking. You are thinking, "But she said one advantage of curricular games is that they create a risk-free environment where students cannot fail." However, there is a big difference between a "fail state" (the explosion) and failing. The difference is that a player can try again with no real-world consequences. But another difference is that a fail state teaches a lesson. If you are trying to save a patient and you give him a certain medicine and he dies, in a curricular game of course, then you learned that medicine did not work in that situation. If a player gets fired from a job, then that player learned not to repeat that same action.

There are ways, however, to help students learn without such harsh consequences, or even when there are, with follow-up feedback, hints, explanations of misconceptions, and scaffolding. For example, when a player is "fired" from say a teaching job in a game, the principal can give an explanation for why the player got fired, such as violating the Family Educational Rights and Privacy Act (FERPA). Getting "fired" for violating FERPA will make it much more likely that understanding FERPA laws will stick rather than just reading about them. This feedback can be given through internal linking by linking to a slide with the feedback; of course you need to keep it "in game," for example, by having a non-playable character (NPC) give you advice or tell you what you did wrong or drop a hint. In Google Forms this can be done in quiz mode by choosing "add answer feedback" in the "answer key" for incorrect answers, although you may also want to include a "That's right" explanation as well in the correct answer in case it was a lucky guess. This is also another way to provide the link to the next level only when players get something correct.

One form of feedback is progress. How much progress has a player made in the game lets a player know how they are doing. One of the disadvantages of using PowerPoint is that it does not have a memory once you exit the PowerPoint, with a few exceptions such as saving drawings on slides. In other words, you cannot "save" the game. One solution we already discussed, creating different slideshows for each level, provides checkpoints, or saving spots, for the players. However, sometimes you just want players to be able to keep track of what they have just gotten correct within a level. You can do this by having a green check mark, or whatever indicator that goes with the story, show up next to or on top of the item to mark it correct or complete. You can program the green check so that when an item is clicked, it appears by defining a trigger in the effect options as discussed above. The problem is, as soon as the player moves to the next slide, whatever happened on the previous slide is lost. Or is it? When you return to that slide, as long as you have not exited the slideshow, whatever effects have been triggered still remain. One trick is to have the clickable item link the player to another slide but also make the green check appear so when the player returns to that slide, the green check, or whatever else you use to mark progress, is visible. When you create an action button, choosing the "last slide viewed" option can make it easy to program PowerPoint so the player is taken to another slide and then returns to the progress bar to see if they were correct—if they got a green check or a red X. You could also use this feature to create an inventory of items. Keep in mind, however, that you can only program an item to be triggered by something that occurs on the same slide. A key feature to game-based learning is receiving feedback on your actions. There are several options in these common tech tools to do so.

Assessment: Making Thinking Visible

It is important to keep in mind that, unlike traditional schooling where mistakes mean a lower grade, what makes curricular games fun and playful is the ability to make mistakes without real-world consequences while experiencing the consequences of those mistakes in the game. As one of my students said, "When students feel like they are in control, and that they can explore a game space without fear of failing, they will actively participate." However, as teachers, we do need to ultimately assign a grade. One way to do this is by creating in-game ways of making students' thinking visible or, in some cases, audible, that are in keeping with the story. Having the player keep a journal or take field notes or submit reports, whatever makes sense for the profession they are playing, can work really well at providing teachers with a way to understand students' thinking. Having students work in partners or small groups or, better yet, make decisions as a whole class so they really have to discuss and hash out their options, can make student thinking audible. Sid Meier's saying about games being a series of interesting decisions (quoted by Prensky, 2011, p. 272), as a teacher, you want to know how students made those decisions. If you don't have a way of accessing that, then you are denying yourself a wealth of knowledge about your game and about how your students are thinking and learning. This also prevents a big problem with curricular games—the trial-and-error method of playing, where students just click randomly or try different answers until they get it right. Even just having students play with one other person forces them to voice their thinking out loud.

However, there are other ways of assessing success. One way is simply completion. If a student is able to progress all the way through the game, especially if it is designed so that they cannot just guess randomly, that demonstrates they were able to perform the core game mechanic, or targeted skill. Making students start all over again when they make a colossal mistake can also help prevent the trial-and-error method. Ideally our schools would operate so that time was not a factor and students could progress and learn at their own rate. However, almost all schooling is structured so that teachers have to give a grade by a certain date. If you grade by progress, you can always have your grades structured so that students who reach the end receive an A, those who get to the level right before the end receive a B, and so forth. You can also turn After Action Reviews into reflection papers, again making thinking visible so you can better assess if lessons are learned. Shute (2011) suggests, however, that in-game actions provide a way to do what she terms "stealth assessments"—keeping track of students learning based on how they approach the different quests within the game. Whatever you use to assess students' learning, it should be in keeping with the game, not divorced from it.

Conclusion

Educators are often under the mistaken impression that creating curricular games that go beyond one-shot recall games like *Kahoot*, a flashcard-type game, is either beyond their capabilities or too time-consuming to learn how to do. However, by using tools that are already familiar, educators can greatly expand their abilities. Often, it just takes knowing these capabilities exist or googling to see if they do. By constructing a game story and using ubiquitous tools such as PowerPoint, Google Slides, Google Forms, Excel, or a combination of them, educators can tell these game stories through text, audio, video, images, animation, transitions, and linking. Options and actions in these game stories allow players to choose the story path and experience the consequences of those choices. Through hypothesis testing—trying one thing, getting feedback, and trying another—players learn through "performance before competence" (Gee, 2007 quoting Cazden). It is through this experiential learning, and then organizing their game experiences into their own stories, that students engage in deeper learning. Repurposing tech tools that teachers are already familiar with provides a way for educators to create immersive and dynamic games where players can learn new materials, perform different skills, and explore new environments, so students can create their own learning stories.

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Chapter 4
Designing and Playing Games in *Scratch*: Smart Pedagogy of a Game-Based Challenge for Probabilistic Reasoning

Efi Paparistodemou, Maria Meletiou-Mavrotheris, and Christina Vasou

Introduction

Although probability is increasingly being integrated into the school mathematics curriculum, students at all levels face difficulties in understanding probabilistic concepts. Probability is difficult to teach because of the gap between intuition and conceptual development, even as regards elementary concepts (Batanero & Díaz, 2012). Statistics education research has long suggested that most young students, but also adults, tend to have poor reasoning about the stochastic and difficulty in using probabilistic ideas appropriately in applied problems. This includes people with substantive formal training in statistical methods. Several studies examining learning outcomes of college-level statistics courses have indicated an alarming lack of probabilistic reasoning and thinking (e.g., delMas et al., 2007; Chiesi et al., 2011) among students who have completed such courses. At the same time, research suggests that when given the opportunity to participate in appropriate, technology-enhanced instructional settings that support active knowledge construction, even very young children can exhibit well-established intuitions for fundamental *stochastical* (statistical and probabilistic) concepts (e.g., English, 2012; Makar, 2014; Paparistodemou et al., 2008). Through data exploration, simulation, and dynamic visualization, children can investigate and begin to comprehend abstract probabilistic ideas, developing a strong conceptual base on which to later build a more formal study of probability and statistics (Ireland & Watson, 2009; Leavy & Hourigan, 2015; Meletiou-Mavrotheris & Paparistodemou, 2015).

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Recognizing the need for fundamental changes to the instructional practices typically employed in the mathematics classroom to teach statistical and probabilistic concepts, researchers have in recent years been exploring new models of teaching that are focused on inquiry-based, technology-enhanced instruction and on statistical problem-solving (e.g., Meletiou-Mavrotheris & Paparistodemou, 2015). One promising approach lately explored is the potential for digital games to transform statistics instruction. Several statistics educators have been experimenting with computer games, investigating the ways in which this massively popular worldwide youth activity could be brought into the classroom in order to capture students' interest and facilitate their learning of statistical concepts (e.g., Erickson, 2014; Meletiou-Mavrotheris, 2013; Pratt et al., 2008). Although – unlike the numerous studies examining the instructional use of computer simulations, animations, and dynamic software – there are only few published studies on the use of games for teaching statistics, the general thrust of the evidence in the existing literature is positive (Boyle et al., 2014). Most of the conducted studies report that employing games has a positive effect on students' motivation and learning of stochastical concepts (e.g., Asbell-Clarke et al., 2012; Gresalfi & Barab, 2011).

The current chapter contributes to the emerging literature on game-based statistics learning by exploring the capabilities of a learning environment that uses programming logic in a game setting, as a tool for facilitating the emergence of young learners' informal reasoning about randomness and other key probabilistic concepts. Based on a case study of a group of students (aged 8–13) who developed their own games through use of the visual block-based programming language Scratch 2.0 (Massachusetts Institute of Technology, 2013), the following question was explored: *How do students use elements of reasoning about probability when designing and playing their own games?*

Literature Review

Findings of the statistics education literature on game-based learning concur with the general educational literature which suggests that, when suitably designed, digital educational games have many potential benefits for teaching and learning at all levels, including the pre-primary and primary school years (Manessis, 2014). It has been shown that educational games captivate children's attention, contributing to their increased motivation and engagement with learning (e.g., Ke, 2008; Vanbecelaere et al., 2020). However, their greatest strength as a medium, according to a meta-analysis on the impact of games on learning conducted by Clark et al. (2014), involves their affordances for supporting higher-order cognitive, intrapersonal, and interpersonal learning objectives. Through the introduction of open-ended, challenging tasks that are meaningful for children and facilitate their interest in exploration, properly designed games can help focus instruction on conceptual understanding and problem-solving rather than on recipes and formal derivations (Koh et al., 2012). Using games, children can engage in exploration of virtual worlds and in authentic problem-solving activities and eventually become reflective and self-directed learners (Van Eck et al., 2015), having also in mind that there should be a balance between freedom, mathematical ideas explored, and communication of the microworld (Healy & Kynigos, 2010). At the same time, games can match challenges to children's skill level and provide them with immediate feedback about the correctness of their strategies and thought processes, while at the same time enabling teachers to observe students' problem-solving strategies in action and to assess their progress (Koh et al., 2012). Thus, placing a focus on game-based learning offers a powerful perspective for transforming statistics instruction at the primary school level and providing children with the tactile and dispositional skills required to meet the needs of a global, information-driven society.

While digital educational games can provide a range of potential benefits for mathematics and statistics teaching and learning, high-quality, developmentally meaningful, digital games for students are less common than hoped. There is a wide variability in content, scope, design, and appropriateness of pedagogical features, with many educational games including mediocre or even inappropriate content, being drill and practice, and focusing on basic academic skills rather than on high-level thinking. Nonetheless, some exceptional exemplars that can help create constructive, meaningful, and valuable learning experiences do exist. Larkin (2015), for example, reported on the findings of a long-term research project that comprehensively reviewed mathematical game apps to determine their usefulness for primary school students. He found that although the majority of apps provide little more than edutainment, a core group of game apps were very effective in supporting children in their development of higher-order mathematical thinking and learning.

One promising type of game applications is coding gaming software, which teach students the concepts behind programming in a playful context. With an increasing focus on programming and coding finding its way onto the curriculum in many different countries across the world, some innovative, educationally sound game-based learning environments that support the development of computer programming skills from a young age have begun to appear. Several educational applications are currently available for helping students with no coding background or expertise to grasp the basics of programming through the exploration and/or creation of interactive games (e.g., Scratch, ScratchJr, HopScotch, Bee-Bot). Often, coding game applications enable students to share their games with others and to play or edit games programmed by others.

Having taken their inspiration from Logo (Papert, 1980), educational programming environments promote a constructionist approach to technology use, with the emphasis being on students using technological tools to become creators instead of consumers of computer games. In addition to the provision of a highly motivational and practical approach for introducing students to computer programming and developing their computational thinking, coding software provide rich opportunities for the reinforcement of problem-solving, critical thinking, and logical thinking skills (e.g., sequencing, estimation, prediction, metacognition) that can be applied across domains. At the same time, they can also be helpful in developing subject-specific mathematical and statistical knowledge.

Methodology

Participants and Context

A total of four afternoon workshops (once a week) were organized and each one lasted for 2 hours. Twenty-six students ($n = 26$, 16 male, 10 female), aged between 8 and 13, participated in all four workshops. Students participated on a volunteer basis. The workshops took place in European University of Cyprus Computer Lab. An invitation to parents was placed in social media. The invitation to social media came from European University social media and was telling that a workshop was organized once a week in the afternoon for 2 hours, for children 8–13 years old who were interested in designing games in Scratch. The announcement was also telling that the workshop was free of charge. Children had a 20-minute break between the two hours and they were served with water and fruits. In the invitation was also clear that the number was limited (26 children) and that we would keep a priority list based on registration date. Additionally, all parents provided their written consent regarding the use and publication of their students' work for research purposes. All participants had the right to pause or stop their participation entirely at any given moment. In this paper, all names used are pseudonyms in order to preserve participants' anonymity.

The main purpose of the workshops was children to design and play their own games in Scratch software. We chose Scratch, a visual programming language developed at the MIT Media Lab, which consists of reusable pieces of code that can easily be combined, shared, and adapted. Scratch can be used to program interactive stories, games, and animations, art, and music and share all of these creations with others in the online community (http://scratch.mit.edu/). It was created to help students think more creatively, reason systematically, and work collaboratively, all of which are essential skills required for the twenty-first century (Resnick, 2007; Roque et al., 2016). The software was first released in 2007, while Scratch 2.0, which is its second current major version, came out in 2013. In this study, we deemed Scratch 2.0 as the most appropriate option to adopt, due to the fact that it enables the user to model random processes. Moreover, Scratch, through its many features, can allow approaches that bring contributions to mathematics learning. A very significant use of this environment is the proposal of situations in which the students prepare programs, with a view to solving problems (Batista & Baptista, 2014).

For each workshop, a different set of extracurricular activities were closely designed based on constructionism (Papert, 1980), and each meeting was structured in such a way as to promote an unhurried and creative process. The *first workshop* aimed at a general introduction to the software, while in the *second workshop*, students worked on activities based on the movement of a sprite around the screen. In the *third workshop*, students worked on variables and the idea of randomness through playing a coin flipping game and learning how to pick a random block. During the same workshop, students also started creating of their own game based on what they had learned. In the *fourth workshop*, the last one, students continued the design of their game, edited it if they wished, played it by themselves, and/or asked a friend to play the game, in order for them to identify any bugs and fix them. Although we introduced the random block in the third workshop, when children constructed their own game, we did not explicitly ask them to use randomness in their games; however, some of them did, while others did not.

Data Collection and Analysis

For the purposes of collecting our data, we used a variety of methods, including live video recording of the workshop and screen capturing of the participants' interactions with the software. Other sources of data also included field notes and classroom observations. In six cases, we also conducted individual mini-interviews of selected students (interviewed while engaging in game design) that expressed some exceptional ideas regarding the element of randomness, in an attempt to study further their contributions to this project. For the purpose of analysis, we did not use an analytical framework with predetermined categories. What we instead did was, through careful reading of the transcripts and field notes and examination of the various interactions for similarities and differences, to identify recurring themes or patterns in the data concerning students' reasoning about probability as expressed through the design of their Scratch games. To increase the reliability of the findings, the activities were analyzed and categorized by all three researchers, and any interrater discrepancies were resolved through discussion. At last we conducted two main categories for designing and playing games: the role of randomness and spatial representations for expressing probability.

Results

In the following paragraphs, we present two main categories of students' reasoning about probability in the context of creating their Scratch games. First, we describe how students used the idea of chance and randomness in their games and secondly how they used spatial representations for expressing probabilistic ideas. The students' games we present here came from the last workshop.

The Role of Randomness in Designing and Playing Games

In our sessions, students experimented with different mathematical and statistical ideas while designing their own games. One of the ideas brought up during the class discussion was that of randomness. The *random pick* block, which allows users to introduce randomness into Scratch projects, was casually explained to students, in a

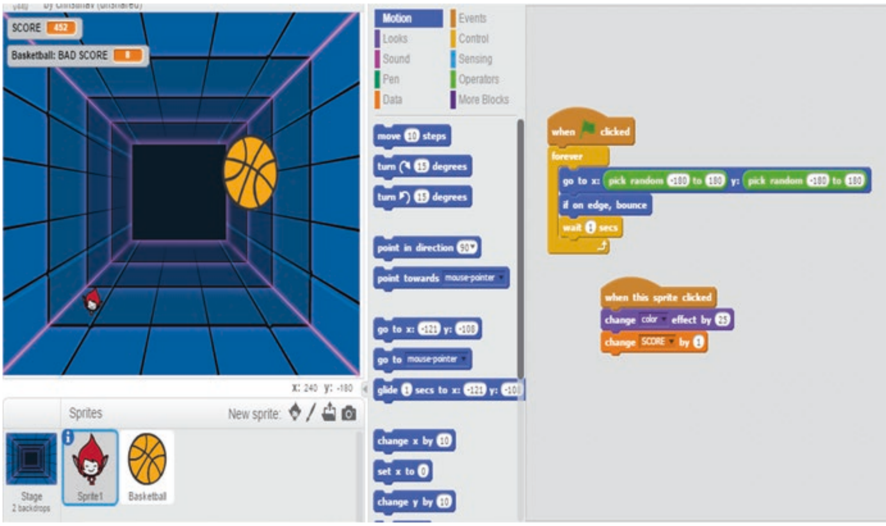

Fig. 4.1 George's game with the elf

similar way to how the rest of the blocks were introduced. It was interesting to find out that many students ended up using randomness in their games.

George (9 years old) constructed the following game, in which an elf moves randomly and the player tries to touch it with a basketball (see Fig. 4.1).

George: The elf is moving randomly...

Researcher: What do you mean?

George: We don't know where exactly it will go next... and we try to touch it with the ball ... Basically I see where the elf goes and try to *predict* where it will go next.

Researcher: How do you make your prediction?

George: I see where it was .... It will move randomly, but it will not continuously go to the same location ... What I'm trying to figure out are possible regions where it might go .... I also made the ball bigger... to have more potential places to touch.

Researcher: What do you mean?

George: I predict a likely region for the elf to land on instead of just a specific point…I put my ball there, and so I take up a range of points... so I have more chances to hit the ball... You see what I'm doing?

It is important to note how George tried to *detect the random position* of the elf using the basketball and how he referred to the *spatial* representation of probability. To increase his probability of hitting the ball, George decided to manipulate the ball, which he had control over, by making it bigger.

Eric (a 10-year-old boy) and Nicole (a 12-year-old girl) designed a game where the first letter of their name appeared randomly when the user clicked on the board.

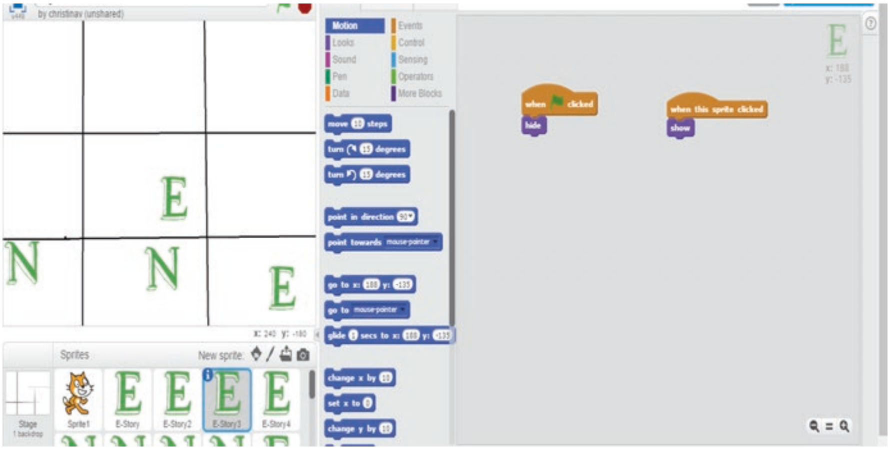

Fig. 4.2 Eric's and Nicole's random game with letters

It was like a tic-tac-toe, but the player was not sure where the letter would go (see Fig. 4.2).

Eric: I like the fact that the letters appear in a random position. This makes our game more *interesting*.

Researcher: Why is that?

Nicole: You have to "see" the probability, where it might go [the letter], and then select the letter.

Eric: You don't know at the beginning…You need to make a guess. If you don't look at the results and just play, then you are more likely to lose…but nothing is for sure.

Researcher: Is your game fair?

Nicole: Yes, you will see this…if *we let it play for a long time* and put a counter, it will end up having the same number [for each letter].

Eric and Nicole used the random rule in their game in order to make it more interesting. Randomness and uncertainty made their game "to have *action*." Nicole referred to the concept of probability in order to make a correct guess based on the game outcomes. Thus, students were playing the game and trying to guess where the next letter would appear by recognizing that, based on their design, each letter had an equal chance of appearing anywhere in space. They then commented on whether the game is fair or not, noting that the probability of each letter to appear is equal for each square, and that this can be verified if one "lets the game play for a long time." This indicates informal understanding of the "law of large numbers."

Charis, a 9-year-old boy, also developed the game shown in Fig. 4.3 by using randomness.

The aim of Charis' game is to click on the dragon. When the dragon is clicked, it appears in a random position. The magician then follows the dragon to its new position:

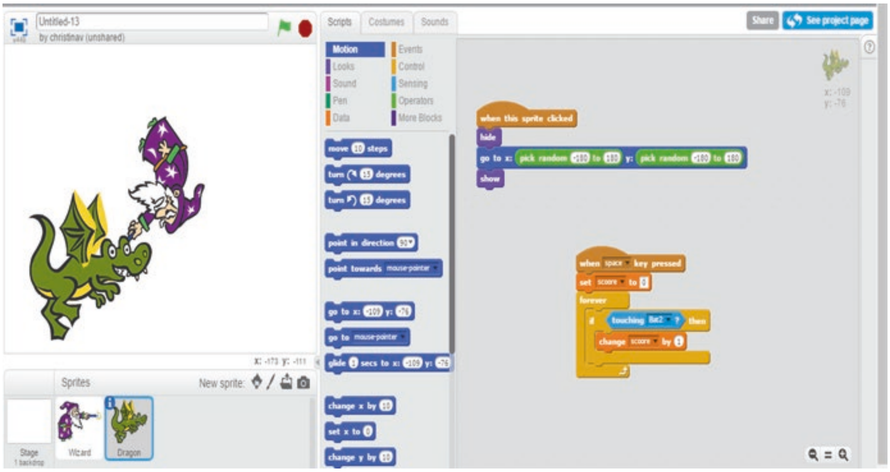

Fig. 4.3 Charis' dragon random game

Charis: You know, I made it just for fun! It is nice to see the dragon moving around without *knowing*…But I will develop it. I made the dragon to move all over the place.

Researcher: How did you do that?

Charis: You tell it what to do [shows the code he developed] and see what happens... If you let the game play you will see that it will move around.

Researcher: So, will it appear again in this position we see it now?

Charis: Of course! I will make something to count where it goes, so we will see which position it takes…May be to touch something…Let me see what I can do…

Charis realized that randomness is something you cannot make accurate predictions about in advance. It is interesting that he designed a dragon with a random move and then tried to predict its movements by counting the dragon's position each time. He noted that this is how the game begins to have fun! The idea of using the x and y variables in a random way and trying to predict the next position helped Charis to recognize that the dragon will move on the predesigned space and after a long time (law of large numbers) it will pass from every point (based on x and y).

Spatial Representations in Designing and Playing Games for Expressing Probability

In the following paragraphs, we present a case of one student who is reasoning about probability in the context of creating his Scratch game. Chris, a 13-year-old boy, was one of the students who really liked using randomness in his games. This

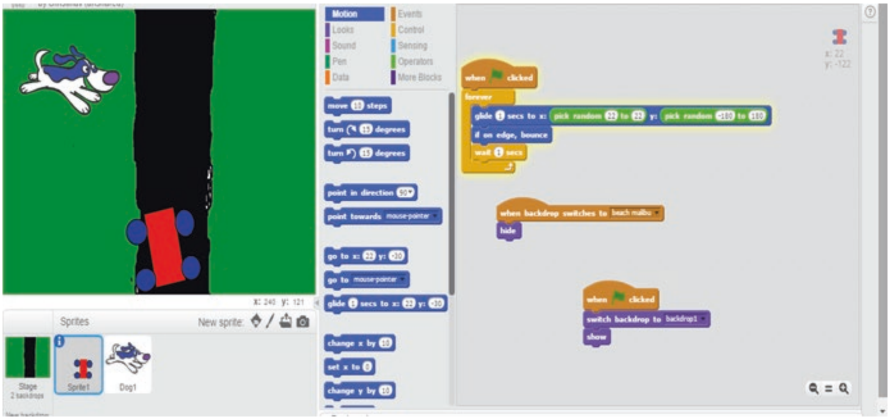

Fig. 4.4 Chris' first version of random game

boy was a talented student, who put lots of effort in building his own game. He was sitting at the back of the classroom and participated in class discussions only if he had to ask or describe something about his game.

Chris designed a game of a dog crossing the street. The aim of the game was to help the dog cross safely, without touching any of the cars (see Fig. 4.4).

Researcher: So, what is the game here?
Chris: Try and see…
Researcher: Interesting… [While Researcher is playing the game.]
Chiris: Yes, you don't know where the car goes. You should be careful!
Researcher: Why? The car will move and cross the road.
Chris: Not exactly…It [the car] moves randomly on this road that I designed. That's the interesting part…So, you don't know where it goes. And when you touch it! You see! *The dog touched the car*. Do you like it?

We have also here the existence of randomness in games as a factor of making a game interesting. It is important how Chris refers to the dog's movement – the one that the player controls – and not to the car's movement. This also shows a realization that randomness in his game is something "uncontrolled" and this was made on purpose for making the game interesting. Chris described the way he built the game as follows:

Researcher: Why didn't you just make the car to move forward?
Chris: This is boring…just seeing the cars move around. Now you don't know…Of course it is easy with one car. …[*Chris is making some changes to his game.*]

The reason underlying Chris' use of randomness in his game was to make the game more interesting. The challenge for him was not only to create a game by using randomness but also to create a stimulating game. We found it interesting that Chris' game was a nondeterministic model of crossing a road. His idea of randomly moving the cars in the road is what makes his game appealing.

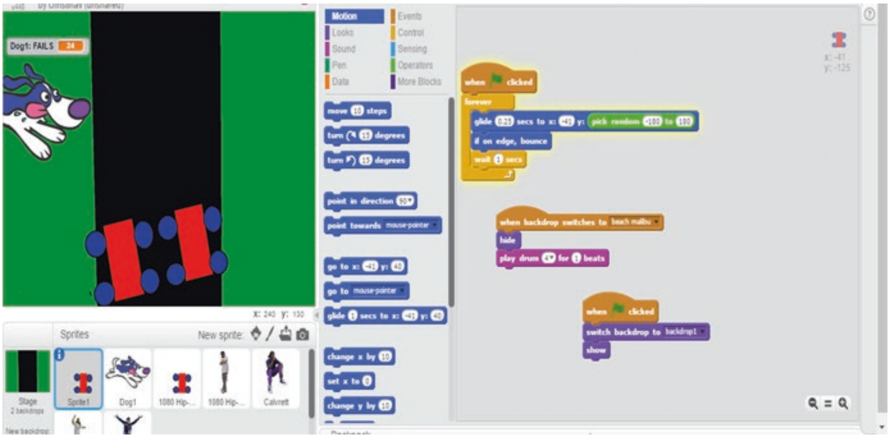

Fig. 4.5 Chris' second version of random game

Chris designed a car that moved in a random way. Although a random movement of the car might have sufficed for the scope of the game, he also used the road as a spatial sample space and tried to increase the difficulty of the game by increasing the number of cars passing by. This also shows that Chris was not really "happy" with his solution and wanted to improve the design of his game. He edited the game to a second version, as shown in Fig. 4.5.

Researcher: What have you done?
Chris: I just put two cars, a counter, made a bigger road and I changed the dog. I changed the code of the cars.
Researcher: Why?
Chris: It is better this way. I made the road bigger and I asked the cars to move randomly all over the road. This makes it more difficult for the dog to cross.

The Researcher plays the game. She cannot cross the road. The counter keeps track of her failed attempts.

Researcher: It is very difficult this way.
Chris: Yes [he laughs]. This is something that reduces the probability of the dog safely crossing the road to less than fifty/fifty. Actually, it makes it go to zero.
Researcher: Would you like to play it yourself?

Thus, after assessing his first version of the game, Chris created a more difficult game. However, after playing the revised game, he concluded:

Chris: Actually, it is not very interesting this way…it's not fair. You know…I can make some change to the design. I will make the dog smaller. That will make it fair…Let's see.

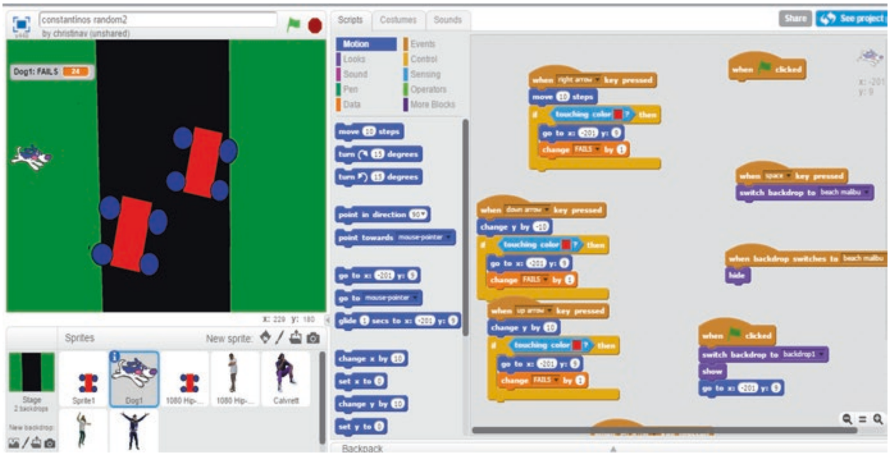

Fig. 4.6 Chris' final version of random game

Chris used the idea of fairness and the probability of 0.5 in his game while he was designing and redesigning his own game. It is interesting that although in the workshop we never referred to spatial probability, Chris in his game connected the concept of space with the concept of probability. We can see that he did not change the code in his game, although he could have done that in order to reduce the probability of the car crossing the road. What he did instead was to come up with the innovative idea of reducing available space in the road.

After completion of Chris' final version of the game (see Fig. 4.6), we asked him whether he was happy with that version or not:

Researcher: Do you think you can play this game with a friend?
Chris: Yes… Now, it works…
Researcher: Why?
Chris: It is a fair game, you can win, but you have to be careful… It's not impossible for the dog to cross the road, but you should develop a strategy based on the cars' movement. It is interesting like this, but if my friend wants me to make some changes, I might do them.

It was obvious that Chris was on the one hand satisfied with his game but on the other hand felt the urge to change the game once more.

Discussion and Conclusions

A drawback of this case study might be the lack of a rigorous research design that would have allowed the drawing of robust conclusions and generalizations. The study was limited in that its focus was on only one small group of students and how they used elements of reasoning about probability when developing their own games using the visual block-based programming language Scratch 2.0. The exploratory nature of the investigation, the qualitative methodology used to research the case, the small scale of the study, its short duration, and its limited geographical nature mean that we cannot draw any generalizations. Further and deeper investigation into the use of coding game apps to teach and learn probabilistic concepts is warranted and timely.

Despite its limitations, the study does contribute to the emerging literature on game-enhanced statistics education, by providing some useful insights into students' reasoning about probability while designing and playing their own games. Our study findings indicate that randomness is an important factor to consider when designing and playing games and that a software like Scratch can provide opportunities to fill the gap between intuition and conceptual development of probabilistic ideas (Batanero & Díaz, 2012; Paparistodemou et al., 2017a, b). When we reconsider prior work on randomness (e.g., Pratt, 2000), we find resonance in the use of symmetry between apparent fairness and the tendency for children to consider the appearance of the dice (or coin, or spinner, or any random device), something that we also found in our study.

The students in the study experienced statistics as an investigative, problem-solving process. Although we attempted to separate the use of randomness from the spatial representation of probability, the reader might notice that this was difficult to do. While engaging in the process of game design, students used simultaneously the ideas of randomness and spatial representation, in terms of the icons they used in their game. We were really surprised with how these ideas came up without even explaining what sample space is or how one calculates the probability of an event. This might be what curriculum designers suggest that it is needed to be considered on setting relations among theoretical probability, true probability, and estimates of the true probability from data on the introductory instruction in probability (e.g., Konold et al., 2011; Batanero et al., 2018).

Findings from this study concur with the research literature, which indicates that the design, coding, revision, and debugging of computer commands help students develop higher-order problem-solving skills such as mathematical modeling deductive reasoning and metacognition (Villarreal et al., 2018). Thus, it becomes crucial to incorporate computer programming into existing mathematics and statistics curricula. Game coding learning environments provide an ideal opportunity for doing so in an engaging, non-threatening, and child-friendly manner (Resnick, 2007). After finishing our sessions, we came to totally agree with Resnick's and Siegel's (2015) four Ps: projects, peers, passion, and play. By keeping these four Ps in mind, educators and others can ensure that coding gives opportunities for new expressions, even for reasoning about probability.

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Chapter 5
Using Game-Based Learning to Prompt Reflective and Holistic Thinking in Project Management

Bassam Hussein

Background

There is ongoing debate in project management literature on how to create reflective project managers (Crawford et al., 2006a; Roger, 2008; Winter et al., 2006a). One part of the debate is related to identifying type of competences that educational institutions should focus on to achieve this objective (Alam et al., 2008; Cicmil et al., 2006; Crawford et al., 2006b; Pant & Baroudi, 2008; Ramazani & Jergeas, 2015; Winter et al., 2006a). The other part of the debate is concentrating on suggesting new means for developing competences needed to create reflective project managers (Córdoba & Piki, 2012; Hingorani et al., 1998; Thomas & Mengel, 2008) (Hussein & Rolstadås, 2002; Ojiako et al., 2011). Game-based learning has been proposed by several researchers to create experimental environments within which learning can occur and observed (Cano & Saenz, 2003; Hussein, 2011; Klassen & Willoughby, 2003; Mario et al., 2005; Ofer & Amnon, 2007). The appeal of using games is that they offer several advantages compared to, for instance, other teaching methods such as lecturing (Elgood, 1997). These advantages include the following: (1) Games can pose a problem, demand an answer, and respond to the answer providing an excellent device for learning by experience rather than by hearsay. (2) Participants are "doing" rather than listening. (3) Games provide an opportunity for group discussions and debates. Rumeser and Emsley (2019) suggest that using games to teach project management enables the instructor to expose participants to complex, realistic project situations which provide learners with practical experience without exposing them to the risks or costs of managing real-world projects. Although there are abundance of games used to support learning in project management, the vast majority of these games are functional games (Hussein, 2007).

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Functional games are usually focusing on offering experimental exercises on how to balance multiple project objectives. The focus of these functional games is therefore on solving problems and less on questioning or thinking about the underlying contexts of these problems.

The need to learn to think and reflect before making a decision in projects is emphasized by Thomas and Mengel (2008) who have pointed out project managers should learn to seek to understand the context first rather than seeking to solve problems. Thomas and Mengel (2008) argue therefore that project management education programs should provide the learners with teaching methods that helps them to become reflective learners so that they avoid basing their decisions on using simplified models of reality. They further suggest that teaching methods should enable the learners to move from breaking into integrating, from asking "how to" to asking "when, where, and why." Thomas and Mengel (2008) argued that in order to be able to do that, it is important that learners recognize the impact of their biases toward problem-solving and to recognize the impact of using simplified models of reality rather than trying to comprehend the project context.

The thing is these biases are difficult to grasp or comprehend, they usually appear under certain conditions, and they are related to both individual and project culture (Shore, 2008) and therefore require further investigation. Lecturing about these biases and their impact might therefore not be the best pedagogical approach. It is important to use an approach that helps the learners to experience and recognize these biases as well as enabling them to experience the consequences of these biases on project outcome.

Our goal in this chapter is to show how game-based methods can be applied in order to create a learning environment that helps the learner to uncover their own biases that impact project outcome. The game presented in this chapter is also used to show typical types of challenges that could arise because of these biases. The learner's biases are used therefore actively in the game play in order to create a sense of involvement and to motivate learners to reflect on their attitudes to projects as an essential strategy to promote more holistic and reflective approach to project management. The game presented here is used as a part of course in project management for continuing education students as well as for students taking their master's degree in project management. Full description of the course and the learning methods used in the course could be found in Hussein (2015).

The chapter is organized as follows; first we start with providing a detailed description of an in-class gaming exercise that has been used as a pathway to uncover biases related to project work and the impact of these biases on decision-making. Biases observed during the game are presented to the game participants and then confirmed through an in-class survey that participants were asked to respond to after completing the game. We shall present the results of the in-class survey obtained from 273 participants who have attended the game during 2014 and 2015 and delivered valid responses to the survey.

The Game

The author's aim of providing this full description is to make it possible for interested instructors to reproduce the games in their own classes. The game has a dual use. It is played during the very first lecture in order to capture the interest of the students and motivate them to learn the subject. The game is also designed to demonstrate and question the impact of biases and assumptions on decision-making in project.

Learning objectives The game is designed to provide the students with an overall view about important concepts such as:

- Importance of understanding project and operational context
- Importance of involving various stakeholders and asking the "when," "why," "what," "where," "who" in addition to "how"
- Importance of thinking about both project outcome and project output
- Understanding of how biases can impact decision-making in projects and in particular in the presence of time pressure and information ambiguity

Type of game Physical simulation using paper and tape only.

Time requirements Approximately 30 min for playing the game and around 45 min for debriefing and summarizing the lessons learned. It is important to perform this assignment under time pressure in order to replicate an important feature of project work and to illustrate to the students the consequences of this time pressure combined with other factors such as ambiguity.

Prior to the game The instructor should make sure that enough material is available for all students. Students are not required to make any preparations prior to coming to the class.

Game play The game includes two main roles: the client (project owner) and the contractor (project organization). In this game, the instructor plays the role of the client, and the groups of students that are formed randomly play the role of the contractor or project organization. The gaming exercise starts in the first lecture of the course when the client announces his intention to construct a paper tower made only of A4 sheets and tape. The information is displayed on the screen in the classroom and includes the requirements regarding the type of materials that are allowed and the expectations that must be met in order to satisfy the client. Information about time frame is also displayed. The client's expectations are deliberately formulated in such way that they give room for multiple interpretations. The expectations that must be met in order to satisfy the client are given to the students as follows:

- The tower should be as tall as possible.
- The tower should be built in the shortest possible time.
- The tower should not be expensive (to use fewest number of sheets).
- The tower should have an attractive design.

Other information that is held back and is not disclosed to the students includes the following:

- The purpose of the project and what the tower will be used for.
- The real needs that the clients are trying to address by constructing this tower.
- Other stakeholders that might have some needs or expectations that must be met by the tower.
- The environment where the tower will be located.
- No information is given about any other functional or operational requirements that the tower must satisfy.

The instructor starts the game session by giving a very brief introduction to the type of roles in the game, the requirements, and time limitations. After presenting the project to the students, project organizations are formed randomly by students. The optimal size of each group should be around five to seven persons. It is not advised to have large groups because this might reduce students' opportunities to actually contribute and influence the game play. The client (instructor) then invites student groups (contractors) to submit a project proposal. The groups are instructed that the submitted proposals should contain information about the proposed height, an estimate of the number of sheets (resembling a cost estimate), and an estimate for the time needed for completion. They are also requested to think of and list potential risk factors that the project might encounter. The groups are also asked to take the assignment seriously and try to think and act as if they were project managers and have this task at hand. This request is deliberately restated several times during the game the introduction and prior starting the actual planning and execution.

Students are instructed that producing the proposal (planning phase) should be completed in 15 min. During the planning session, the instructor must be present and visible to the students. The instructor should also answer questions regarding scope, objectives, other stakeholders, priorities between expectations, or about the purpose of the project only if asked. It is important that the instructor does not interfere or try to influence the students during this phase by any means.

It is also important to note here that there will be very few groups who would actually initiate a contact with the client to seek more information during this stage. On occasions, some groups ask for more information about the project. They want to know what the tower would be used for or what kind of tower is needed, and sometimes they show different sketches to select among. It is important that the instructor answers the questions and provides the groups with the information available.

After the planning session is completed, all proposals are then collected by the instructor and rewritten on the blackboard so that every student in the class could see the proposals of all the other groups as shown in Table 5.1. They are informed that they can amend their proposals if they prefer to do so. Once all proposals are displayed on the blackboard, groups are requested to start the execution phase.

Execution phase is the phase where the actual building of the tower takes place. The time frame for this phase is set to 15 min. In this phase, student groups are busy

Table 5.1 Information collected and displayed on the blackboard at the end of the planning phase

Group number	Height	Time needed to complete the project	Number of sheets that will be used	Risk factors
1				
2				
3				
n				

and work very hard to construct their structures. Furthermore, it is evident that they are focusing very strongly on the assignment.

Game debriefing During planning and execution, the instructor should observe and make notes of how the students approached the task. These observations include, for example, (1) students concerns in the planning session, (2) what are they talking about or doing together in the planning session?, (3) who is talking and who is silent in the group?, (4) what kind of discussions they have in the group?, (5) who leads these discussions?, (6) how they take decisions in the group?, (7) are they making any efforts to uncover the ambiguity in the task given to them?, and (8) are they trying to uncover or discuss the priorities of the requirements given to them?

The observations made by the instructor during the planning and execution phases are the focus of the debriefing session. The observations noted during playing the game will indeed vary as more games are played by different classes. All observations made should therefore be documented and stored in, for example, a word file right after during each game. The more the game is played, the list of observations will become larger and should be added to the stored document. The instructor should therefore update the stored observation document, by eliminating duplicate, combining similar observations, or adding new observations. The following pattern of students' attitudes has been observed by the author over the years:

- Vast majority of the groups use the planning session to experiment with the game material, such as trying out different methods to roll the sheets of paper to form a cylinder or truss elements that will be used to build or support the tower.
- They seem very concerned with figuring out the best way to construct the tower.
- Very little effort is made to actually identify or find out the functions of tower. This may suggest that there is a strong focus on figuring out how the actual construction should be done with less attention to other contextual information such as needs, expectations, and other evaluation criteria.
- They use time during planning to come to an agreement on who will do what during the execution phase. This observation also strengthens the previous observation about having stronger focus on doing planning activities in order to ensure delivery on time.
- They seem very eager to start with the execution phase, and some groups use less than the allocated 15 min. This observation suggests that there is a strong sense of "just do it" attitude and they are very eager to start the real work (delivery).

- Very little and sometimes virtually no discussions on what are the needs the client is trying to address by embarking on this project are observed.
- No questions or discussions with the client to identify the operating environment of the tower are observed.
- No questions or discussions to understand the project context, other stakeholders, or other contextual requirements are observed.
- Students seem very absorbed by the assignment during both the planning and execution phase.
- The atmosphere within each group seems to be at ease, and no signs of confrontations or hostilities within each group are observed.
- Very few groups actually initiate any type of contact with the client; occasionally they would ask if they could start the execution phase before other groups.
- Most of the risk factors identified by the group focus on technical aspects such as risk of collapse or toppling. Some groups identified other risk factors such as lack of material (sheets of papers or tape) or failing to finish on time or failing to attain the targeted height. Virtually none identify risk factors related to client or other stakeholders' satisfaction.
- They seem very excited about and proud of their final products.

In the debriefing phase, the above-described observations are presented to the game participants, and we emphasize the problems associated with each observation to project management context. The observations are presented to the participants in a form survey that consists of postulates and questions the participants are asked to answer using a binary scale of measurement (Agree or Disagree) or YES or NO. The postulates are presented to the participants using a survey tool available in a game-based platform called Kahoot (Kahoot, 2015). This tool allows the instructor to obtain an individual response from each participant in real time. The results are then displayed on the screen, and everybody could see how many respondents agreed or disagreed on each postulate or question. The results obtained on each postulate offer a good ground for discussing the observed biases and attitudes participants had during the simulation. In order to demonstrate the scope of the problems the game demonstrates, we shall in the next section present the participants' response to these postulates from running this gaming exercise in four different courses. We shall then show how the results obtained confirmed that the game managed to reveal several existing biases. We shall also demonstrate the impact of these biases on the way participants evaluate project success and on the way they identify and involve project stakeholders.

Findings

The survey consisted of seven postulates and four questions that the participants were asked to respond to. These postulates were based on observations made during the simulation. The list of the postulates and the justification of each is shown in

Table 5.2. For each postulate the participants were asked to respond with either Agree or Disagree. The reason for selecting this limited scale was to obtain a sharp response on each postulate from each participant.

In addition to these seven postulates, the participants were also asked to answer four additional questions to collect information about how they evaluate their performance and results. The goal was to understand the link between participant's evaluation of their own performance and their answers to the abovementioned postulates. The questions and purpose of each question are shown in Table 5.3.

Table 5.2 Postulates and justification

Postulate	Justification (what the claim reveals)
P1) I took my role in the game seriously	The purpose of this postulate was to collect information on how the participants actually played their role during the simulation. As indicated previously playing the game as if it was a real project was very important so that we would be able to collect valid and reliable data
P2) I was focused on figuring out how to build	The purpose of this postulate was to collect information on what was the central focus of each player during the game in order to reveal the scope of biases toward focusing on problem-solving (focusing on the how's)
P3) I have not thought of the context or what the project will be used for	The purpose of this postulate was to measure whether the participants have actually thought of other elements beyond problem-solving during the simulation. Elements such as the project context (additional constraints) or operational context (goal and expected benefits)
P4) I established my own assumptions to compensate for missing information	This postulate was used to examine the degree participants base their decision-making on simplified models in light of ambiguous information
P5) I did not want to confront the rest of group with my opinions	This postulate is used to measure the impact of diffidence, inclination to hold back opinions or views within each group during the game
P6) I felt group pressure to begin the "real work" and I got carried away	This postulate was used to measure the impact of groupthink on problem-solving bias
P7) I thought the information provided was sufficient	The purpose of this statement was to collect information from participants about how they have perceived the set of requirements and expectations they were given at start-up. This could help to reveal whether the main cause of problem-solving bias is correlated with lack of information or if it is an inherent characteristic on how project practitioners approach project work

Table 5.3 Questions and their purpose

Question	Purpose
Q1) Are you pleased with your results?	To measure how participants evaluate their own results. Possible answers to select were limited to "Yes" or "No"
Q2) Have you delivered the project?	To measure possible reason of their answers to question 1. Are they pleased because they have delivered the project (produced an output)? Possible answer to select from was "Yes" or "No"
Q3) Have you managed to make the client satisfied?	To measure possible reasons of their answers to question 1. Are they pleased because they have satisfied the client (produced an outcome)? Participants had to select from three possible answers to select from, "Yes," "No," or "I do not Know"
Q4) Have you involved and collaborated with the client in order to understand the real needs of the client?	This is the final question and was aiming to investigate an important success factor in projects, the involvement of the client and other stakeholders, understanding their real needs and expectations. Possible answers displayed were "Yes" or "No"

Results from the Survey

Table 5.4 shows the results obtained on each postulate. The results are based on responses collected from 320 participants who have attended the courses in the last 2 years. From these, 273 delivered valid responses with no missing values.

Responses on P7 suggest that the participants failed to detect that information was not enough or that it was ambiguous. The first question we raise here is whether information ambiguity had any impact on the results obtained from postulates P2, P3, P4, and P5.

All these figures lead us to conclude that information ambiguity did not have any strong significant impact on participants' biases toward focusing on delivery P2 and on having less attention to understanding contextual factors P3. Quality of information however had some impact on tendency to base decision-making on using simplified models of reality P4. Quality of information seems also to slightly influence participants' inclination to avoid sharing their opinions and thoughts with the rest of the group P5. Reasons for this inclination have not yet been investigated.

Correlation Between Lack of Involvement and Biases in Decision-Making

Table 5.4 shows that only 9% of the participants reported that they have contacted the client during the simulation. The question we raise therefore is whether we could link this lack of involvement to other observations made during the simulation. In order to answer this question, we constructed a cross tabulation between (P2, P3, P4, P5, P6) and Q4 as shown in Table 5.5.

Table 5.4 Participants' response to postulates $N = 273$

Postulate	Agree	Disagree	Comments
P1) I took my role in the game seriously	93.4%	6.2%	This result confirms that the vast majority of the participants have played their role in the game sincerely and acted accordingly. This result provides good reliability of the experiment. It shows also that the subsequent results provide a good basis for measuring how decision-making was performed during the simulation
P2) I was focused on figuring out how to build the tower	94.5%	5.5%	The results affirm the existence of individual biases toward delivery
P3) I have not thought of the context or what the project will be used for	80.6%	19.4%	The results show that participants were less focused on trying to understand or seek to know more about project and operational context
P4) I established my own assumptions to compensate for missing information	75.1%	24.9%	The results further confirm that majority of participants based their decision-making on using simplified model about project context in order to be able to go about in the game
P5) I wanted to do things differently, but I did not want to challenge the group with my opinions	13.9%	86.1%	The results also show that only 13% of the participants opted to keep their views for themselves. This figure is quite low in light of the type of information that were given at start-up and should have motivated the individuals to question the way the group went about in the game
P6) There was an atmosphere of "just do it" in the group and I just got carried away	69.1%	30.8%	We also see that that the bias toward starting the (delivery) is also evident on the group level as well and not only on the individual level
P7) I thought the information provided was sufficient	48%	52%	It is evident from these numbers that almost half of the participants failed to detect that information was not enough or that it was ambiguous. The other half who have detected ambiguity failed to respond to it
P8) We have collaborated with the client in order to gain understanding to their needs and expectations	11.4%	89.6%	There is also an overwhelming majority that affirms that they have not communicated or collaborated with the client to understand constraints or expectations

We see from Table 5.5 that there is a significant association between involving and collaborating with the client and (P3, P4, and P5). For instance, the table shows that 86% of the respondents who have reported that they *have not involved the client* have also reported that they have not thought of the context or operational use. This figure is compared to only 50% of those who have reported that they *have actually collaborated with the client but have not thought of the context. Similar results were obtained for association between P4 and Q4. The results show that collaboration with the client is substituted with making simplified models about reality. Groupthink*

Table 5.5 Cross tabulation between Q4 and P2, P3, P4, P4

		Q4) Have you involved and collaborated with the client in order to understand the real needs of the client?	
		No (91%)	Yes (9%)
P2) I was focused on finding a solution (figuring out how to build the tower)	Agree (95%)	95%	86%
	Disagree (5%)	5%	14%
P3) I have not thought of the context or what the project will be used for	Agree (82%)	**86%**	**50%**
	Disagree (18%)	14%	50%
P4) I established my own assumptions to compensate for missing information	Agree (80%)	**85%**	**36%**
	Disagree (20%)	15%	64%
P5) I did not want to challenge the group with my opinions	Agree (13%)	14%	7%
	Disagree (87%)	86%	93%
P6) I felt group pressure to begin the "real work" and I got carried away	Agree (71%)	**77%**	**21%**
	Disagree (29%)	23%	79%

and pressure to start the real work appears also to be very significant factor to the lack of involvement.

Discussions

The accumulated data from participant's responses to the survey demonstrate the following biases:

Strong focus on delivery is evident on both individual level and on group level. This focus appears also to be an influential factor on how participants evaluated project results. We observed also that this strong focus on delivery was also combined with lack of substantial efforts to try to understand the problem or the needs the clients are trying to address. Shenhar and Dvir (2007) argued this sort of focus leads to overfocus on short-term results on the expense of achieving the long-term results of projects. It also leads to failing to have a holistic view of the project in terms of context and managing the exogenous factors (Winter et al., 2006b). This focus on delivery could be explained in terms of known bias called the focusing effect bias (Legrenzi et al., 1993). The focusing effect bias occurs when people make decisions on the basis of the most obvious and explicit information they have available, and for this reason, other pieces of possibly useful information are ignored or excluded. In the game, the requirement about delivering a high tower on time was very much in focus during the game simulation.

The game demonstrated that in light of information ambiguity, the participants appear to rely on using simplified models of reality and then base decision-making on these simplified assumptions. This tendency might be explained in terms of **bounded rationality bias** (Simon, 1986). Bounded rationality takes place when decision-makers have to work: (1) only limited, often unreliable information is available, (2) human mind has only limited capacity to evaluate and process the information that is available, and (3) only a limited amount of time is available to make a decision. Decision-makers in this view act as satisfiers who can only seek a satisfactory solution lacking the ability and resources to arrive at the optimal one. In the game, inadequate information should have triggered more curiosity and more efforts to try to understand and reveal different important aspects such as goals, needs, and stakeholders' expectations and constraints or more efforts to discuss and debate within each group, but the results show that the participants had very strong biases to (finding the how's), and in order to do so and in light of inadequacy of information given, they opted for establishing their own simplified models about context, goals, and objectives in order to reach a satisfactory decision. Those few people who had different opinions seem to have also kept these opinions to themselves, and the rest was carried away with the group.

The game also demonstrated that focus on delivery is also evident on the group level. And that disagreement within each group is limited or negligible. Individuals seem to avoid raising controversial issues or suggesting different approach. Information ambiguity appears to be a contributing factor. This observation could be explained using the groupthink bias when members of a group under pressure think alike and resist evidence that may threaten their view (Janis, 1971). According to Janis, this group pressures lead to irrational thinking since groups experiencing groupthink fail to consider all alternatives and seek to maintain unanimity. Janis has documented several symptoms of **groupthink**, which are also evident in the game:

- Collective rationalization – Members do not consider their assumptions.
- Self-censorship – Doubts and deviations from the perceived group consensus are not expressed.
- Illusion of unanimity – The majority view and judgments are assumed to be unanimous.
- These above factors have collectively contributed to failing to involve and collaborate with the client in order to understand the problem and expected outcome of the project.

Conclusion

Carefully designed games could be used to uncover biases and assumptions about project work as an important step to make students rethink about how project work is different than other type of process-oriented assignments as a perquisite to create reflective and holistic learners. We believe that the game managed to demonstrate the following biases:

- Focus on delivery
- Basing decision-making on simplified models
- Groupthink that strengthens the strong focus on delivery and contributes to collective rationalization of the unfounded assumptions about the project and operational context

The game also demonstrates that these biases result in:

- Evaluation of project success is based on ability to deliver.
- Level of involvement of cooperation with stakeholders in project and operational context.

The core pedagogics of the game has been based on demonstrating how the lack (or presence) of certain skills, traits, and attitudes can impact how decisions are taken in the project and affect project results. This is an important factor for creating a sense of involvement and to motivate the students to learn. The actual learning and reflection take place during the debriefing session. This session should therefore be planned carefully. We believe that the game helped to create an active and participatory context where it was possible for learners to experience and uncover their own biases and the impact of these biases on project. The impact of this game on students is illustrated using some of the responses we got from the students after completing the game.

> The game gave me very good kick-start to understand typical challenges related to project work and the knowledge I gained from this game is applicable to my work.
>
> I have learned that you should not jump to doing but dare to question first

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Chapter 6
Game-Based Learning for Teaching Multiplication and Division to Kindergarten Students

Nicholas Zaranis and Fotini Alexandraki

Introduction

The use of information and communications technology (ICT) in kindergarten is very important because it allows children to develop various skills. Primarily, they promote skills related to the use of computers or tablets, like tactile, auditory, and visual abilities. Particularly, studies have demonstrated that computers and tablets have supported the development of the abilities in children's problem-solving, literacy, and math (Dimakos & Zaranis, 2010; Judge, 2005; Manolitsis et al., 2013).

Research results show that the students who were taught with the educational intervention based on tablet computers and RME had a significant improvement in their total mathematical achievement, addition and subtraction to those taught using the traditional teaching method (Zaranis, 2018). Another study by 2–3-year-old children shows that at this age the children are independent enough to handle the touchscreen devices consciously and they are acquiring the language and skills necessary for everyday life (Kalnina & Kalnins, 2020).

Numerous studies on the integration of ICT in school classrooms show that teachers continue to work within a traditional vision of student learning (Honey et al., 2003). Today, there is talk of strengthening ICT in education as most research findings make them effective in supporting the teaching and learning process, enhancing students' knowledge, and improving their performance. The terms digital culture and digital education are included in most curricula at all levels of education (Dissanayake et al., 2007; Voogt et al., 2013).

The use of ICT in education can create new attractive educational environments from preschool education to higher education, provide teaching methods, complement the traditional way of teaching, improve the quality of education, and offer

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innovations (Toki & Pange, 2012; Walcott et al., 2009). Our online society poses new challenges, but it also offers a wealth of technologies that can support innovative pedagogies to improve teaching and learning. There are platforms that allow teachers to use gaming technology to develop learning environments for students (Dewey, 2018). In addition, gamification is defined as the use of dynamics, mechanics, and game elements in nongame environments (Deterding et al., 2011). One of the most important differences between game-based learning environments and conventional classrooms is that students rarely feel they are going to play in the latter (Lu & Lien, 2019). The concept of gamification uses achievements, appointments, bonuses, levels, and points as some of the game engineers to help students participate in the learning process.

Rationale

The terms digital culture and digital education are included in most curricula at all levels of education (Trouche & Drijvers, 2010; Voogt et al., 2013). Proper implementation and proper use of ICT is a real opportunity for educational progress (Shahmir et al., 2011; Kalnina & Kalnins, 2020). The use of digital devices in education can shape new attractive educational environments from preschool education, provide teaching methods, complement the traditional way of teaching, improve the quality of education, and offer innovations (Kroesbergen et al., 2007; Toki & Pange, 2012).

Remarkable is the independence that preschoolers use when using digital devices as they provide an exciting multimodal communication that includes a touchscreen, portability, and various symbolic display functions that can contribute to both independent and collaborative learning (Petersen, 2015).

Nowadays, tablet computers combined with the concept of gamification are applied to many educational programs, helping teachers find the balance between achieving their goals and meeting evolving student needs (Huang & Soman, 2013). Gamification was presented as an idea for the use of this human behavior that engages in gaming activities and combines it with their work, so as to apply the results in the field of education (Gupta & Gomathi, 2017).

Game-based learning (GBL) is being used to encourage students to participate in learning while playing and make the learning process more interesting by adding fun to the learning process. It has a positive effect on cognitive development (Lin et al., 2014). Gamification is different from learning-based games because it takes the entire learning process and turns it into a game (Rula Al-Azawi et al., 2016).

One of the main advantages of introducing gamification in the educational context is that gamification affects students' behavior, commitment, and motivation, which can lead to improved knowledge and skills (Huang & Soman, 2013). A mathematical learning activity allows students to acquire knowledge, improve skills, and cultivate positive traits through the game designed specifically for learning purposes. It is well known that in order to achieve mastery in the learning process, it is necessary to involve students deeply in the learning process. Gamification can be thought of as the use of game elements and game design techniques in nongame environments in an effort to improve user engagement and productivity (Hosseini et al., 2019).

Pérez Garcias and Marín (2016) summarize the elements of the game that can be used and support the learning process: points, numerical values that are given for each individual action or combination of actions; ranking, classification, or comparison between students from the same class or year; levels, a system that shows students' progress in assigned activities, badges, special awards for achieving a goal; and progression, a dynamic in which success is displayed. These game elements can create authentic and constructive learning environments that can be used in a variety of educational settings. In today's digital generation, gamification has become a popular tactic to encourage specific behaviors and increase motivation and engagement.

Our study presents the teaching of multiplication and division, based on the theory of realistic mathematics for preschool education, which is based on three-level game, with increasing degree of difficulty (Freudenthal, 1973).

The first game level is the linear level. At this level both the counting and the calculation of objects are based on the line.

The second game level is the group level. At this level, the counting of objects, groupings, and their calculation are based on the group.

The third game level is the combination level. This level includes the previous two levels, the line and the group. At this level, the calculation of objects and their calculation are based on the combination of line and group levels, creating a table (Van den Heuvel-Panhuizen, 2001, 2008).

According to the Greek kindergarten curriculum, multiplication and division are learning objectives for preschool children. The process of learning multiplication and division, within the context of RME, begins with the solution of game problems, where their contexts contain corresponding mathematical concepts. The approach of the game of multiplication and division uses realistic situations, which allow students to develop their own mathematics and give less emphasis to algorithms and more to the gradual and logical improvement of informal processes as well as to the systematization of understanding. Discussion and reflection play an important role in student support (Dickinson & Hough, 2012).

Moreover, studies have shown that the use of smart mobile devices with mathematical applications has significantly improved the mathematics of young children (Pitchford, 2015; Outhwaite et al., 2017). In terms of problem-solving, preschoolers who were taught addition and subtraction using a computer and smart mobile devices and the application of digital applications, based on Realistic Mathematics Education, showed significant improvement in performance compared to children taught by the traditional method (Zaranis et al., 2015).

Following the theoretical framework that blends together Realistic Mathematics Education (RME) and the use of ICT in kindergarten, we designed a new game model referred to as the Kindergarten Tablet Multiplication and Division Game (KTMDG) which consisted of three levels. The majority of previous studies aggregately examined the effects of various teaching on mathematics. However, a small number of studies have been found at the kindergarten level in the area of the division.

Our study was based on the aforementioned international literature, and therefore we investigated the following research questions:

1. Will the children who will be taught mathematics based on KTMDG have a significant improvement on multiplication than those taught using traditional teaching method based on the current kindergarten curriculum?
2. What is the mathematical level of children who had the highest benefit from KTMDG on multiplication?
3. Will the children who will be taught mathematics based on KTMDG have significant improvement on division than those taught using traditional teaching method based on the current kindergarten curriculum?
4. What is the mathematical level of children who had the highest benefit from KTMDG on division?

The overall aim of the study was to investigate the effect of teaching intervention, using the game of multiplication and division for kindergarten, with mathematical activities and software based on Realistic Mathematics Education.

Methodology

This study was conducted in three phases. In the first and third phases, the pretest and posttest were given to the students, before and after the teaching intervention, respectively. In the second phase, the teaching intervention took place. The study was conducted during the school year 2016–2017 in seven public kindergartens located in the city of Rethymnon in Greece. It was an experimental study that compared the process of teaching ICT game with traditional teaching based on the kindergarten curriculum. The sample included 119 kindergarteners consisting of 55 girls and 64 boys aged 4–6 years. There were two groups in the study, one control ($n = 60$, boys = 32, girls = 28) and one experimental ($n = 59$, boys = 32, girls = 27). In the control group, there was no computer available for students to use in class. The lessons in the experimental group had tablet computers for everyday use by children as part of the teaching process. For the uniformity of the research, instructions were given to the kindergarten teachers who taught the experimental groups or the control groups.

Ethical considerations and guidelines on the privacy of persons and other relevant ethical issues in social research were carefully considered throughout the process of research. Requirements relating to information, informed consent, confidentiality, and use of data are held carefully, both orally and in writing, by informing preschool staff, children, and guardians for the purpose of the study and their rights to refrain from participation.

First Phase

In the first phase, the pretest was given to the experimental groups and control groups in early December 2016 to isolate the results of the treatment by looking for inherent inequalities in the mathematical achievement potential of the two groups. The pretest was a test based on the third edition of the Test of Early Mathematics Ability, TEMA-3 (Ginsburg & Baroogy, 2003).

TEMA-3 is a norm-referenced, reliable, and valid early math test that is suitable for children aged 3 years and 0 month to 8 years and 11 months. The TEMA-3 form contains 72 items. The objectives of TEMA-3 are to (a) identify children who are significantly behind or ahead of their peers in the development of mathematical thinking, (b) identify specific strengths and weaknesses in mathematical thinking, (c) suggest appropriate educational practices for individual children, (d) document children's progress in learning arithmetic, and (e) serve as a measure in research projects. Also, one of the purposes of developing TEMA-3 was to provide researchers with a statistical test based on current research and theories on mathematical thinking. In particular, the availability of TEMA-3 would encourage the study of mathematical thinking in young children (Ginsburg & Baroogy, 2003).

Due to the young age of the students, the pretests were given separately to each student as an interview. These were pencil and paper works. Examples from the assessment test are given in pictures below where students were asked to calculate the objects in the three children (Fig. 6.1a) or to separate objects by drawing a line between them (Fig. 6.1b). Each task had a grade calculated from the student's answers. The scores were calculated for each of the individual mathematical tasks. The total correct answers for each of the 12 tasks were created by adding all the correct answers to each problem in this task. On average, students will be able to complete the test in about 30 minutes.

(a) (b)

Fig. 6.1 Tasks from the assessment test of multiplication (**a**) and division (**b**)

Second Phase

In the second phase, the control group was taught by the conventional method according to the kindergarten curriculum. The content of the teaching was a 3-week program according to the kindergarten curriculum and included mathematical activities for multiplication and division. Additional activities were given to the students of the control group, to cover the time corresponding to the computer activities of the experimental group. Activities were assigned daily, which were carried out individually and in small groups. For example, in the activity of the zoo, the kindergarten teacher in circle time gave three animals to "child A" and three animals to "child B." Then the kindergarten teacher asks a child: "How many animals do 'child B' and 'child A' have together?" "How many animals did I give to each child?" "How many children are there?" Another activity was the fisherman. The children had to fish from the "lake." Then the children who fished had to share all the fish fairly.

The experimental group covered the same teaching at the same time according to the KTMDG method. The content of the 3-week curriculum of the KTMDG was divided into three levels. Each level had computer activities and noncomputer activities. Computer activities were designed using the Flash CS6 Professional Edition program.

The first game level of the experimental group started with a noncomputer activity for the line structure for multiplication and division. The objects were placed in a line in groups and the students had to calculate how many there are. For example, in the multiplication of the "Anna's laundry" activity, the kindergarten teacher in circle time gave two red t-shirts to "child A" and asked her to hang them on a rope. Then, he gave "child B" two green t-shirts, two yellow ones for "child C," and two white ones for "child D" and asked them to hang them on the same rope. Then the kindergarten teacher asks a child, "How many t-shirts are hanging on the rope?" "How many t-shirts did each child hang?" "How many kids hung t-shirts?" (Fig. 6.2a). Computer-assisted activities were then carried out. An example of this

(a) (b)

Fig. 6.2 Computer (**b**) and noncomputer (**a**) activities of the experimental group for the first game level (line structure) is the "Star Competition." In this activity, the seven dwarves appear on the computer screen who have read some books. Sleepy read three books and Doc twice as many books as Sleepy. For each book, the student must draw a star on the line (Fig. 6.2b). The activity asked the students "How many books did Sleepy read?," and the student had to answer by choosing the correct number each time.

The second game level of the experimental group began with a noncomputer activity of group structure for multiplication and division. An indicative activity for the division is the following. The kindergarten teacher gave some apples to "child A," and "child A" had to divide the apples into two bags fairly (Fig. 6.3a). The kindergarten teacher then asked "child A," "How many apples do you have to put in each bag?" Then, the computer activity "The pigs and the apple tree" took place. The student had to draw an equal amount of apples from an apple tree in each basket on the computer screen. The activity asked students: "How many apples are in the baskets? How many apples did we put in each basket?" And the student had to answer by choosing the correct number each time (Fig. 6.3b).

The third game level of the experimental group teaching began with noncomputer activities of the rectangular structure for multiplication and division. For example, students played the "Flag" game. Students were encouraged to make their own flags from stars, determining how many lines and how many columns their own flag wanted to have. They then answered questions such as "How many star lines does your flag have? How many stars does each line have? How many stars are there?" (Fig. 6.4a). After each correct answer, the student had to show, read, and write the correct number. The last part of this level included computer activities. For example, on the computer screen are the grandfather, the two grandchildren, and an estate with cherries. The student is then asked to divide the estate with the cherries into two equal parts, moving a green line on the screen so that each grandson gets an equal part of the grandfather's estate (Fig. 6.4b). The student should then answer a series of questions: "How many cherries are there in total? How many children share cherries?"

(a) (b)

Fig. 6.3 Computer (**b**) and noncomputer (**a**) activities of the experimental group for the second game level (group structure)

(a) (b)

Fig. 6.4 Computer (**b**) and noncomputer (**a**) activities of the experimental group for the third game level (rectangular structure)

Third Phase

Similarly, during the third and final phase of the study, after the teaching intervention, the same test was given to all students in both the experimental and control groups as a posttest at the end of March 2017 to measure their improvement on multiplication and division.

Results

Analysis of the data was carried out using the SPSS (ver. 21) statistical analysis computer program. The independent variable was the group (experimental group and control group). The dependent variable was the students' posttest score.

Evaluate the Effectiveness of KTMDG for Mathematical Achievement on Multiplication

The first analysis was a t-test among the students' pretest scores of mathematical achievement on multiplication in order to examine whether the experimental and control group started at the same level. There was no significant difference in the students' pretest scores on multiplication for the experimental ($M = 9.05$, SD = 1.26) and the control groups ($M = 9.51$, SD = 2.34), $t(90.94) = -1.351$, $p = 0.180$.

Before conducting the analysis of ANCOVA on the students' posttest scores for mathematical achievement on multiplication to evaluate the effectiveness of the intervention, checks were performed to confirm that there were no violations of the

Table 6.1 Comparison of student scores for mathematical achievement on multiplication in posttest: ANCOVA analysis

Sources	Type III sum of squares	df	Mean square	*F*	Sig.	Partial eta squared
Pretest	124.078	1	124.078	243.082	0.000	0.677
Group	91.539	1	91.539	179.336	0.000	0.607
Error	59.211	116	0.510			

assumptions of homogeneity of variances (Pallant, 2001). The result of Levene's test when pretest for mathematical achievement on multiplication was included in the game model as a covariate was not significant, indicating that the group variances were equal, $F(1, 117) = 0.084$, $p = 0.772$; hence the assumption of homogeneity of variance was not violated.

After adjusting for students' posttest scores for mathematical achievement on multiplication in the pretest (covariate), the following results were obtained from the analysis of covariance (ANCOVA). A statistically significant main effect was found for type of intervention on the posttest scores for mathematical achievement on multiplication, $F(1, 116) = 179.336$, $p < 0.001$, partial eta squared = 0.607 (Table 6.1). The experimental group ($M = 11.83$, SD = 0.42) performed significantly higher in the posttest for mathematical achievement on multiplication than the control group ($M = 10.31$, SD = 1.71).

Evaluate the Effectiveness of KTMDG for Mathematical Achievement on Division

The next analysis was a t-test among the students' pretest scores of mathematical achievement on division in order to examine whether the experimental and control group started at the same level. There was significant difference in the students' pretest scores on division for the experimental ($M = 5.98$, SD = 1.29) and the control groups ($M = 6.86$, SD = 2.81), $t(83.17) = -2.207$, $p = 0.030$. The result of Levene's test when pretest for mathematical achievement was included in the game model as a covariate was not significant, indicating that the group variances were equal, $F(1, 117) = 0.157$, $p = 0.693$; hence the assumption of homogeneity of variance was not violated.

After adjusting for students' posttest scores for mathematical achievement on division in the pretest (covariate), the following results were obtained from the analysis of covariance (ANCOVA). A statistically significant main effect was found for type of intervention on the posttest scores for general mathematical achievement on multiplication, $F(1, 116) = 333.571$, $p < 0.001$, *partial eta squared* = 0.742 (Table 6.2). The experimental group ($M = 11.08$, SD = 1.03) performed significantly higher in the posttest for mathematical achievement on division than the control group ($M = 7.78$, SD = 2.13).

Table 6.2 Comparison of student scores for mathematical achievement on division in posttest: ANCOVA analysis

Sources	Type III sum of squares	df	Mean square	*F*	Sig.	Partial eta squared
Pretest	186.559	1	186.559	150.075	0.000	0.564
Group	414.664	1	414.664	333.571	0.000	0.742
Error	144.200	116	1.243			

Table 6.3 Frequencies of the two groups in the pretest of mathematical achievement

Pretest	Experimental group		Control group	
Grading	*N*	*f%*	*N*	*f%*
Low	14	23.7	16	26.7
Medium	32	54.3	15	25.0
High	13	22.0	29	48.3
Total	59		60	

Evaluating the Stratification of Students on Multiplication According to Their Success in Pretest

Moreover, a stratification of the experimental and control groups according to their success in mathematical achievement of the pretest was divided into three equal categories: less than 14 (33.33th percentile, low), 14 to 16 (33.33th to 66.66th percentile, medium), and more than 16 (66.66th percentile, high). In Table 6.3 the students' performance is presented including both groups (i.e., the experimental and the control group) before teaching intervention.

Table 6.3 shows that 22.0% of the students of the experimental group achieved high grades, 54.3% achieved medium grades, whereas 23.7% achieved low grades. Likewise, 48.3% of the control group achieved high grades, 25.0% medium, and 26.7% low. In other words, students' performance in the medium category of the experimental group (54.3%) appeared to be superior compared with the control group (25.0%).

A two-way ANOVA was conducted that examined the effect of class (experimental versus control) and the students' level of mathematical achievement (low versus medium versus high) on their improvement on multiplication (posttest minus pretest score). There was no significant interaction between the effects of class and mathematical level on students according to their success in posttest improvement, $F(2, 113) = 1.291$, $p = 0.279$, *partial eta squared* = 0.022. On the contrary, the effect of mathematical level was significant ($F(2, 113) = 45.042$, $p < 0.001$, *partial eta squared* = 0.444) with the improvements on multiplication in the low level which was higher (low, $M = 2.900$, SD = 1.470) than those in the medium and high levels (medium, $M = 2.021$, SD = 1.242; high, $M = 0.241$, SD = 0.576) after the teaching intervention (Table 6.4 and Fig. 6.5).

Also, the effect of the group was also significant ($F(1, 113) = 128.611$, $p < 0.001$, *partial eta squared* = 0.532), with children in the experimental group scoring higher

Table 6.4 Mean and standard deviation of mathematical improvement on multiplication according to the levels of mathematical skills

Level	Class	*M*	SD	*N*
Low	Experimental	4.071	0.916	14
	Control	1.875	1.024	16
	Total	2.900	1.470	30
Medium	Experimental	2.625	0.870	32
	Control	0.733	0.883	15
	Total	2.021	1.242	47
High	Experimental	1.769	0.926	13
	Control	0.241	0.576	29
	Total	0.241	0.576	29
Total	Experimental	2.7797	1.190	59
	Control	0.800	1.038	60
	Total	1.781	1.490	119

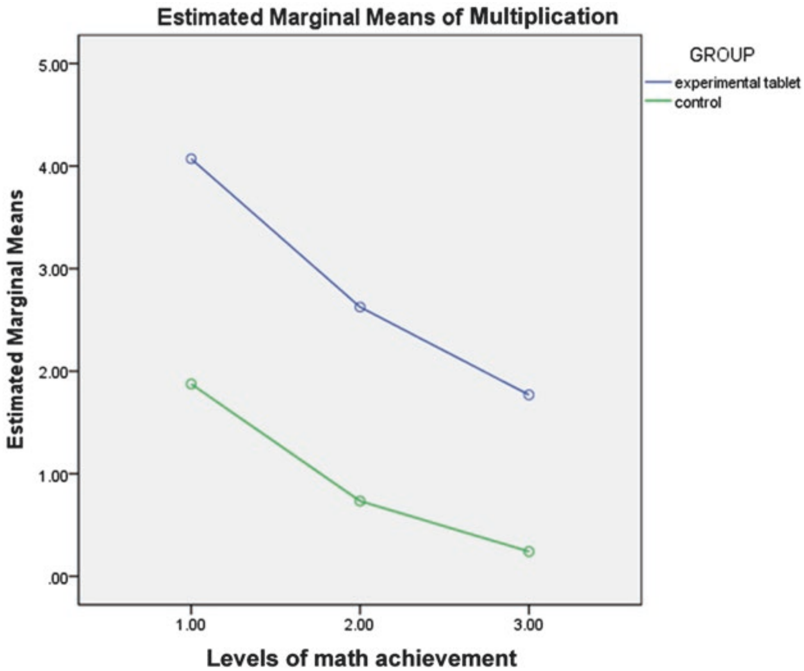

Fig. 6.5 Mathematical improvement on multiplication after the teaching intervention according to the levels of mathematical achievement

(M = 2.7797, SD = 1.190) than those in the control group (M = 0.800, SD 1.038) after the teaching intervention.

The Bonferroni post hoc tests indicated that students' improvement on multiplication among the experimental group of the low-level group differed significantly from students' improvement in the medium-level ($p < 0.001$) and the high-level ($p < 0.001$) groups. Also, the medium-level group differed significantly from students' improvement in the high-level ($p = 0.015$) group.

Evaluating the Stratification of Students on Division According to Their Success in Pretest

Moreover, a stratification of the experimental and control groups according to their success on mathematical achievement of the pretest was divided into three equal categories, as it has been shown in Table 6.3.

A two-way ANOVA was conducted that examined the effect of class (experimental versus control) and the students' level of mathematical achievement (low versus medium versus high) on their improvement on division (posttest minus pretest score). There was no significant interaction between the effects of class and mathematical level on students according to their success in posttest improvement, $F(2, 113) = 0.850$, $p = 0.430$, *partial eta squared* = 0.015. Similarly, the effect of mathematical level was significant ($F(2, 113) = 19.518$, $p < 0.001$, *partial eta squared* = 0.257) with the improvements on division in the low level which was higher (low, $M = 4.033$, SD = 2.525) than those in the medium and high levels (medium, $M = 3.723$, SD = 2.242; high, $M = 1.428$, SD = 2.154) after the teaching intervention (Table 6.5 and Fig. 6.6).

Also, the effect of the group was also significant ($F(1, 113) = 274.442$, $p < 0.001$, *partial eta squared* = 0.708), with children in the experimental group scoring higher ($M = 5.101$, SD = 1.505) than those in the control group ($M = 0.916$, SD 1.393) after the teaching intervention.

Table 6.5 Mean and standard deviation of mathematical improvement on division according to the levels of mathematical skills

Level	Class	*M*	SD	*N*
Low	Experimental	6.2857	1.32599	14
	Control	2.0625	1.38894	16
	Total	4.0333	2.52550	30
Medium	Experimental	4.8750	1.51870	32
	Control	1.2667	1.38701	15
	Total	3.7234	2.24288	47
High	Experimental	4.3846	0.86972	13
	Control	0.1034	0.77205	29
	Total	1.4286	2.15432	42
Total	Experimental	5.1017	1.50511	59
	Control	0.9167	1.39359	60
	Total	2.9916	2.54950	119

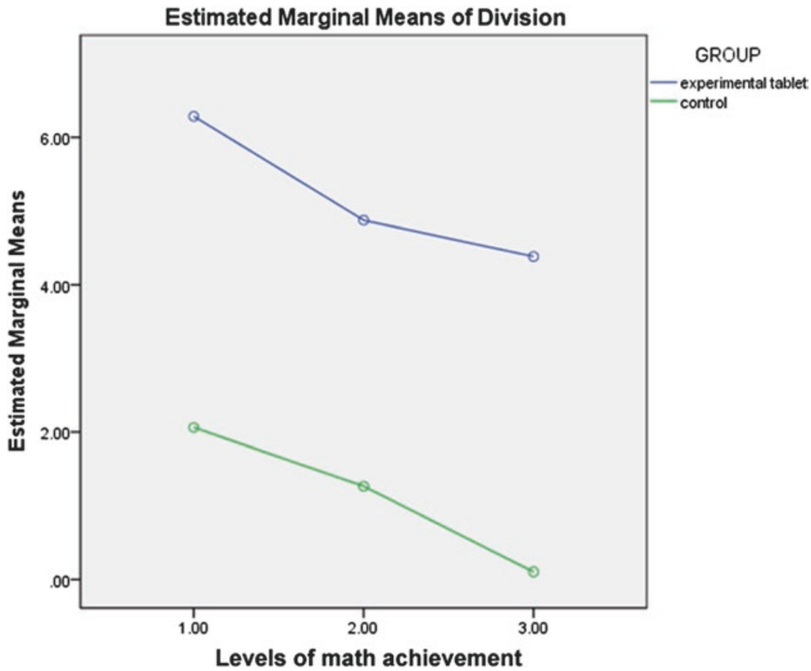

Fig. 6.6 Mathematical improvement on division after the teaching intervention according to the levels of mathematical achievement

The Bonferroni post hoc tests indicated that students' improvement on division among the experimental group of the low-level and the medium-level groups differed significantly from students' improvement on the high-level ($p < 0.001$) groups.

Conclusions and Discussion

The overall aim of the study was to investigate the effect of teaching intervention, using the Kindergarten Tablet Multiplication and Division Game (KTMDG). In particular, the mathematical activities and software based on Realistic Mathematics Education were designed to teach the mathematical concepts of multiplication and division (Freudenthal, 1973; Van den Heuvel-Panhuizen, 2001, 2008).

With the method of game-based learning, students become active participants in learning. In addition, for the process they use their previous knowledge which they enrich with new ones. In addition, it is very important that the feedback is provided directly during the game, as well as the self-assessment that the students make through the scoring that each game has. Students learn through action and reaction as well as collaboration (Oblinger, 2004). Game-based learning can improve learning motivation of students. When students enter a flow state in playing, their concentration is higher than usual (Squire, 2003).

In this survey, we found that students taught with the educational intervention based on KTMDG had significant improvement on multiplication in comparison to those taught using the traditional teaching method according to the kindergarten curriculum. Our results coincide with the results of other similar studies showing the positive effect of a computer-based mathematics teaching model (Dissanayake et al., 2007; Judge, 2005; Keong et al., 2005; Kroesbergen et al., 2007; Manolitsis et al., 2013). Therefore, the first research question was confirmed.

Also, our findings suggest that students belonging to the low level of mathematical achievement being taught a multiplication with educational intervention based on KTMDG had significant improvement, compared to the students in the medium and high levels of mathematical achievement. Our findings agree with similar studies (Zaranis, 2016, 2018; Zaranis et al., 2015), which implied that ICT helps students understand mathematical concepts more effectively. So the second research question was addressed.

Furthermore, as mentioned in the results section, the students taught with educational intervention based on KTMDG had a significant improvement on division than those taught using traditional teaching according to the kindergarten curriculum. Our results agree with the results of other similar studies showing the positive outcomes of a computer-based model of teaching mathematical concepts (Dimakos & Zaranis, 2010; Trouche & Drijvers, 2010). Therefore, the third research question was also answered positively.

Moreover, our findings suggest that students with a low level of mathematical achievement being taught division with educational intervention based on KTMDG had significant improvement, compared to those with a high level of mathematical achievement. Our results surpassed the results of other similar studies showing the positive results of a computer-based math teaching model (Keong et al., 2005; Walcott et al., 2009). Thus, the fourth research question was also addressed. In other words, the overall conclusion of this study was that our game model, with mathematical activities and software based on Realistic Mathematics Education, helps students with low levels of mathematical achievement improve their knowledge of multiplication and division more than students belonging to the other levels.

Regarding the educational value of this study, its findings should be taken into account by a number of stakeholders, such as students, teachers, researchers, and curriculum designers. In particular, our planned teaching approaches could be created as a wide-ranging study to examine the extent to which children help to understand multiplication and division. We as instructors of educators will certainly try to inform our students about these results, which they will need to keep in mind when designing activities for children. Moreover, the learning method based on Realistic Mathematics Education (RME) using ICT can interfere in various mathematical subjects as a research plan. The result of this research can be extended by developing various similar studies in geometry and mathematics (geometry shapes, problem-solving, etc.) in the kindergarten and the first classes of the primary education.

The above discussion should be mentioned in light of some of the limitations of this study. The first limitation of the study is that the data collected came from participants living in the city of Rethymno, Crete. The second limitation was the generalizability of this study which was limited to participants attending public schools. The third limitation was that the intervention fidelity had not been controlled. Therefore, this research may be extended by developing tools in order to measure the intervention fidelity. As a result, the outcomes of this research can be generalized only to similar groups of students. The results may not adequately describe students from other regions of Greece. However, as the study was on a specific context, any application of the findings should be done with caution.

Furthermore, the undertaken computer-assisted educational game revealed an extended interest in the tasks involved from the part of the students. It is an ongoing challenge for the reflective teacher to decide how this technology can be best utilized in education; especially in light of the current researches on the effects of such an implementation. This study is one small piece in the puzzle of math education at the kindergarten level.

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Chapter 7
Gamify Gamifying: Learning with Breakouts

Mariano Sanz-Prieto and Gema de Pablo González

Game-Based Learning in Education

Playing has been always something intrinsic of human beings and some animals, as it is one of the most efficient learning transmission methods. Playing first became a learning experience for adult life to survive, and later, it became an initiation rite or a training activity. Nowadays, it is only a way to spend some time (Revuelta & Guerra, 2012).

These days, the way of playing has changed, becoming more abstract and multifunctional and dependent on electronic devices such as video consoles, computers, tablets, etc.

Until recently, video games were associated with various stereotypes and were considered negative for the mental and physical health of the players. However, subsequent studies have shown that video games, as well as other activities practiced in excess, could have negative results if a reasonable time is exceeded, but if playing habits are respected (e.g. adequate time, environment, online games moderation, etc.), this activity could be considered satisfactory and safe (Martínez et al., 2018).

Thus, movements such as the serious games have emerged, which urge the use of playful technologies for educational and training purposes. They investigate the educational, therapeutic and social impact of video games designed with or without pedagogical intention (López, 2016). Serious games can be used to train skills, and therefore they have a very interesting application in learning. Turning learning into a game makes the person using it to be very motivated towards it. In fact, gamification is built on the principles of games and, in particular, also on serious games to promote learning. That is, game-based learning is the application of game design to

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achieve some kind of behavioural change or the learning of some skills or knowledge (Felicia, 2020).

The movement has emerged to adapt to the needs of a new generation of students, often known as the digital generation (Generation Y, Z, Global Generation), whose distinctive characteristics should be recognized to ensure satisfactory pedagogical results and the necessary motivation on their part (Prensky, 2001). This generation has been familiar with digital technology from an early age (Hockly, 2011). They use digital devices frequently, and ICT (information and communication technologies) is the language with which they communicate, express themselves and understand the world around them. The digital generations also play a great deal of video games and are fervent users of social networks, sometimes in the form of virtual worlds. They often engage in activities that reward their perseverance, so they expect the same level of reward from educational activities.

On the other hand, we know that as teachers in the classroom we have sometimes had problems in engaging and motivating these generations to participate in traditional educational activities, perhaps because the format used for formal education has not been able to adapt to the needs, preferences and expectations of students.

Some educators have accepted the characteristics of the digital generations and are aware of the important role of play in education or vocational training. They have used immersive environments and play technology to reach their students, and recent advances in play technology have supported this shift in teaching. Today, there are many tools that make it easy to gamify the classroom. Thus, teachers who intend to create games can focus on pedagogical aspects instead of technical ones.

However, it must be clarified that gamifying the classroom, although it has a history of about 10 years, has also been surrounded by false myths or clichés that have made its implementation in the classroom not easy. Some of these myths, according to García-Ruiz et al. (2018), are:

- It is not about introducing playful objects as if they were toys, but about applying the elements of gaming to the learning scenario.
- It is about generating motivation, which is proven through play, but it is not a fad of an emerging resource.
- Gamification is not exclusive to education; it can also be applied to other disciplines such as psychology, human resources or marketing.
- You don't have to be an expert in technology, in games or in video games.
- You do not need extra economic resources to gamify the classroom, nor invest a lot of time in the design of a gamified project. It is important to know how the game works and to use creativity.
- Gamification is not used to entertain students in their free time. It is not a question of giving them a break, but to include gamification in the classes to get the most out of it.

Gamification and Cognitive Processes

The educational theories that support gamification in the classroom are diverse, and the main ones are cognitivism, behaviourism and constructivism (Vygotsky, 1978; Piaget, 1977; Skinner, 1974; Gagne et al., 1990). All of them give theoretical support to the idea that using methodologies based on the play promotes learning, although each one of them puts the focus on some elements in front of others.

In the **behavioural** approach, the subjects are not directly responsible for their learning activities; instead, they are conditioned to react to the stimuli. Behaviourism argues that we learn based on the reinforcing consequences we obtain when executing a behaviour.

For **cognitive** theories, the subject has an internal map (knowledge) that is updated by external events. These theories place special emphasis on the underlying cognitive process.

Finally, in **constructivist** theories, subjects learn by interacting with their environment and with their peers, implying a trial-and-error process and the ability of the subject to interpret past and present experiences and thus update their knowledge.

Not all games aimed at leisure respond to theories about how we learn; however, some of them intrinsically implement some known pedagogical concepts. For example, they usually include a high interactive intensity, specific objectives, continuous challenges and sense of commitment.

Norman (1993) associated these concepts with successful learning environments. To some extent, video games have behavioural, cognitive and constructivist characteristics. However, while the first pedagogical programs emphasized the first two theories, the most recent video games, due to their complexity, open endings and their collaborative nature, encourage the constructivist approach to learning. With video games, players can elaborate theories and hypotheses, test them and adjust their knowledge and skills accordingly. The latest video games, with realistic 3D environments and physical engines, allow simulation environments that react to the actions of players in a very realistic way.

In relation to cognition and learning processes, gamification can be analysed by several models such as Carroll's minimalist theory Carroll (1998), Vygotsky's zone of proximal development (ZPD) (1978) or Kolb's basic learning model (1984).

Kolb's (1984) basic model of learning illustrates the process of accumulation through which students modify their internal map (knowledge) based on the information and answers obtained from previous actions; they successively carry out active experiments, concrete experiences, reflective observations, abstract conceptualizations and return to active experiments. In a sense, the learning cycle in game-based methodology can be compared to Kolb's learning cycle: players experience failure or gain and then need to reflect and identify the cause of the failure. Following this analysis, they formulate hypotheses about the cause or causes of the failure and action plans to help them solve the problem and then test and evaluate their hypotheses.

Also, according to Vygotsky's concept of the zone of proximal development (ZPD), subjects should be helped with *scaffolding* and progressively made them more autonomous. The more they develop their skills, the less help they will be given. The autonomy of the subjects and the metacognitive skills are progressively developed.

This principle is also found in game-based learning; as it offers a simple learning curve, the first levels are usually simple so that players can become familiar with the mechanisms of the game and be more efficient (Barzilai & Blau, 2014). Players have to learn new skills to excel and, in a way, take responsibility for learning. This ability of video games motivates and involves students in their learning to improve themselves and is by far the most interesting feature to help teachers make learning an attractive and motivating activity (Erhel & Jamet, 2013).

Gamification with Breakouts

In recent years and in the field of leisure, new modes of entertainment and games have emerged, such as escape rooms, in which participants have to discover clues to get out, or escape, from the room they are in. The key to this type of game is to solve a series of clues related to the environment.

Derived from these have emerged the "breakouts", which are immersive games. However, in a breakout you do not have to leave a room where a group is locked up, but in this case the objective is to solve clues that will lead participants to open a box with different types of locks. To get the codes that open the locks, it is necessary to solve problems, questionnaires and enigmas, so that the clues are not limited to answering questions, but to solve real challenges and enigmas that turn the players into adventurers, detectives, etc.

According to Galanis and Duckworth,[1] quoted in De Leon (2017), the reasons why we should use breakouts in education are:

- They are tools capable of adapting to any curricular content.
- They promote collaboration and teamwork.
- They develop critical thinking and problem-solving skills.
- They improve verbal competence.
- They pose challenges to which one must persevere.
- They build deductive thinking.
- Participants learn to work under pressure.
- Students are the protagonists of their learning process.
- They are fun for everyone.

[1] Illustration accessible in Twitter at https://twitter.com/sylviaduckworth/status/687826202179014657/photo/1.

Reasons match perfectly with the constructivist theories about learning and also mean a very powerful way of learning.

Experience with Digital Breakouts

The present chapter deals with an experience carried out in two courses at university, with students from the Faculty of Education. The experience was carried out in the subject of *ICT for the Digital Society*, where they have to learn to use digital tools and resources for the classroom.

So, the aim was to get them to design gamified resources; at the same time, they learned through play. In other words, the aim was to make them learn by doing.

This was carried out in two groups, one in the first year of the double degree of Early Childhood and Primary Education and the other group in the second year of the Early Childhood Education degree.

Objectives of the Activity

The main objective was to use digital breakout as a learning methodology to design, in turn, gamified resources for the classroom.

This main objective is specified in the following specific objectives:

- Recognizing tools for creating gamified content such as Genial.ly or Google Forms
- Analysing the curricular levels for which to design the gamified resources and adapt them
- Learning by doing
- Reflecting on the importance of the game in learning
- Creating gamified resources for the Primary and Early Childhood Education's classroom

Procedure

Within the subject of ICT for the Digital Society in the university degree of Early Childhood and Primary Education, students work on how to create gamified resources using the tools Genial.ly and Google Forms.

This experience was carried out in two groups of students in the following way:

- A group of first year students from the Early Childhood and Primary Education degree composed of 40 students. This group was totally taught in-person.
- A second year group of Early Childhood Education composed of 69 students. With this group the teaching was totally online due to the situation of COVID-19.

In this way, several topics were proposed so that they could choose and generate educational resources for students between 11 and 12 years old in the first group and for students between 5 and 6 years old in the second group.

Tools Learning Phase

Before they begin the development of the resources, there is a phase of learning the tools with which students will design educational resources, which are mainly Genial.ly, although it is also explained how to work with Google Forms.

The tool Genial.ly has easy-to-use breakout templates and therefore has been the tool used by all participants to develop their resources.

In order for them to know the tools, the teachers provide different breakouts to the students so that they can play with them and discover how this methodology works. In this phase they are briefly taught how to create digital locks (Fig. 7.1).

The teacher's Genial.ly account was used to create the breakouts of the templates chosen by each group. This allows for the use of templates that students would not be able to use without a paid account and, at the same time, allows for greater control of the work to help them in their development.

Development Phase in Cooperative Groups

For the development of the resources, cooperative base teams composed of four or five members are initially designed. Each team will choose a theme to develop its breakout. These themes can be about:

- Mathematics curriculum content for students from 4 to 6 years old, in the case of future teachers of Early Childhood Education.

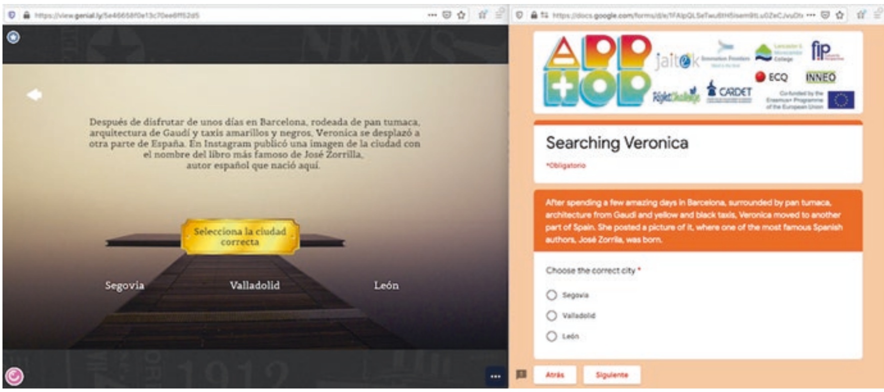

Fig. 7.1 Examples for students of breakouts using Genial.ly and Google Forms (own creation)

- For the case of the Primary Education stage, specifically for students from 11 to 12 years of age, the topics to choose from and to relate to some part of the curriculum are:
  – Environment
  – Climate change
  – Artificial intelligence
  – Computational thinking
  – Autonomy and personal independence
  – Blockchains

  Each team has to perform a number of tasks which are:

1. Create a common group account in Genial.ly using their university Google account.
2. Select a breakout model in Genial.ly at https://app.genial.ly/templates/games.
3. Send the choice to the teacher of the created email account and the chosen breakout model. He or she will create it and share it with that email.
4. The breakout must be digital, but it must also have a paper support of the process so that it can be used by a teacher.
5. Developing the breakout using digital locks.
6. Delivering the url, the code to be able to embed the breakout in other tools such as blogs and the documents related to the educational breakout created.

Once developed, the double-degree students of Early Childhood and Primary Education[2] presented their breakouts to all their classmates, then there was a vote and the three winners presented it at the *Educaparty* at the International Congress and Professional Fair Expo-eLearning (Fig. 7.2).[3]

In the case of the Early Childhood Education degree, they are still in the process of finishing the course, but they have already finished the breakouts and are in the phase of presentation to peers and voting (Fig. 7.3).

Finally, a questionnaire was given to both students and teachers (Appendix 1) about their satisfaction, learning and perception using this methodology. From the answers obtained in this questionnaire, we will comment on the data below.

Obtained Results

The objective of the questionnaire was to know the level of knowledge of both students and teachers about the gamification methodology. It also aimed to know the level of satisfaction of the development of the breakout activity.

[2] Breakouts developed can be found at https://sites.google.com/eduticuam.es/expolearning/.
[3] https://www.expoelearning.com/.

Fig. 7.2 Presentation of a students' group in Expo-eLearning Conference

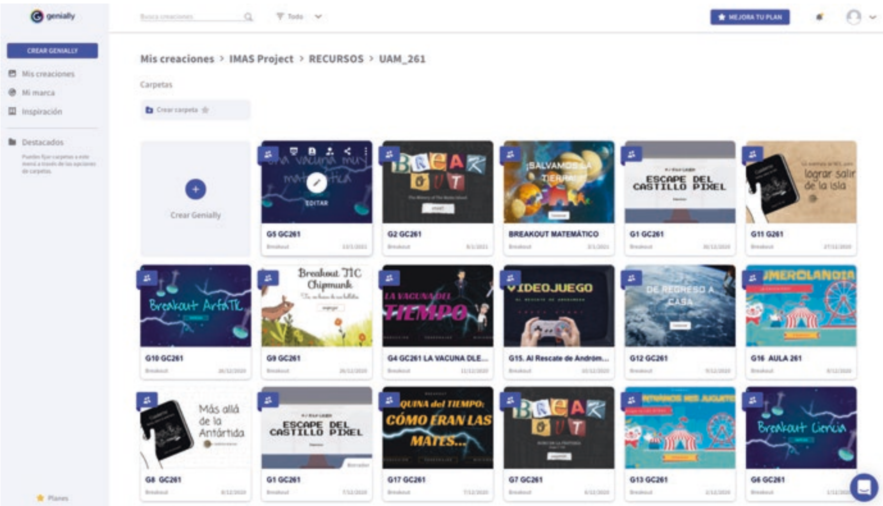

Fig. 7.3 Breakouts created by students of Early Childhood Education degree (own creation)

The results show that the activity in the classroom has been very satisfactory, both for the teacher and for the students, which makes us think that it is a methodology to continue using and deepening.

A total of 88 responses were completed and all incomplete surveys were deleted, which were another 8. Of these 88, 71 responses are from students, of which 66 were women, which is normal given the overwhelming majority of female students, especially in the Early Childhood Education degree.

With regard to the 17 responses from teachers, the distribution by sex is more equal, as there are 8 responses from women and 9 from men.

The initial impressions are quite similar in both cases and are very positive as it can be seen in Fig. 7.4 which includes both student and teacher responses.

As it can be seen, in general terms, when asked what they thought about gamification, a large majority said that gamification makes learning more fun. Also most of them, although a lower percentage than in the previous case, think that teachers can teach more and better through the game.

We will focus on the students' answers from the following question, since they are very similar to those from teachers, and we will only quote the teachers' answers if there are significant discrepancies.

One of the questions they are asked is to specify which tools, from a given list of options to create gamified activities, they know and to what extent. In this case, the results, as can be seen in Fig. 7.5, show that they know very well the tool used in the activity, Genial.ly, and also Kahoot, and at a medium level ClassDojo and Quizizz. There is more diversity of responses and less knowledge of the rest.

These results indicate that, for successive courses, the use of other tools could be considered to expand the design of gamified teaching activities.

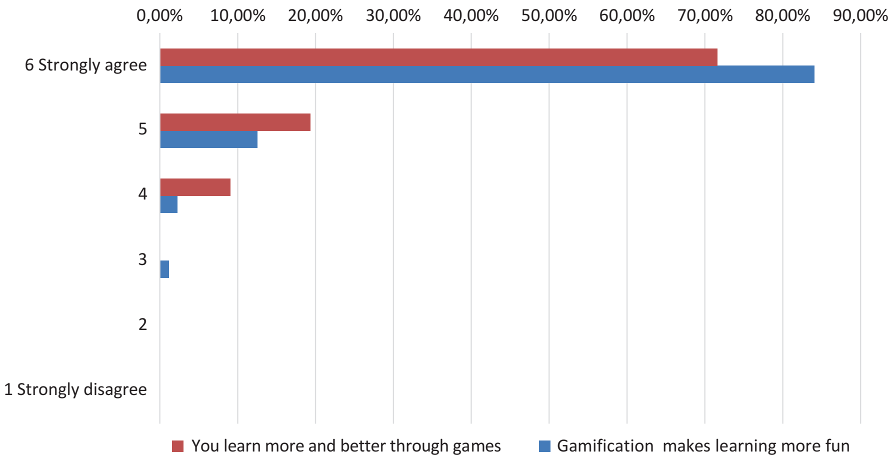

Fig. 7.4 Initial perception of participants

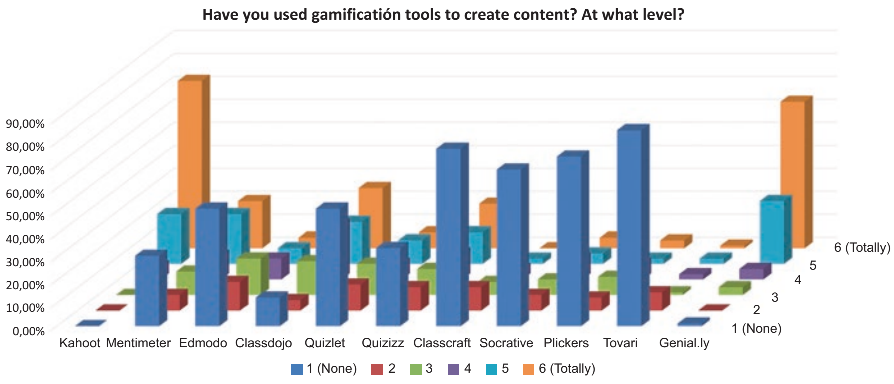

Fig. 7.5 Level of knowledge of tools to create gamified pedagogical activities

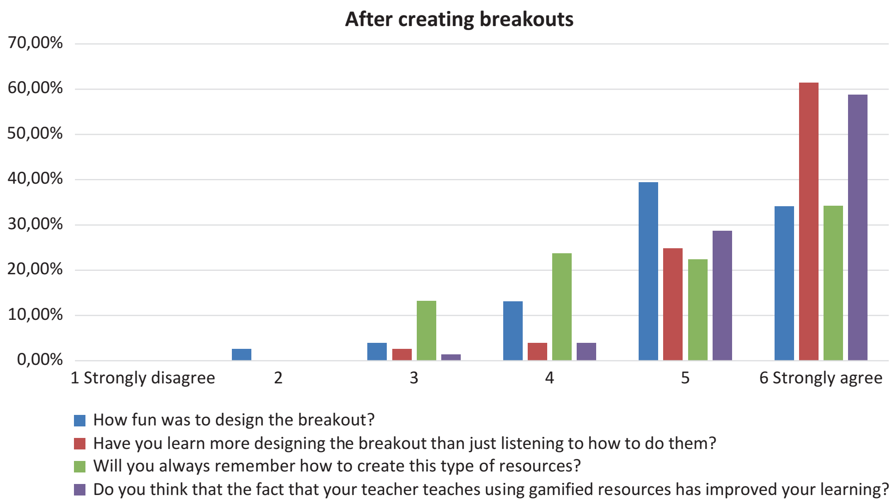

Fig. 7.6 Perception of the process after creating breakouts

Concerning the question of whether they think they have learned more from the teacher's use of gamification, Fig. 7.6 shows that most of them have given an affirmative response.

They also think they have learned more from the process of designing and implementing it than if they had simply attended the teacher's explanation of the process without having to do so. In short, they think that the whole process of designing a digital breakout has been fun and has involved a lot of learning.

The only aspect with which they have a little more doubt is the possibility of always remembering how this activity is carried out with the tools used.

As for the question of what differences they find between traditional and game-based learning, they generally agree with almost all of the options raised. As it can

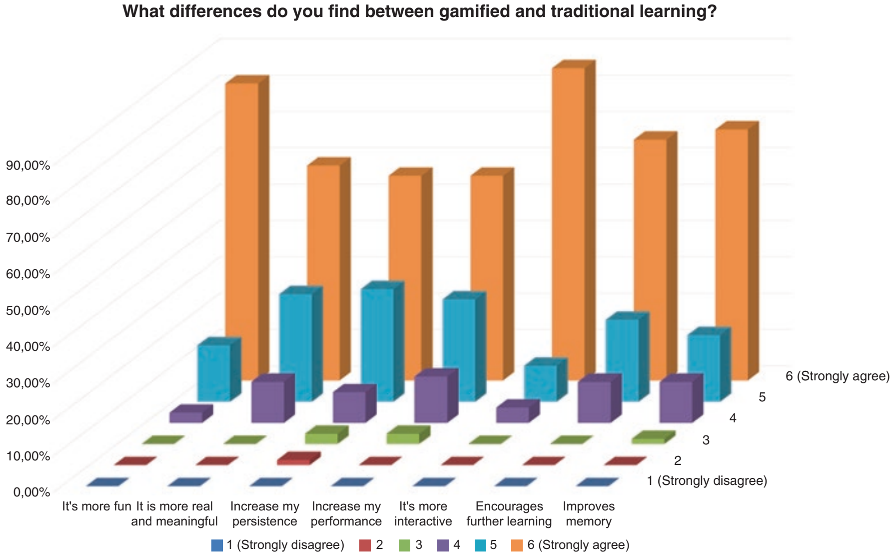

Fig. 7.7 What differences do you find between gamified and traditional learning?

be seen in Fig. 7.7, there are two options that are above 80% in the maximum option (6) which are that learning using gamification is more interactive and more fun.

However, the rest of the options have also a high acceptance, and placing them in order of their average achieved would lead to the following list:

- It's more interactive.
- It's more fun.
- Improves memory.
- Encourages further learning.
- It is more real and meaningful.
- Increase my persistence.
- Increase my performance.

With the latter having an average response of 5.4, this shows how highly students rate this learning activity.

Conclusions

Regarding the conclusions of this experience, it can be said that initially it has been really successful and the students have achieved the objectives of the activity in a more satisfactory and fun way than through the traditional methodologies that were being used until now for these same contents.

It must be taken into account that this experience pursues several objectives, linked not only to learning the tool and the design of the games, but, above all, to learning by doing. As future teachers, it is important to give them tools that allow them to acquire skills they will need in their professional future. Having designed activities through a methodology by which they themselves have learned by playing allows them to learn that through the game they learn more and better than through a traditional methodology, as it can be seen in the obtained results.

As we set out in the objectives, we can say that the goal of learning new tools to create gamified resources, such as Genial.ly, has been achieved. Moreover, as it is shown in the results, they know other tools, but they don't know many of them yet. Perhaps one of the points that we could consider as future options would be to incorporate new tools to gamify the classroom and design content.

In addition, having to design a resource adapted to the Early Childhood Education or Primary Education stage, depending on their level, they have had to analyse the curricular level and adapt the design of their resources to it. Through this work, students develop skills for their professional future. The fact of learning by doing makes them not only learn the content but also the experience of experiencing how to learn by playing.

Most students have stressed the importance of play in learning, with special emphasis on learning more and better than with traditional methodologies. The theories of significant learning highlight the need to build new knowledge into existing knowledge. In this sense, the fact of being able to experience the learning by means of the game implies the need to incorporate playful and motivating methodologies in the acquisition of learnings.

Finally, we have also found that for teachers the game-based learning methodology is very motivating and generates greater satisfaction in their teaching experience.

Appendix 1. Questionnaire Used

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Your Data

Some data about you

* 1. Sex

- Male
- Female
- Rather not answer

* 2. How old are you?

* 3. Profile using gamification

- Student
- Teacher

Initial views

Your opinions before using gamification, either as a student or as a creator

* 4. Do you think the play makes learning more fun?

1 Strongly disagree | 2 | 3 | 4 | 5 | 6 Strongly agree

* 5. Do you think you learn more and better through play?

1 Strongly disagree | 2 | 3 | 4 | 5 | 6 Strongly agree

6. Do you know something about breakouts?

1 Nothing | 2 | 3 | 4 | 5 | 6 Everything

* 7. Have you ever created a breakout?

- My teachers have never used breakouts for their content
- I have used them as a student
- I have created breakouts

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* 8. Do you know the following gamification tools because teachers have used them with you as a student? And at which level?

	1 Noting	2	3	4	5	6 Totally
Kahoot						
Mentimeter						
Edmodo						
Classdojo						
Quizlet						
Quizizz						
Classcraft						
Socrative						
Plickers						
Toovari						
Genial.ly						

* 9. Have you used any of these tools to create content? And how well do you know them? (6 wolud be the maximun level of knowledge, 1 if you do not know them at all)

	1 Nothing	2	3	4	5	6 Totally
Kahoot						
Mentimeter						
Edmodo						
Classdojo						
Quizlet						
Quizizz						
Classcraft						
Socrative						
Plickers						
Toovari						
Genial.ly						

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After using gamification

And having created a digital breakout

* 10. How much fun was it to design this breakout?

1. Not at all	2	3	4	5	6. Very fun
◯	◯	◯	◯	◯	◯

* 11. Do you think you have learned more by designing it than by listening to how it is made??

1. Strongly disagree	2	3	4	5	6. Strongly agree
◯	◯	◯	◯	◯	◯

* 12. Do you think you will always remember how to create this type of resources?

1. Strongly disagree	2	3	4	5	6. Strongly agree
◯	◯	◯	◯	◯	◯

* 13. Do you think that your learning has improved because your teacher uses gamified resources?

1. Strongly disagree	2	3	4	5	6. Strongly agree
◯	◯	◯	◯	◯	◯

* 14. What differences do you find between learning by playing or by using traditional methods?

	1 Strongly disagree	2	3	4	5	6 Strongly agree
It is more fun	◯	◯	◯	◯	◯	◯
It is more real and meaningful	◯	◯	◯	◯	◯	◯
Increases my persistence	◯	◯	◯	◯	◯	◯
Increases my efficiency	◯	◯	◯	◯	◯	◯
It is more interactive	◯	◯	◯	◯	◯	◯
Encourages greater learning	◯	◯	◯	◯	◯	◯
Improves the memory	◯	◯	◯	◯	◯	◯

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Chapter 8
Designing an Online Escape Room as an Educational Tool

Elīna Grāvelsiņa and Linda Daniela

Introduction

In Latvian schools, more and more teachers are looking for ways to enrich their teaching practice with active learning possibilities. There are Facebook pages for teachers to share their materials, new companies that make educational board games, and individual teachers who share their views on how to make the learning process more attractive. There is still a long way to go; however it seems that the possibilities are endless. When the learning process is displayed as an educational board game, class game, role-playing game, or digital game, it is known by the umbrella term "game-based learning" (Blass & Tolnai, 2019; Tang et al., 2009; Papastergiou, 2009). It is not made purely for students to play; it is a goal-orientated design process (Pho & Dinscore, 2015).

The COVID-19 pandemic caused a situation where educational institutions had to search for different solutions on how to organize remote learning, i.e., how to ensure that students are actively involved in the learning process, not just passively reading materials or looking at the screen. Remote learning changed the learning landscape drastically, and educators are searching for new solutions to motivate students to keep learning. Game-based learning is one of the possible solutions to make students actively involved in the learning process because games can provide exciting opportunities and motivation to construct new knowledge (Noroozi et al., 2020; Menon & Romero, 2020; Andrew et al., 2019; Egenfeldt-Nielsen, 2006). In remote learning, online games can merge digital and urban spaces to connect meanings, understand contexts, and construct new knowledge (Dreimane & Upenieks, 2020; Sailer et al., 2017; Admiraal et al., 2011).

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State of the Art

This section describes online escape rooms as a part of the game-based learning (GBL) concept and defines its main characteristics, recognizing it as a good addition to e-learning and as support for active learning strategies in a remote learning context. In GBL, escape rooms can be paired with role-playing games, although their closest historical form is real-life escape rooms; they have evolved out of role-playing games and live-action games (Wiemker et al., 2015). An escape room is an interactive, problem-solving activity where a group of people work together for a limited period of time (Huang et al., 2020; Nicholson, 2015). In its essence, it contains three main factors – a challenge to overcome, a solution, and a reward (Wiemker et al., 2015) that could be the breakout itself or the finding of a clue. The "escape" in escape games is the unlocking of a box, and in escape rooms, it is usually the symbolic escaping of a room. This game has evolved from difficult logic puzzles to well-designed immersive environment games that are growing in popularity not only in the entertainment industry but also in corporate training and pedagogy (Wiemker et al., 2015). In education, it provides the possibility for students to be involved in active learning (Franco & DeLuca, 2019; Zamora-Polo et al., 2019; Misseyanni et al., 2017; Bonwell & Eison, 1991) and has shown results of a deeper understanding of content and the possibility to transfer gained skills beyond the classroom (Ho, 2018).

GBL can provide interactivity and build intrinsic motivation (Noroozi et al., 2020; Menon & Romero, 2020; Andrew et al., 2019; Sailer et al., 2017; Egenfeldt-Nielsen, 2006; Jan & Gaydos, 2016); however it is important to put emphasis on the learning part. The most important thing when designing any game for learning is to plan for the process to be user-friendly and to ensure it resonates with the educational goals. There should be a good balance between the entertainment parts and the learning parts (Franco & DeLuca, 2019; Bylieva, 2018). Importantly, it has to be aligned with the curriculum (Cain, 2019; Gómez-Martín et al., 2009). In the best scenario, when the learner reaches the game goal, like breaking out of a room, he/she should also reach the educational goals set by the teacher (Veldkamp et al., 2020). As indicated by Ucus (2015), GBL is based on five major dimensions that contribute to the GBL efficiency of the students: learning environment, learner, pedagogy, context, and teacher. Also, Sánchez-Martín et al. (2020) believe that analyses of these experiences under a pedagogical, didactical point of view are scarce, and this leads to the necessity to bring ideas of smart pedagogy to the front line where the focal points are how to incorporate innovative solutions in learning, what needs to be taught, what competences will enhance the learning process, what learning goals the students should achieve during their technology-enhanced learning, what learning objectives should be reached, and what pedagogical activities can support such learning (Daniela, 2020, 2019; Barr, 2019; Hsu et al., 2017). It was found a long time ago that the time that students spend practicing their learning tasks positively correlates with learning outcomes (Ericsson et al., 1993), but in remote learning, practice is not so easy to organize, and this leads to the necessity to search for new solutions; GBL can be one of these.

Elements such as solving complicated tasks, remembering information, finding connections, communicating information, and working to a time limit and under pressure are common in practically any education process and afterward can be found in work, but they can also be found in escape rooms (Mills & King, 2019; See, 2016). They can help motivate students in various fields, and similar results have been gathered using digital versions of escape rooms (Sánchez-Martín et al., 2020; López-Pernas et al., 2019). It is known that escape rooms and escape games are good motivators. They can serve as learning agents to improve one's knowledge and can be used in various disciplines like pharmacy (Jeffres, 2019; Eukel et al., 2017), science (Huang et al., 2020), computer science (Borrego et al., 2017), entomology (Healy, 2019), learning equations and algebraic fractions (Jiménez et al., 2020), and so on. With schools closed due to the current situation, this format can be designed, for example, using Google Forms (Jiménez et al., 2020). Combining story, challenge, and an escape into a digital space provides "experiences suited for the COVID-19 learning environment" (Gomez, 2020).

Unlike real-life escape rooms that require classroom availability, budget availability, and logistics with large classes (Veldkamp et al., 2020), the digital version only has to deal with the time it takes to prepare it. However, their development for educational purposes is in its infancy, although there are many initiatives where teachers are trying to use escape room ideas for educational purposes (Ucus, 2015). The previous literature suggests that escape rooms are a social activity (See, 2016; Huang et al., 2020; Jiménez et al., 2020) that is done in groups; however, the digital version does not provide the elements of cooperation and socializing between students. These can be done, but they are not essential. On the other hand, it takes a lot less tangible resources to make one, and it can be played simultaneously in different classes and schools by many students, but it should be noted that it can take a lot of effort from pedagogical staff to develop such rooms.

A game to support the development of civic competence based on historical facts about Latvia was shared in November 2020 because in Latvia this is a month of honoring the fallen soldiers who died in the Latvian War of Independence and celebrating Latvia's proclamation of independence that took place on November 18, 1918. As the pandemic caused a situation in which it is not possible to organize face-to-face activities with students about these historic events and increase their citizenship and digital competences, this timely topic was selected and an online escape room was developed using GBL principles, keeping the cultural perspective of GBL in mind (Pimpa, 2011), and a meaningful story (Kapp, 2012) was developed. Flexible learning itinerary principles were chosen in which participants can choose how to direct the flow of learning, based on ideas by Martín-SanJosé et al. (2014).

Although real-life escape rooms have been used frequently for educational purposes in Latvia, the same cannot be said about their digital versions. Still, as predicted, new digital learning applications, platforms, and other resources are being implemented in e-learning due to COVID-19 (European Data Portal, 2020), so it is important to test them. That resulted in the leading research objective for this paper – design an online escape room and assess it from an educational perspective.

Research Design

This section aims to describe the design process and results that were explored to understand what the possibilities are of building an online escape room for students of general education.

Online escape rooms are still a completely new educational tool in Latvia that can alter regular remote classes. According to literature analyses, it is known that escape room should first be in line with the curriculum students learn (Bylieva, 2018; Cain, 2019; Veldkamp et al., 2020) and have a meaningful story (Kapp, 2012) that afterward is complemented with the game elements. The design process for the online escape room started after researching the chosen time period and selecting ten questions about that particular period. The goal of the online escape room was not to teach history but rather to assess the escape room as an educational tool for schools to ensure active learning through playing in a remote context.

Choosing a topic was the first step in making a new original online escape room that could be used for educational purposes, and the structure was made based on flexible learning itinerary principles (Martín-SanJosé et al., 2014). The design process consisted of seven steps:

1. Selecting the topic
2. Selecting the platform where the online escape room would be built
3. Gathering visuals and constructing a story
4. Implementing the topic questions and the visuals in the Google platform
5. Testing and improving the game
6. Making instructional documents for the teachers
7. Providing teachers with a link to the online escape room and information about it

Research suggests that an online escape room can be built in Google Forms (Jiménez et al., 2020). Although it is a relatively simple tool to use, it does not give the real feeling of a room that the players can look around and find something in. The best way to see what teachers in Latvia could use is to see what other teachers around the world are already using to make educational escape rooms. This was done by searching for the keywords “digital educational escape room” in YouTube and looking at the most recent videos by relevance that had an educational purpose of helping teachers make their own escape rooms. Five videos provided tutorials on how to make a digital escape room using Google Forms, as previously suggested, two videos suggested using Google Forms and Slides, and one showed only Google Slides and did not give specifics on how the answers are gathered. Two videos showed the usage of Google Forms, Slides, and Sites that provided the most options in comparison to the other videos. This combination can resemble a real-life escape room, helps organize the information, and is highly interactive.

The third step required a story that could be supplemented with visuals and would go nicely with the topic of Latvia's independence celebration. A simple story was created: "For unknown reasons, the security service has detained you in a room. A password is required to get out of the room. If you fill in the message correctly, you will be released, if not...." Pictures were gathered from pexels.com and pixabay.com and compiled in a collage using photo-processing software. The picture collage was added to Google Slides and 12 hyperlinks were attached to it (Fig. 8.1).

By clicking on details in the picture, the links were activated and showed hidden questions:

1. Q. When was Latvia declared as an independent, democratic country?
2. Q. Latvia's birthday, or its _____. Assemble the answer from the mixed letters rocamatpioln (proclamation).
3. Q. Which song by Kārlis Baumanis was played to proclaim Latvia's independence in 1918?
4. Q. The proclamation of the Latvian state took place at the Second Riga City Theater, presently known as...

   + Q. Who were the 37 men and 1 woman who had gathered to proclaim the state of Latvia?
5. Q. Shortly after the proclamation of the Republic of Latvia, the war of freedom or the war of ______ began.

Fig. 8.1 The online escape room. The ringed areas show the hidden links

6. Q. On what date each year is the day that symbolizes the victory of the Latvian national hero over the black knight (predicted in Andrejs Pumpurs' epos "Lāčplēsis") celebrated?
   + Q. What happened on November 11, 1919?
7. Q. What is the name of the special red color in the Latvian flag?
8. Q. How many Lats (the currency used in Latvia before the Euro) did Latvians donate to build a Monument of Freedom?
   + Q. What is the connection between the Monument of Freedom and the author of "Kaķīša dzirnavas" (a famous Latvian fairy tale)?
9. The print screen of phone chat with a hint.
10. Link to a mentimeters.com word cloud.
11. False lead: the name of the first president of Latvia.
12. Password entry to escape the room.

Google Sites was used as the main platform for the Google Slides presentation, and all the hyperlinks led to Google Forms or other pages with pictures. On the first try, there was one Google Form under the interactive presentation; the eight hyperlinks took the user to a hidden page on Google Sites where they found a question, and then they had to go back to the home page to insert the answer. After testing, this feature was changed to eight different Google Forms due to the possibility of closing the home page and losing all the information gathered.

There are three paths by which the main objective can be achieved in escape rooms – linear, open, or multilinear (Jiménez et al., 2020). In this game, the flexible learning itinerary was used (Martín-SanJosé et al., 2014). This new system provides open paths so the player does not have to follow a sequenced pattern, as with linear and multilinear paths. It allows the player to find and solve problems in any order. This means that the user clicks on a link in the picture and is sent to another page with a question and a Google Form to complete. When an answer is given to the question, the player receives a letter or part of the password that needs to be given to the security guard at the exit (Fig. 8.2).

A couple of links did not have a Google Form attached to them. The picture on the wall was a red herring that led to a page with the description: "The first president of Latvia was Jānis Čakste." The phone under the table opened up a print screen of phone chat describing a conversation between someone who has been captured and his friend. It gives a little bit more to the story and reveals that the middle word of the password is "and." The third link without a Form led to a question on www.mentimeter.com. The participants were asked to write a word on the "whiteboard" that they associated with this escape room. Eighty-two participants found this hidden address and wrote a word connected to Latvia or the escape room activity. The rest of the clues (1–8) hid the ten previously selected history questions mentioned above.

Teachers received information on how to use the escape room and tips on how to instruct the learning process on the home page of Google Sites before students started to use the escape room, and a description was also given to the participants on how to use the room. A time limit of 30 minutes to answer the questions was

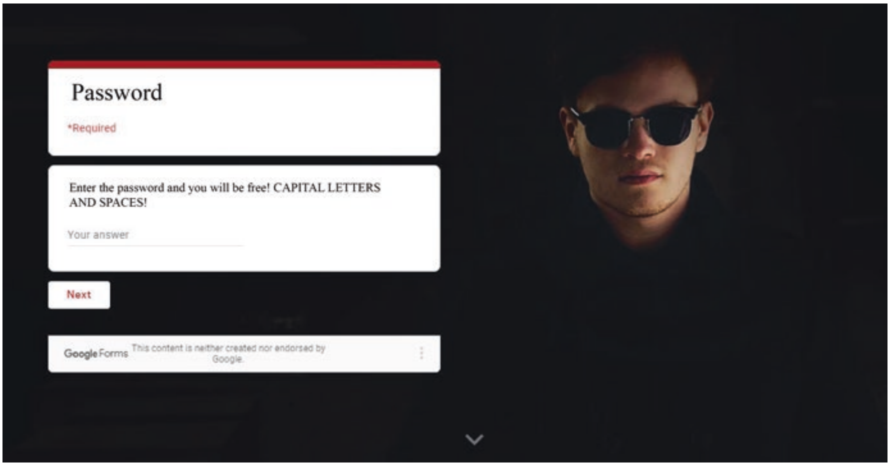

Fig. 8.2 When clicking on the door (12), a hyperlink opens to a new page with a security guard asking for the password

given, and it was suggested that students could search for information on different websites.

Eight out of ten questions given in the escape room did not have a response validation, meaning participants could write any answer, and in the end, they received a clue to the password to get out of the escape room. After every question, participants had to indicate their school and class, or they could use the status of "guest." Furthermore, if they did not know the answer, students were encouraged to search for information online and to provide a link to the site where they found the information. This was done to see if the students would try to find the right answers, indicate their findings, or skip the learning process entirely.

When the design process was finished, a link to the first escape room was sent to a couple of people for testing. There are three main aspects that should be included when testing the game – usability, which affects the game's flow; playability, which focuses on players' experience; and gameplay metrics, which observe the players' interaction with the game (Canossa & Drachen, 2009). As mentioned before, some problems, like the usage of only one Google Form that slowed down the escape experience, were found. Also, some limitations were found when testing the room from a smartphone. It was possible to use it, but it slowed down the process, opened the Google Slides in a different window, and did not allow zooming in on the details. Other technical details, such as share possibilities and question formats, were replaced in Google Forms after the testing. After the alterations were made, the escape room was ready to be sent out and offered to schools for teachers and students to test. In addition to the Google Sites link, an informational document for the teachers was added. This included the instructions on how to use the room, a "cheat sheet" with the hidden clues, answers to all the questions, and reference questions to talk about with the class after finishing the escape room. The game was played from November 17 until December 24, 2020, and the data was collected after.

Results

The data was collected in Google Forms, and later an Excel sheet was downloaded to analyze the results. The most viewed and answered question had 121 respondents. The number of answers given to each hidden question varies. This may also be due to the game's time limit, which was 30 minutes, or the level of participants' involvement. However, the results show that 64 participants succeeded in escaping the room, meaning that they had played most of the game and found the hidden clues.

Since the room was developed using Google Forms, the answers were gathered as in a regular survey and analyzed by looking for answer patterns, their accuracy, and their sources.

The next subject to discuss is the response validation. On the one hand, it gives a good overview of how many students gave an answer without checking its validity and perceived the game as a challenge. The results show that 38% of the answers given were wrong. We can speculate that students did not search for reliable information and used a game as entertainment rather than a challenge for learning, but this assumption should be researched further. For learning purposes, the fact that students gave wrong answers can serve as a signal for teachers to discuss the facts and ensure that mistakes are treated as learning agents. For questions that required validated answers to be given, it was important to form them as precisely as possible because if the end of the keyword(s) was entered differently, which is more possible in Latvian, the answer was not accepted. In this situation, it is better to use numbers or words, which cannot be written in different forms as answers.

For every question to which the participant sought the answer on the Internet, they were requested to add a reference. This type of request is not mandatory, but for this research it would have been useful to know the participants' search patterns. However, on average only four participants felt the need to use a source or to add it to the answer. The number of sources used varied from 1 to 10 per question. Although it is not enough to make justified conclusions, it can give an insight into the participants' digital competences to use online sources for learning purposes. In three cases, seven to ten sources were found to provide the answer to questions. The second question asked for a synonym for Latvia's Independence Day ceremony, and it was expected that the word "proclamation" would be given as the answer. In the game, the word was already given as a clue, but the letters were mixed up in a different order. Forty percent of participants gave the wrong answer, and some even wrote its date. In the next stages of the research, it needs to be understood why such a simple question was so difficult for the students. At this stage, we can only speculate on possible reasons.

It can be concluded that this tool would work better if it were to be used in classes first and the results discussed later, as it was realized that it is hard to analyze the results without knowing the background of the students. The use of eight different Google Forms also complicated the task of analyzing the results gathered. By using one Google Form, it would have been easier to sort the participants' data by school, class, and guests.

After finishing the escape room game, participants were asked to rate their experience in a ten-point system where one is bad and ten is excellent. Seventy-five percent of all players who finished the game gave 8–10 points, which could imply that, from a player's point of view, the game seemed interesting and useful.

Discussion

From a designer's point of view, it should be acknowledged that it takes a lot of time to develop an escape room, at least at the beginning. The designer has to be familiar with all the Google apps and know the technical details that can alter the gameplay. The time spent on development includes information and resource gathering, setting up all the elements, and activating all the links. No doubt it would be easier with a sample or draft ready to copy and change the main elements, but for their first time making one, the teacher should be prepared to spend a day or two on getting to know this system. Given the time spent on development, it is also wise to be able to use this room for more than one class and possibly include it as a project for the students: to test them, gather their results, and use this room as an example for making their own escape rooms.

The biggest problems that could occur from the player's side are finding all the clues, answering the unknown questions, and escaping in the given time. If the lessons in general education are 40 minutes long and there are two lessons in a row, then it would be possible to play the escape room game in the first part, and, in the second part, there could be reflections on the activities. Otherwise, 40 minutes for giving instructions, breaking out of the room, and reflecting is not enough. Another option is to use escape rooms as a substitute for tests for a previously studied topic.

Overall, the experience was significant. It gave an insight into how to use this tool and what its pros and cons are. It is not an easy tool to use at first attempt, but it is a novelty for the regular remote classes. A suggestion would be not only for the teacher to design it but for the students to design one too. This project could include information gathering; picture processing; the making of Google Forms, Sites, and Slides; testing it on their peers; and gathering results; it could be a promising interdisciplinary experience that should be further researched.

Conclusions

Our findings demonstrate that digital escape rooms motivate students and can be a novelty when used in e-learning. Google's platforms can provide interactive and visual material for students to use. There is a variety of options as on how to provide clues and gather information that is given by Google Forms. As a free, online tool, it can provide a good platform for game-based studies; however it comes with its limitations. First of all, a digital escape room done in Google Forms, Slides, and Sites is a time-consuming process the first time. Another thing to mention is the necessity to understand the educational goals that will highly affect the design process and the differences between the mechanisms to be used. For example, in Google Forms, patterns were found in students' and teachers' answers, suggesting that, without response validation, students are less motivated to find the right answers and lack effortful thinking, and most of their attention was given to the escape room's/game's entertainment value, not to learning.

The third limitation concerns data gathering and analysis, which does not allow precise performance tracking of each individual, especially if the questions are arranged in several separate Google Form files. If a student does not indicate his/her name in each answer, then it is very difficult to trace his/her actions, look at which answers to the questions were found first, look at which answers were found but did not support the learning, and evaluate which questions should be revised. Ideally, a more sophisticated analysis system and single-user access would be required whereby the player's name or school would be entered once and the system itself would be able to track all the user's activities.

Despite the limitations of the tools used for the development of this particular online escape room, it is not doubtable that such an approach can be successfully used for remote learning as it can support practicing the knowledge students have gained and support their active participation in the learning process because they are allowed to search for answers. Such a tool can also help teachers to organize active learning in a digital environment for remote learning contexts.

For further research directions, online escape rooms can be used in educational settings for learning purposes, but further analysis should be done on why students did not search for information but used a *guessing* strategy. It is also important to understand what kind of game-based design works better for learning and how teachers can use such a methodology to support learning and effortful thinking.

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Chapter 9
Factors Affecting Game-Based Learning Experience: The Case of Serious Games

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Introduction

Game-based learning consists of challenge; response; and feedback; which are three key elements of any learning-game design; known as the magic cycle of playful learning. Game design features (i.e.; motivational elements; game mechanics; visual aesthetics; narrative; and background sounds) provide the learning experience (Plass et al., 2015). Learning dynamics are based on the quality of game design features which are common either for games or within the encapsulating gamification process; that is; a less structured playful activity using a part of game elements such as points; badges; and leaderboards (Deterding et al., 2011). A sub-genre of digital games is the serious games (SGs).

The earliest and widely used definition states that SGs are deliberately educational; the goal of engaging users for entertainment purposes is absent (Abt, 1970). SGs' flexibility allows them to be used in many educational scenarios and domains (Feng et al., 2018). Also; many researchers have acknowledged their instructional value; the relevant literature reports; in most cases; positive learning outcomes (Connolly et al., 2012; de Freitas, 2018; Erhel & Jamet, 2019). However; the evaluation process of the functional components of SGs remains rather unclear (Alonso-Fernández et al., 2018; Zhonggen, 2019). Many supported the view that we lack a well-grounded methodology for measuring their effectiveness (Serrano-Laguna et al., 2018) and that past studies have not solved this problem (Shi & Shih, 2015). Several reasons are responsible for the absence of a rational solution. The field of

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SGs is fragmented across diverse disciplines (de Freitas & Ketelhut, 2014). An additional difficulty is the existence of different game genres; which; in most cases; have few in common. Thus; the results can be generalized only to SGs of the same genre (Ravyse et al., 2017). Research trying to take into consideration many salient factors that render SGs effective is rather uncommon (Ravyse et al., 2017). Finally; there is no common consensus on how some features are defined or what sub-features are incorporated in a factor. Many researchers used different terms for describing the same factor or used different evaluation methods for examining it (Fokides & Atsikpasi, 2018). Thus; the problem is not so much the lack of assessment methods as other researchers suggested (e.g.; Serrano-Laguna et al., 2018); but issues in these methods per se.

Educators; policy-makers; and software designers have to be reassured that SGs are effective enough to be used in teaching (Westera, 2019). In this respect; solid evaluation methods are needed; able to overcome the abovementioned problems. Toward this end; certain steps have to be taken with the first one being to listen carefully to what the users have to say. What is more; attention to their views has to be paid without making any a priori assumptions on how or what shapes their experiences when playing SGs; so as to avoid the biases and weaknesses of previous research. This was exactly the study's objective. As it will be scrutinized in the sections to follow; by using a questionnaire consisting of ten open-ended questions; it tried to examine the users' experience in SGs (both playing and learning) in an effort to determine which factors are important; which are not; and how they are related to each other.

Factors Commonly Used in Serious Games' Assessment

Given SGs' complexity and the fusion of leisure and "serious" purposes; established evaluation methods may fall short; more suitable methods need to be employed (de Freitas & Ketelhut, 2014). Not only pedagogical aspects need to be considered; but equally influential variables are features such as gameplay; game mechanics; aesthetics; and narrative (Faizan et al., 2019). For some; engagement and motivation were the most significant factors (e.g.; Huang et al., 2010). Others examined narration as a contributing factor (Khan & Webster, 2017). Winn (2009) focused on learning (in terms of content and pedagogy); storytelling (such as narrative; character; and settings); gameplay/mechanics; and interface. Enjoyment; usability; and learning effectiveness were the most commonly used evaluation criteria when measuring both the game's quality and effectiveness (Steiner et al., 2015). Others focused on immersion; interaction; gameplay; feedback; challenge; scenario; fun; and learning-game integration (e.g.; Faizan et al., 2019). In a comprehensive literature review; Calderón and Ruiz (2015) identified 18 features for assessing serious games (e.g.; learning outcomes; understandability; game design and aesthetics; user's satisfaction; usability-ease of use-playability-learnability; usefulness; motivation; educational aspects; engagement; user's attitudes-emotions;

efficacy; social impact; enjoyment; and interface). After reviewing the relevant literature; ten factors were identified; commonly used for measuring SGs' impact on the users' experience:

- Motivation. The foremost reason for using SGs in an educational context is their appeal (e.g.; motivation; fun) (Westera, 2019). The user is willing to invest effort (and time) in playing because the activity; by itself; is rewarding and not because he/she is expecting some extrinsic rewards. The assumption is based on the close relationship SGs have with commercial games and the high entertainment value the latter have. The positive influence of SGs on intrinsic motivation was also emphasized (e.g.; Dreimane & Upenieks, 2020; Kaimara & Deliyannis, 2019).
- Realism-interactions. Realism stipulates how closely real life is replicated within a game. While realism certainly has visual and audial aspects; it is not limited to these. Psychological dimensions are also included (Ravyse et al., 2017). Another factor to consider is interaction modalities. That is because interactions enhance the sense of realism (Mortara et al., 2014). Therefore; in this study; realism and interactions were treated as a single factor.
- Presence-immersion. These subjective experiences suffer from definitional problems; though they are quite similar; they highlight different facets of what the players feel during playing (Fokides & Atsikpasi, 2018). Presence describes the psychological state in which one perceives the virtual objects as being real (Ivory & Kalyanaraman, 2007). Immersion is the sense of "being" in the application/game. Immersion is a manifold construct; conceptualized as challenge-based; sensory-based; and imagination-based (Ermi & Mäyrä, 2005). Nevertheless; it can be argued that immersion is a more suitable construct; given that it can explain a broader range of subjective experiences (Jennett et al., 2008). Given the above; this study used "immersion" as an umbrella term; encapsulating presence.
- Playability-usability. Playability can be viewed as the experiences a player has when interacting with a game (Voida & Greenberg, 2012). A subset of playability is usability; a term describing how easily a player can learn how to control a game (Pinelle et al., 2008). The terms usability and playability are used interchangeably in many circumstances (Sánchez et al., 2012). Therefore; in this study; the term "playability" was used for both playability and usability.
- Enjoyment. The enjoyment one feels when playing games is related to a range of attributes such as satisfaction and motivation (Boyle et al., 2012). Enjoyment is used in most evaluation frameworks; and many studies reported enjoyment as a contributing factor in the effectiveness of digital educational games (e.g.; Connolly et al., 2012; Kaimara et al., 2020; Steiner et al., 2015).
- Feedback. Feedback gives players the sense of progress (Cheng et al., 2015). Therefore; the role of feedback's mechanism is to inform players of the results of their actions/activities; to allow them to reflect on these results; and to reconsider their strategies. As a result; self-directed learning is fostered leading to positive learning outcomes and knowledge retention (Sušnik et al., 2018).
- Narration. The narrative portrays the game's events; introduces the game's fictional context (Charsky, 2010); and keeps players tied up to the game (Couceiro

et al., 2013). In the context of SGs; the role of the narrative is to provide declarative knowledge for players (Kiili, 2005).
- Interface. The interface's role is to assist and guide players through the game. It is an important aspect in educational games; and; as such; designing a friendly interface requires consideration and attention to details (Laamarti et al., 2014).
- Learning goals. Well-designed; tough; but achievable goals motivate players while providing an engaging and pleasurable experience (Shi & Shih, 2015). In SGs; goals are not limited to gaming. There are also learning goals that have to be reached. Regardless of the goals' nature; SGs are goal-directed through clearly defined and measurable achievements (Bellotti et al., 2013).
- Learning outcomes. All the above factors were used for assessing learning; which is the ultimate goal of SGs and the most well-studied factor (Faizan et al., 2019). The learning outcomes' assessment can be based on educational objectives' taxonomies; while psychomotor; cognitive; and affective domains can outline the learner capabilities (Gilbert & Gale, 2007).

What became evident from the above literature review is that different factors for SGs' assessment were used; different genres of SGs were studied; and the learning subjects/settings were also dissimilar. What is more; it seems that researchers have not reached an agreement on the definition of many factors; others are ill-defined; and; in some cases; their boundaries are supple; given that they may incorporate other factors as well (e.g.; presence and immersion; playability and usability). Thus; there might be a significant problem in quantitative studies which utilized scales (with close-ended questions). Trying to capture elusive factors using just a few items in a scale leaves room for misinterpretations. Even more importantly; participants are asked to answer questions that might not even be relevant to how they view a given factor. On the other hand; qualitative studies give enough freedom to users to express themselves; thus achieving an in-depth understanding of their views (i.e.; how they define the factors and how they think they interact); but they suffer from limited sample sizes.

Consequently; researchers; in order to surpass the abovementioned limitations; are in need of a different methodological approach for examining the users' experience (both playing and learning) when playing SGs. On the one hand; this method should allow researchers to draw conclusions based on robust sample sizes. On the other hand; the method should give participants the chance to freely express their views. As it will be further elaborated in the following section; this was exactly what the study at hand tried to achieve.

Method

As already mentioned; the study's objective was to examine the users' experience (both playing and learning) and to determine how different factors are related to each other. On the basis of the arguments presented in the preceding section; it was decided to focus on the ten most commonly used factors in SGs' evaluation. A descriptive research method was followed (Bernard & Bernard, 2012); using a survey tool consisting of ten open-ended items. As the raw data were qualitative in nature (open-ended questions); they were thematically coded and then they were quantified. By following this method; a large sample size was achieved; while; at the same time; participants freely expressed their views and feelings.

Research Questions

One general research question traversed the whole study; which may be expressed as "How do users believe that the aforementioned factors interplay with each other and shape their experience when playing SGs?" This general research question was then broken into ten specific ones (one for each factor analyzed in the preceding section); as presented in Table 9.1.

Participants and Duration of the Project

Students enrolled at the Department of Primary Education (University of the Aegean) and the Department of Audio and Visual Arts (Ionian University) were recruited; as both groups are potential users of the SGs employed in this study (presented in the "Materials" section). Besides being potential SGs users; students from both departments attend a number of courses related to the development of educational software (educational games and SGs included). Thus; they were aware of the main principles behind the use and design of SGs. An invitation was posted to the Facebook groups these two departments maintain; addressed to students interested to participate. Students were also informed that they will be asked to play an SG (or two if they were interested in doing so) and complete a short questionnaire. An

Table 9.1 The research questions

Research question	
Which factors/features the users think that	RQ1. have an impact on their feeling of immersion?
	RQ2. shape their feeling of enjoyment?
	RQ3. have an impact on their motivation to learn?
	RQ4. render SGs more realistic?
	RQ5. have an impact on SGs narration/storyline?
	RQ6. have an impact on learning goals' clarity?
	RQ7. have an impact on the feedback's adequacy?
	RQ8. have an impact on playability?
	RQ9. have an impact on the interface's adequacy?
	RQ10. have an impact on learning effectiveness?

outline of both games was also provided (e.g.; learning content; games' scenario; and genre); so as to avoid unengaged participants. Participating students were also informed that the study was conducted on a voluntary basis and that personal data from each game session was going to be recorded (i.e.; the computer's IP address and the session's duration). Furthermore; instructions were provided on how to install the games and log in to them. The total number of recruited students was 384.

Materials

An issue the study had to resolve; prior to the beginning of the research process; was what SGs to select. Then again; one has to be reminded that the study's objective was not to examine/evaluate specific SGs; the objective was to record users' views (either good or bad) and through this to examine specific factors' interconnections. In this respect; the game's quality and genre were irrelevant. What was important was to select SGs in which the ten factors/features discussed in the preceding section were present, so as users to be able to comment on them. Following this line of thinking; two games developed by Triseum (https://triseum.com) were chosen as the study's material. Although they differ quite a lot; both are typical SGs; addressed to young adults (university students). Moreover; both are well received by their intended audience and awarded on several occasions.

The first one; called "ARTé Mecenas;" is a turn-based 2D game; supporting courses related to arts' history. Users assume the role of the head of the Medici family during the tumultuous Italian Renaissance. They have to balance relationships with powerful states; the Catholic Church; and merchant fractions; as they struggle for financial dominance. At the same time; users try to play an essential role in the creation of famous artworks and monuments of the Renaissance. Players' decisions affect the welfare of the Medici Bank and ultimately the course of art history. While playing; the actual course material is presented (e.g.; details for actual artworks; buildings; and historical facts). The game's objective is to enable students to appreciate the interconnectedness of economy and art (e.g.; through art patronage). The second game; called "Variant: Limits" is a 3D game attempting to connect mathematics and gameplay; empowering deeper engagement with the content; while making the learning experience more fun. The game's goal is students to appreciate the notion of curriculum-based calculus concepts. The calculus topics covered are (a) finite limits (e.g.; one-sided limits); (b) continuity (e.g.; intermediate value theorem and continuity at a point); and (c) infinite limits (horizontal and vertical asymptotes). Users explore a vast virtual world (a fictitious planet) and manipulate objects for opening and passing through gates within it; using calculus principles and theories. The objective is users to successfully understand increasingly complex calculus concepts and to help the game's main character to save the planet by reaching her final destination.

Instrument

A questionnaire available online was used which consisted of ten open-ended questions. Each research question had a corresponding item in this questionnaire (Table 9.2). All items urged the participants to make suggestions that would improve a specific game factor. The rationale behind this setting was that these suggestions might reveal other factors that may have an effect on the factors in question. Answering all the questions was not mandatory as it was possible that some participants might not be able to come up with a suggestion or might not be willing to provide a response. On the other hand; they were asked to be as specific and as analytic as possible in their responses. The questionnaire was open for submissions for the whole duration of the project.

Procedure and Data Processing

As already mentioned; the participants were asked to play either (or both) of the two games. The only condition was that they had to play them for a minimum of 2 hours and/or complete at least two levels. As both games included an introductory/tutoring level; for familiarizing the players with the interface/controls; time spent by playing this level did not count as playing the game(s) per se. After confirming that a participant actually played the game(s) (by examining the log files); he/she was provided with the questionnaire's link.

Given that the research questions were epistemological in nature; meaning that they were related to knowing and understanding the phenomena of interest; and given that participants responded to open-ended questions; a thematic coding analysis was considered more appropriate (Saldaña, 2015). This method involves the identification of text passages linked by a common theme; the indexing of these passages into categories; and the establishment of thematic ideas (Gibbs, 2007). There was no need to transcribe verbatim the participants' responses as these were

Table 9.2 The open-ended questions

Question	
What are your suggestions for:	improving the sense of immersion?
	making the game more enjoyable?
	making the game more motivative to learn?
	making the game more realistic?
	improving the game's narration/storyline?
	improving the clarity of the learning goals?
	improving the feedback?
	improving the game's playability?
	improving the interface?
	improving the game's learning effectiveness?

already in a digital form. Ten documents were created (one for each question) and the corresponding replies were copy-pasted to them. Two individuals with expertise in SGs acted as coders and ATLAS.ti was used for extracting/labeling the codes and themes. The coders' reliability was assessed (a) in a pilot test in which a randomly selected quarter of the responses was used and (b) formally during the coding of the full dataset. Cohen's kappa coefficient was used for determining the raters' consistency; and it was found to be very good [$\kappa = 0.910$; $p < 0.001$; 95% CI (0.903; 0.917)] (Landis & Koch, 1977). During the coding of the full sample; all responses were viewed once; for identifying the main ideas. A second round followed; having as an objective to label these ideas with codes. This process was repeated twice for reducing the redundancy of the codes and themes.

The next stage was to obtain quantitative data. The most common strategy for quantifying the qualitative data in a single comprehensive dataset was followed; that of counting the number of times a qualitative code or theme occurred (Driscoll et al., 2007). The results of this process are presented in the following section.

Results

The total number of responses was 3863. Following data screening; 1118 were excluded; leaving 2745 valid ones; coming from 384 participants who played 239 times the 2D game and 189 times the 3D game. The excluded responses were either (a) too general (e.g.; "the game was not motivating;" "everything was ok") or (b) irrelevant and unresponsive (e.g.; "I don't play games;" "I don't know"). All in all; eight themes were identified; and the number of codes in each ranged from 7 to 22.

Table 9.3 presents the results of the coding procedure regarding what might improve the games' sense of immersion. Evidently; the games' audiovisual features ($N = 112$) and realism ($N = 79$) were considered important for improving immersion. Quite interestingly; feedback ($N = 61$) and the quality of the learning material ($N = 40$) were also important factors in making a game more immersive. The games' realism can enhance enjoyment ($N = 148$); as well as the audiovisual features ($N = 98$) and the quality of the learning material ($N = 86$) (Table 9.4).

According to the participants' responses; learning effectiveness; besides being shaped by features related to the quality of the learning material ($N = 113$); can be influenced by feedback's quality ($N = 115$) and; far less; by the clarity of the learning goals ($N = 34$) (Table 9.5). Audiovisual features ($N = 215$); together with features that enhance realism per se ($N = 91$); can improve the games' realism. No other factor seems to have played an important role (Table 9.6).

Features that improve narration ($N = 98$); the games' feedback ($N = 54$); and the quality of the learning material ($N = 53$) were the prominent ones affecting the quality of narration/storyline (Table 9.7). The clarity of the learning goals was almost equally affected by feedback's features ($N = 82$) and the quality of the learning material ($N = 75$); closely followed by learning goals' features per se ($N = 65$) (Table 9.8).

Table 9.3 Immersion

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	45	39
Realism (47/32)	3D game instead of 2D game	22	–
	More interactions/action	22	25
	More characters	5	7
Audiovisual features (68/44)	Better sound/music	22	12
	Better graphics	37	32
	More videos/images	9	–
Feedback (24/37)	More instructions/help	24	37
Playability (4/0)	Easier to use	4	–
Learning material (26/14)	More/better exercises	13	–
	Enrich learning material	6	14
	Less learning material	7	–
Narration/storyline (10/9)	Better storyline	10	9
Goals' clarity (11/0)	Clearer learning goals	11	–
Interface (17/6)	Translate to Greek	14	6
	Bigger fonts	3	–

Note: The numbers in parenthesis (*x*/*y*) are the sum of the occurrence of a theme in each game; *x* = 2D game; *y* = 3D game

Table 9.4 Enjoyment

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	30	26
Realism (102/46)	More interactions/action	56	34
	Better gaming environment	23	–
	More characters	23	12
Audiovisual features (47/51)	Better graphics	24	22
	Better sound/music	23	29
Feedback (15/7)	Better instructions	15	7
Playability (0)	–	–	–
Learning material (51/35)	Easier exercises	13	14
	More exercises	16	–
	Less learning material	7	–
	Better activities	15	21
Narration/storyline (13/17)	Better narration	13	17
Goals' clarity (10/6)	Clearer learning goals	10	6
Interface (3/0)	Translate to Greek	3	–

Table 9.5 Learning effectiveness

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	37	22
Realism (19/0)	More interactions/action	19	–
Audiovisual features (7/2)	Better graphics	7	2
Feedback (40/75)	Better instructions	40	75
Playability (4/4)	Needs to be easier in its use	4	4
Learning material (77/36)	Easier exercises	7	9
	Better activities	11	20
	Exercises of escalating difficulty	–	3
	Exercises that boost reflective/critical thinking	8	4
	More exercises	10	–
	More learning material	41	–
Narration/storyline (5/0)	Better narration	5	–
Goals' clarity (20/14)	Clearer learning goals	20	14
Interface (10/8)	Translate to Greek	10	8

Table 9.6 Realism

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	53	36
Realism (63/28)	More interactions/action	25	28
	More characters	17	–
	3D game instead of 2D game	21	–
Audiovisual features (102/113)	Better graphics	83	99
	Better sound/music	19	14
Feedback (0)	–	–	–
Playability (0)	–	–	–
Learning material (17/4)	Enrich learning material	17	4
Narration/storyline (0)	–	–	–
Goals' clarity (0)	–	–	–
Interface (0/3)	Better interface	–	3

Only features related to feedback itself can improve this factor ($N = 116$) (Table 9.9). On the other hand; feedback's features greatly affected playability ($N = 115$); while the interface's quality was far less important ($N = 51$) (Table 9.10).

For improving the interface; the participants suggested changes in feedback's features ($N = 76$) and playability ($N = 60$) (Table 9.11). Finally; the most influential factor regarding motivation to learn was the quality of the learning material ($N = 196$). Indeed; the participants indicated a multitude of features directly connected to this factor (Table 9.12). Realism was also a factor; but its impact seems to be far less important ($N = 44$).

Table 9.7 Narration/storyline

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	68	44
Realism (0/18)	Better gaming environment	–	9
	More characters	–	9
Audiovisual features (18/4)	Better graphics	–	4
	More videos/images	18	–
Feedback (40/14)	More instructions/help	3	–
	Clearer instructions/help	37	14
Playability (3/0)	Less complicated controls	3	–
Learning material (26/27)	More learning material		27
	Better learning material	8	–
	Less learning material	18	–
Narration/storyline (55/43)	Better storyline	14	28
	Less storyline	–	15
	Agent (storyteller)	41	–
Goals' clarity (0)	–	–	–
Interface (8/12)	Translate to Greek	8	12

Table 9.8 Learning goals

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	72	52
Realism (0)	–	–	–
Audiovisual features (3/0)	Better graphics	3	–
Feedback (21/61)	Better feedback	18	61
	Fewer instructions	3	–
Playability (0)	–	–	–
Learning material (58/17)	Less learning material	39	3
	Easier exercises	5	7
	Variety of exercises	4	7
	Better exercises	10	–
Narration/storyline (0)	–	–	–
Goals' clarity (48/17)	Clearer learning goals	48	17
Interface (5/2)	Translate to Greek	5	2

Table 9.13 and Figs. 9.1 and 9.2 summarize the number of responses in each factor. Given that the 2D game was played 239 times; while the 3D game was played 189 times; the results of the latter were multiplied by 1.265; in order for the responses on both games to be comparable. On the basis of the participants' number of responses in each question; the following were observed (less than 30 responses in a factor were considered insignificant):

Table 9.9 Feedback

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	112	82
Realism (12/2)	More characters	–	2
	More interactions/action	12	–
Audiovisual features (6/3)	Better graphics	6	3
Feedback (57/59)	Indicate the player's progress	3	7
	More feedback	13	12
	Better feedback	22	25
	Clearer messages/help	19	15
Playability (0)	–	–	–
Learning material (0)	–	–	–
Narration/storyline (0)	–	–	–
Goals' clarity (5/0)	Clearer learning goals	5	–
Interface (2/3)	Translate to Greek	2	3

Table 9.10 Playability

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	96	55
Realism (6/10)	Better camera movement	–	10
	More interactions/action	6	–
Audiovisual features (1/1)	Better graphics	1	1
Feedback (72/43)	Better instructions/help	72	32
	More instructions/help	–	11
Playability (4/27)	Better controls	–	27
	More controls	4	–
Learning material (8/4)	Easier exercises	8	4
Narration/storyline (0)	–	–	–
Goals' clarity (0)	–	–	–
Interface (38/13)	Translate to Greek	34	13
	Bigger fonts	4	–

- Although it was not included as a question in the questionnaire; a new factor emerged; that of audiovisual features. Moreover; in both games; participants suggested that improvements in this factor will improve the games' realism ($N = 102/143$); enjoyment ($N = 47/65$); and immersion ($N = 68/56$).
- In both games; participants suggested that features related to realism can improve enjoyment ($N = 102/58$) as well as immersion ($N = 47/40$).
- The quality of the learning material seems to be a very influential factor in both the 2D and the 3D game; it strongly affected motivation ($N = 118/102$); learning effectiveness ($N = 77/46$); and enjoyment ($N = 51/44$). A minor difference was noted between the two games concerning this factor; as in the 2D game it also

Table 9.11 Interface

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	121	64
Realism (0)	–	–	–
Audiovisual features (7/9)	Better graphics	7	9
Feedback (40/36)	Better instructions/help	40	36
Playability (24/36)	Better controls	24	36
Learning material (0)	–	–	–
Narration/storyline (0)	–	–	–
Goals' clarity (0)	–	–	–
Interface (18/11)	Translate to Greek	5	3
	Correct interface errors	2	3
	Simpler interface	4	–
	Enrich interface	7	5

Table 9.12 Motivation

Themes/factors	Codes	2D game *N*	3D game *N*
Excluded responses	–	41	31
Realism (28/16)	More interactions/action	22	13
	Online players	6	–
	More levels	–	3
Audiovisual features (14/3)	Better graphics	14	3
Feedback (0)	–	–	–
Playability (0)	–	–	–
Learning material (115/81)	Simpler learning material	6	16
	Escalating difficulty	8	8
	Practice in real conditions	6	7
	Negative score for mistakes	3	–
	Easier exercises	3	–
	Show correct answers	4	–
	Explain mistakes	5	–
	More activities	5	–
	More learning material	34	–
	Better examples	8	19
	More exercises	9	
	Enrich exercises	24	24
	Better explanations	–	5
	Summary of the chapter	–	2
Narration/storyline (4/15)	Better storyline	4	15
Goals' clarity (11/8)	Clearer learning goals	11	8
Interface (1/4)	Translate to Greek	1	4

Table 9.13 Factors' matrix for both games

		Affecting factors							
		Realism	Feedback	Narration/ storyline	Goals' clarity	Interface	Playability	Audiovisual features	Learning material
Affected factors	Realism	– (63/35)	0	0	0	0/4	0	102/143	17/5
	Feedback	12/3	– (55/75)	0	5/0	2/4	0	6/4	0
	Narration/storyline	0/23	40/18	– (55/54)	0	8/15	3/0	18/5	26/34
	Goals' clarity	0	21/77	0	– (48/22)	5/3	0	3/0	58/22
	Interface	0	40/46	0	0	– (18/11)	24/46	7/11	0
	Playability	6/13	72/54	0	0	38/13	– (4/34)	1/1	8/5
	Immersion	47/40	24/47	10/11	11/0	17/6	4/0	68/56	26/18
	Enjoyment	102/58	15/9	13/22	10/8	3/0	0	47/65	51/44
	Motivation	28/20	0	4/19	11/10	1/4	0	14/4	118/102
	Learning effectiveness	19/0	40/95	5/0	20/18	10/8	4/5	7/3	77/46

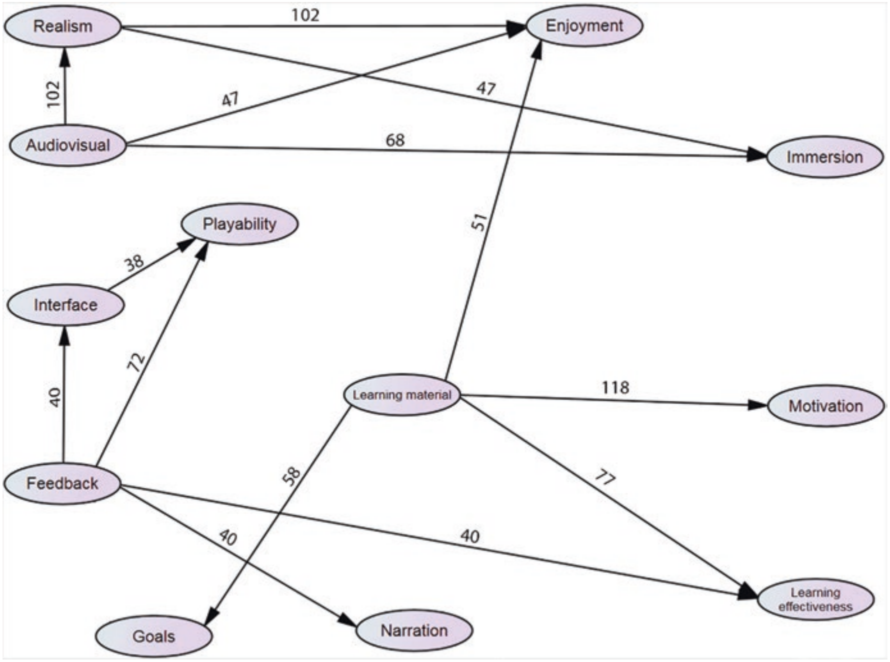

Fig. 9.1 Factors' interactions in the 2D game

affected the learning goals' clarity ($N = 58$); while in the 3D game it affected the quality of narration/storyline ($N = 34$).

- Feedback also proved to be an influential factor. That is because; in both games; features related to this factor can improve the interface's quality (N = 40/46); playability ($N = 72/54$); and learning effectiveness ($N = 40/95$). Two differences between the two games were noted concerning this factor. In the 2D game; changes in feedback can influence narration's quality ($N = 40$); while in the 3D game; they can affect immersion ($N = 47$) and the learning goals' clarity ($N = 77$).
- It seems that playability and the interface's quality have interchangeable roles in the two games. In the 2D game; the latter affected the former ($N = 38$); while in the 3D game; the former affected the latter ($N = 46$).
- Quite interestingly; enhancements in enjoyment; immersion; narration; motivation; and learning goals' clarity will not have an impact on any other factor.

Discussion

For examining the users' experience when playing SGs and for revealing how factors essential for determining this experience interact; the study's participants played two SGs and recorded their views by answering a short questionnaire. It has

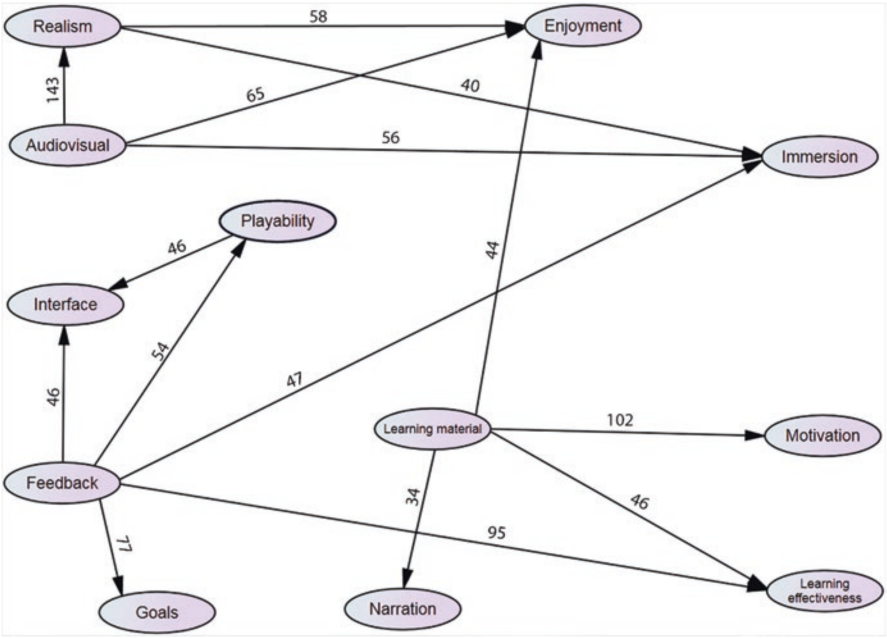

Fig. 9.2 Factors' interactions in the 3D game *(Effects with less than 30 responses were omitted)*

to be noted that the games were fundamentally different. Even so; remarkable similarities between the two games were noted. Indeed; the data analysis established the dominant role of two factors in both games; that of leaning material's and feedback's quality. Besides; according to participants' responses; improvements in these factors will greatly improve the SGs' learning effectiveness (N = 123/135). In this respect; the findings of this study are in line with previous research which established the significant effect the learning content (e.g.; Mortara et al., 2014) and feedback (e.g.; Alonso-Fernández et al., 2018; Cheng et al., 2015; Ravyse et al., 2017) have on the learning outcomes.

Moreover; the quality of the learning material had an overwhelming impact on motivation in both games (N = 118/102). This finding is interesting as there are only a few references in the literature signifying such a connection. Then again; it is not irrational. If the learning material is boring or hard to understand; learners will lose their interest and will not be motivated to continue studying (or playing an SG). For example; Habgood and Ainsworth (2011) advised that the learning content and game mechanics have to be well integrated in order for the game to be more motivating. In the same line of thought; Gunter et al. (2008) added that if the learning content does not fit well in the game situation; the motivation for learning is not enhanced at all. What is also very interesting is that participants connected their views for the quality of the learning material with their sense of enjoyment (N = 51/44). The relevant literature suggested either that such connections do not exist or that the path has the opposite direction. For example; Connolly et al. (2012)

suggested that the games' fun and enjoyment increase the players' interest for the subject matter and not the other way around. This finding suggests that if users consider the learning material not well presented and difficult; not only their motivation to learn will be negatively affected but also their sense of enjoyment.

As for feedback; the results indicated that in addition to learning effectiveness (*N* = 40/95); it also had an impact on playability (*N* = 72/54); interface's quality (*N* = 40/46); goals' clarity (only in the 3D game) (*N* = 77); narration's quality (only in the 2D game) (*N* = 40); and one's sense of immersion (only in the 2D game) (*N* = 47). Feedback's role in SGs was mostly related to the learning outcomes (Sušnik et al., 2018). Few suggested that feedback might have an effect on other factors as well. The study's findings imply that feedback might have a more important role than previously suggested. For example; Prensky (2007) stated that feedback and learning goals are closely related; players can monitor their progress to a goal through the game's feedback (e.g.; through score changes and through changes in the game world per se).

According to participants' responses; audiovisual features had an impressive effect on realism (*N* = 102/143); while both had a strong impact on enjoyment (*N* = 47/65 and *N* = 102/58; respectively) and on immersion (*N* = 68/56 and *N* = 40/47; respectively). These findings further support the findings of other studies. For instance; Hunicke et al. (2004) in their Mechanics; Dynamics; and Aesthetics Framework considered aesthetics as the component that encapsulated the games' fun element. Huang et al. (2010) viewed advanced graphics (i.e.; realism) and audiovisual effects as features that can make a game more attractive. Ivory and Kalyanaraman (2007) found that high realism had a significant impact on presence; involvement; and arousal; while Nacke et al. (2010) noted that sound and music affected immersion.

Although the data analysis brought to light interesting factors' interactions; more intriguing was the absence of some connections. This is probably the study's most significant finding; yet the most puzzling one. To start with; realism and audiovisual features did not have an impact on the games' learning effectiveness. Contrary to this; research has demonstrated that the level of realism had an impact on the learning outcomes (e.g.; Ravyse et al., 2017). On the basis of the study's results; it can be supported that there is no positive correlation between fidelity levels and knowledge transfer (Vogel et al., 2006). This finding may also serve as an indicator that participants did not consider two of SGs most prominent gaming features as being important for their learning experience when playing them.

Immersion; enjoyment; and motivation did not emerge as themes from the data analysis. In addition; they seem to be at the receiving end of factors' relationships. The same applied for playability and the interface's adequacy as they affected only each other. Thus; there are many missing links suggested by the relevant literature. One such is the link between enjoyment and learning effectiveness (Connolly et al., 2012). This result suggests that what is learned when playing SGs is not attributable to the game's enjoyment but to other more decisive factors; such as instruction; support; and explicit learning tasks (Iten & Petko, 2016). Another missing link is between motivation and learning effectiveness. Although research suggested that a strong link between these two factors exists (Westera, 2019); a meta-analysis has concluded that the motivational appeal of serious games is not that much more different than other instructional methods (Wouters et al., 2013). Moreover; others suggested that a delicate balance has to be achieved (e.g.; learning vs playing and freedom vs control) in order to develop really engaging SGs. In this respect; the study's findings might have reflected a problematic integration of the above; which; in turn; resulted in the SGs lack of motivational appeal (Wouters et al., 2011).

A number of studies concluded that engagement and immersion; in addition to mediated effects; had a direct positive impact on learning (e.g.; Abrantes & Gouveia, 2012). Contrary to that; Hamari et al. (2016) found that although engagement in the game had a positive effect on learning; immersion did not. The findings of the present study are in support of the latter with some reservations; as immersion is an elusive and ill-defined factor. Finally; the results did not link narration with learning effectiveness. Then again; it is not that clear whether the narrative fosters learning given that some studies reported positive (Cordova & Lepper, 1996); contradictory; or even negative results (McQuiggan et al., 2008).

On the basis of the study's findings and their subsequent discussion; it can be concluded that the games were viewed as a form of digital learning material rather than as educational/serious games; the participants knew that they were actually studying a digitally presented subject matter and not playing a game. In support of this argument are the observed as well as the missing factors' interactions. It has to be reminded that the only factors linked to learning effectiveness were feedback and quality of the learning material. Both factors are related to the "serious" or "learning" aspects of SGs. Learning effectiveness was not found to be influenced by SGs' "gaming" aspects (i.e.; immersion; playability; enjoyment; audiovisual features; and realism).

Implications for Research and Practice

Though research regarding SGs has been building up gradually over the past years; it has resulted in a fragmented and; up to a point; in inconsistent literature. Several factors contributed; SGs are cross-disciplinary in nature; key SGs' features are defined differently and used in different contexts; and multi-methodological approaches are used for their assessment (de Freitas, 2018). The lack of common consensus on how to measure SGs' effectiveness; as well as on how to measure the users' views for these applications; suggests that we have to rethink the suitability of the assessment tools used in this kind of research and develop more robust ones. There are a number of steps that have to be followed in order to achieve this; the first one being to give voice to SGs users; after all; they are the ones at the receiving end of the line and the ultimate judges of their effectiveness; pros; and cons. The present study suggested that open-ended questions can be used for recording the users' views. Although these questions were limited in number and many more could have been included; interesting results emerged. Given that; it is recommended that future studies can also utilize open-ended questions in order to gain a deeper understanding of participants' views and attitudes toward SGs. The SGs' industry can also benefit in a similar way. For example; developers can focus on certain features of interest and compare versions of the same SG and determine how the latest version compared to the previous one.

What is more; the study's findings suggested that users were not "deluded" by the SGs gaming features; they were aware that they were using a piece of educational software and not a game. This finding confirms; almost word-for-word; Michael's and Chen's (2005) definition for SGs; that of being games not having entertainment; enjoyment; and fun as their primary objective. Yet; it has significant implications for researches and SGs' developers alike; as it raises some straightforward questions such as: "What is the added value of SGs; if users already know that their purpose is to teach something?" and "Where is the balancing point between learning and gaming in an SG?" It goes beyond the scope of the present study to give answers to these questions; it is up to the developers to decide whether they want to add more gaming features or not and up to the researches to examine the impact of such decisions. What it can be suggested is that our views for SGs are far from being consolidated; much more research is needed in a domain characterized by blurred boundaries which also relies on very diverse perspectives and approaches.

Limitations and Future Research

Although the study's results were thought-provoking; there are limitations that should be acknowledged but also provide several avenues for future research. The sample size; although more than adequate; could have been larger and more diverse; students from other areas of study could have been recruited. Therefore; reservations do arise regarding the generalizability of the results. The participants were asked to play the SGs for at least 2 hours. One might argue that this was a rather limited length of time and might raise concerns whether this was enough for players/participants to develop a comprehensive view for the SGs. Only two SGs were examined. On the other hand; SGs cover a wide range of genres and learning domains. It is possible that different factors' interactions might have emerged if other SGs were used.

Future research will help to identify similarities (or differences) with the findings of this study. In addition; the target group can encompass students from other disciplines or even individuals of all ages; so as to examine if and how different age groups and individuals from different scientific backgrounds view SGs. Moreover; a larger variety of SGs can be examined in order to further refine the differences. Other research tools can also be utilized; observations and interviews will allow an in-depth understanding of how subjective and objective SGs' features interact. Finally; the study's findings can provide quite a lot of ideas for the development of a more comprehensive scale for assessing SGs. Indeed; this is a path worth exploring; as there is still the need for establishing evaluation criteria and tools for assessing the various dimensions of SGs.

Conclusion

Despite the above limitations; the study provided an idea of players' views; feelings; and attitudes toward SGs; not indirectly through a scale (which is the norm) but directly; by asking for their thoughts and judgments. What is more; the study examined ten factors that was theorized to be important; while the bulk of the existing literature focused on a much smaller number of factors. Thus; the study's contribution to the relevant literature is that it (a) utilized a method that is not commonly used; (b) examined a substantial number of factors that have an impact on one's learning/gaming experience when using SGs; (c) quantified the results; which; in turn; revealed interesting factors' interactions; and (d) indicated that users probably view SGs as form of digital learning material rather than as games. In conclusion; the study's findings might prove useful to researchers in understanding the factors' interactions responsible for shaping one's learning experience when playing SGs.

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Chapter 10
Implementing Quiz Apps as Game-Based Learning Tools in Higher Education for the Enhancement of Learning Motivation

Santa Dreimane

Introduction

Game implementation in the learning process is one of the oldest and most useful ideas in pedagogy (Ferreira et al., 2016) and is applicable as a pedagogical method not only for children but for adults as well. But it is important to distinguish different concepts related to games and game elements' application in learning – game-based learning, gamification, serious games, etc. What is the difference?

In some cases, gamification and serious games are considered as similar concepts, but there are some essential differences between them. Serious games are a contemporary pedagogical strategy designed for learning in a virtual or mixed reality environment with predefined learning objectives (Landers & Landers, 2014; Karagiorgas & Niemann, 2017) to promote learning and solve problems with game-based techniques. Although serious games use game elements and game design, the purpose is not to entertain people but to train and instruct (Dreimane & Upenieks, 2020). On the other hand, gamification is a concept whereby game design elements are used in a nongame context (Deterding et al., 2011; Doherty et al., 2017; Woodcock & Johnson, 2017), not as a whole game as in the case of serious games, but as particular game elements or meaningful combinations of game elements applied to nongame processes (Landers & Landers, 2014). In this case, the purpose is not related to entertainment either (Karagiorgas & Niemann, 2017) but to motivation, engagement, and changing the attitude of the student in order to improve learning outcomes (Landers & Landers, 2014) with or without technology. Serious games try to improve knowledge and skills through the game, while gamification uses game elements to make the learning more engaging and thus improve the learning.

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But what distinguishes game-based learning from these two concepts? Game-based learning refers to the use of video games to support teaching and learning (Gros, 2006) and can be described as games that teach students. But it must be added that when talking about game-based learning, we can distinguish two concepts: game-based learning and digital game-based learning. The term "digital game-based learning" was coined by Prensky and refers to any form of the use or integration of digital games into learning environments (Prensky, 2001). This means that game-based learning is not always constructed through digital platforms and technology. Game-based learning combines game design used to fulfilling learning objectives and games that are developed for fun while pursuing learning objectives (Gros, 2006) with or without technology. In 1982, James Paul Gee published "What Video Games Have to Teach Us About Learning and Literacy," in which he explains several learning principles that are incorporated in good games; in his later works, he argues that well-designed video games are efficient learning machines that engage students in the learning without being aware of it (Gee, 2003). Some authors propose that modern education faces a whole series of complex challenges related to technological development (Liu et al., 2020), but on the other hand, it can also be seen as an opportunity to grab students' attention, motivate and engage them, and make learning more interesting using the tools that they may find relatable. But despite the potential of the games that many researchers describe, some studies reveal a lack of implementation of games as a learning tool in formal education (Gros, 2006).

In many cases in the learning process, knowledge assessments have negative associations related to stress and fear. But there is scientific evidence that games are one of those things that can make people happy. When a person experiences excitement during a game, gets a prize, or wins, a substance called dopamine is released in the middle of the brain, which is closely linked to a person's desire to enjoy various things that make them happy, including food, money, gambling, computer games, etc. (Kapp, 2012; Howard-Jones & Demetrious, 2008). So, some game-based learning tools have been created to address many unpleasant learning activities – to make knowledge assessments more enjoyable, engaging, and even fun. An example that can be mentioned is the so-called game-based student response system, where the classroom is temporarily transformed into a game show where the teacher is the game show host and the students are the contenders (Wang, 2015). The most well-known and most studied game-based student response system is called Kahoot!, which is known to be the first student response system using game design principles from theory on intrinsic motivation to provide a game experience (Malone, 1981; Wang & Tahir, 2020).

This study focuses on this particular game-based learning tool – the game-based student response system that can also simply be called a quiz app that provides a safe environment for learning and mistakes by integrating elements of games that make the learning process and knowledge assessment more interesting and motivational and with which students are more likely to become more actively involved. Quiz apps can be defined as digital game-based learning tools because tests designed to be used through digital platforms use game elements and game design to make learning and knowledge assessment more fun. This kind of knowledge assessment is confused in many studies with gamification because of the use of game elements, but the opportunity to provide learning and assess knowledge through the activity makes quiz apps a digital game-based learning tool, not a gamification of learning.

When talking about game-based learning, a word that often follows is motivation, so it is important to understand what makes game-based student response systems motivational and which techniques and game elements they use to enhance students' learning motivation.

Research conducted in 2019 searching for the most commonly used motivation theories in contemporary research articles related to technology-enhanced learning showed that these were the self-determination theory of Richard M. Ryan and Edward L. Deci and the self-efficacy theory of Albert Bandura (Dreimane, 2019). Self-determination theory was coined by Ryan and Deci in 1970, and in this theory they identify the three basic psychological needs of a person: (1) the need to feel competent; (2) the need for connectedness and commitment, i.e., to know that someone cares about you; and (3) the need for autonomy, which is very important for a person to feel good – it is a feeling of self-affirmed action that you have given your consent and acceptance (Ryan & Deci, 2000; Forster-Heinzer et al., 2016). All these three needs nourish the self-determined motivation of a person. Self-determination theory also posits that there are two types of motivation – intrinsic and extrinsic – which are important in explaining the potential impact of game-based learning on the development of learning motivation. Extrinsic motivation is characterized by an immediate or faster result, but the effect is not as long-lasting as intrinsic motivation; it is not a real interest to acquire knowledge or perform an action. Extrinsically motivated behavior is characterized by reward and punishment systems. On the other hand, with intrinsic motivation, the person has a real interest in the action to be taken; intrinsic motivation is thus desirable because it ensures the persistence and depth of knowledge and interest in the subject is long-lasting. In the context of the game-based student response system, some elements of these tools provide extrinsic motivation, like points, competition, time limits, etc., but on the other hand, an engaging and game-based way of assessing knowledge can help to achieve intrinsic learning motivation.

On the other hand, Bandura's self-efficacy theory refers to our overall belief that a person can successfully achieve a particular result, and students with high self-efficacy can achieve better results in their learning activities (Chang et al., 2018). Self-efficacy and motivation are determined by four components: (1) performance outcomes, i.e., past performances and achievements, that is, a person's own positive or negative experiences; (2) vicarious or substitute experience, which means that a person can be motivated to lift their own self-efficacy through the observation of other people's experiences; (3) verbal persuasion or influence, which includes the influence on a person by other people's comments, both positive and negative, because verbal encouragement or critique can increase or decrease self-efficacy; and (4) physiological feedback, where physical well-being and anxiety affect a person's performance, thus also affecting self-efficacy (Bandura, 1977). Previous performance, the belief in one's own ability to perform the task, verbal praise, comments, and feedback are very important aspects for the enhancement of learning motivation, and the game-based student response system can enhance increases to self-efficacy and learning motivation, both extrinsic and intrinsic.

Game applications in the learning process and game-based learning have been researched and described from their theoretical and empirical aspects, and motivation theories in the context of technology-enhanced learning have also been studied for years, but it is important to understand how to use game-based learning tools in a reasonable, thoughtful, and meaningful way that meets the needs of the education system and students of the twenty-first century. Thus, such research is essential to understand how to provide teachers with knowledge about digital tools that can make the learning process more interesting and provide students with opportunities to learn.

Methodology

The aim of this study is to explore the game-based student response system – quiz apps as game-based learning tools for the repetition and mastery of a subject and to enhance students' learning motivation in higher education. To achieve this aim, a survey was carried out involving bachelor's and master's study program students at a Latvian university. Students replied to the survey sharing their opinion on the quiz apps and what elements they find engaging and motivational. Students were also asked about game-based applications in lessons – do academic staff implement them, how often are they implemented, what are the most common quiz apps if used in classes, what the purpose of these apps is, and what feedback is provided by the apps and academic staff. The questionnaire was designed by the author to achieve the research objectives considering the theoretical framework of learning motivation and game-based learning and contained nine questions. The survey was developed on the platform *latvia.questionpro.com*, which allows students to answer questions at a time and place that is convenient for them, either using a smart device or a computer. Students were informed about the purpose of the study and that all answers will only be used in a summarized way, guaranteeing their anonymity and data security.

Results

The survey carried out gathered a total of 129 bachelor's and master's study program students' opinions and experiences connected with quiz apps' implementation in their classes by academic staff. Of the 129 students who participated in the study, 50% ($n = 64$) said that academic staff do not apply game-based apps for the assessment and repetition of knowledge, but almost the same amount of respondents (47%, $n = 61$) gave a positive answer, saying that game-based apps are used in their classes. The remaining 3% of respondents chose the answer "Other," writing that only one teacher uses this kind of app or that they have been used "once," "two times," or "sometimes."

The questionnaire revealed that the most applied game-based student response system is Kahoot! (40%), followed by Mentimeter (19%), Quizizz (16%), and Nearpod (10%), but 15% of the respondents marked "Other," answering that they have not encountered the use of quiz applications in classes or gave examples like Peardeck.com, Edpuzzle, Padlet, or QuizUp.

Respondents who answered that quiz apps are not used in their classes had the opportunity to skip certain questions in the survey that were applicable to the subject. Thus, 111 respondents answered the question about the frequency of the apps' application, where 45% (n = 50) gave the answer that they are used rarely, 33% (n = 37) said "never," and 19% (n = 21) "sometimes," while only two respondents said that quiz apps are used "often" and just one person said "every lesson."

When assessing knowledge, there always is a place for errors, but it is important for the student to get feedback about any questions answered incorrectly. That is why students were asked, "Do academic staff provide any explanations if any questions are answered incorrectly?" Half (51%) of the respondents gave a positive answer to the question, 21% said "sometimes," and 17% marked the answer that some professors give explanations, but 7% of respondents said that teachers do not give them feedback after tests.

Students were also asked their opinion about the purpose of the implementation of quiz apps in their classes (see Fig. 10.1). They were asked to answer statements about the purpose of the knowledge assessment by marking points on a Likert scale. Giving answers to the statement that quiz apps are used to prepare students for exams, 36% of the respondents marked the answer "rather agree," 24% marked "agree," 20% chose the answer "rather disagree," and 13% disagreed with the statement. The other 7% of the respondents said that it is hard to say.

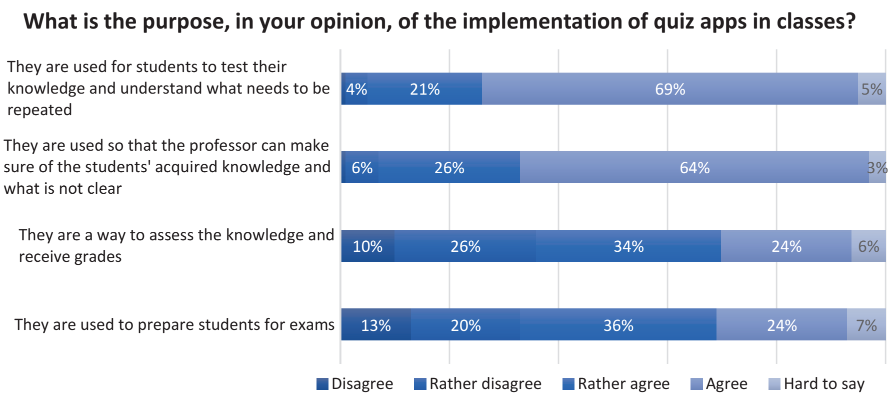

Fig. 10.1 Students' answers to statements about the purpose of the knowledge assessment

To the statement "They are a way to assess knowledge and receive grades," 34% of respondents said that they "rather agree," followed by those who answered "rather disagree" (26%) and "agree" (24%). This shows that students see game-based knowledge tests as a way to assess knowledge and receive grades.

Unlike the last two statements, which received ambiguous answers, the responses to the first two statements were more clear-cut. Sixty-four percent of respondents agreed with the statement that game-based knowledge tests are used so that the academic staff can make sure of the students' acquired knowledge and what is not clear, and 26% marked the answer "rather agree."

For the statement that game-based knowledge tests are used for students to test their knowledge and understand what needs to be repeated, 69% of the respondents agreed, and 21% marked that they "rather agree" with this statement. This shows that game-based knowledge tests have a positive impact on the knowledge acquisition of the students and are good for providing feedback that is useful both for the teacher to prepare lessons and also for students who are interested in self-directed learning.

Next, students were asked to evaluate the statements about game-based quiz apps for knowledge assessment by ticking the most appropriate answers on a Likert scale (see Fig. 10.2). Forty-seven percent of respondents agreed and 36% rather agreed with the statement that quiz apps are motivational. Ten percent of the respondents marked that they rather disagree, just 2% disagreed, and for 5% of the respondents, it was hard to say. Fifty-three percent of the respondents agreed that game-based quiz apps help to strengthen knowledge, 31% rather agreed, but 7% of the respondents rather disagreed and 2% disagreed. For 6% of the respondents, it was hard to say. Positive responses can also be seen for the statement that game-based quiz apps help students to understand the topic better – 39% of the respondents agreed and 35% rather agreed with this statement, but 17% said that they "rather disagree." A significant predominance is observed in the statement that quiz apps are an interesting way of learning, as 67% of the respondents agreed and 17% rather agreed with the statement. For the statement that there are no positive aspects concerning

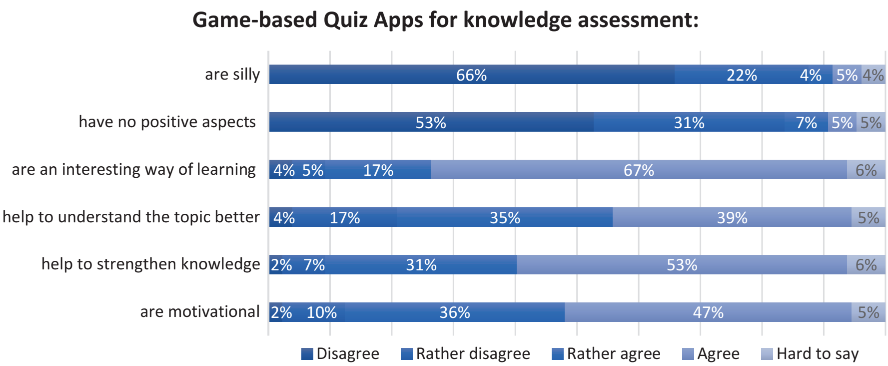

Fig. 10.2 Students' answers to statements about game-based quiz apps for knowledge assessment

game-based quiz apps, the largest part of the respondents (53%) disagreed and 31% rather disagreed, while 66% disagreed with the statement that quiz apps are silly. These data show that students see positive effects of game-based knowledge tests' application in the learning environment.

When the students were asked whether they agreed with the statement that lessons seem more attractive if game-based apps are used, there was a significant predominance of the response "Yes" (85%); only 15% of respondents disagreed with this statement.

Students were also asked about what type of knowledge evaluation they prefer and had a chance to mark several choices; 33% of the respondents said that they prefer knowledge tests on a mobile device or computer. Opinions were divided on the issue of obtaining a grade for the knowledge test, as 26% noted that they prefer tests for which a grade is received, but 23% disagreed and said that they prefer not to be graded after knowledge tests. This correlates with the answers that show that students like to receive feedback to understand the development and level of their knowledge.

The last question was about the elements of game-based quiz apps that students find engaging and motivating. They were allowed to mark several answers and choose elements that they find most appealing. As Fig. 10.3 shows, 19% of responses (n = 104) state that giving the correct answers and results immediately to provide instant feedback is very important. Points (n = 70) and cooperation (n = 57) are also considered to be motivational elements, followed by grades (n = 52), and 44 respondents noted that the aesthetics of the graphic is a very important aspect as well. Interestingly, 38 students marked that they find competition engaging and motivational, but this is understandable because it is possible to distinguish four player types after Bartle's player typology – explorers, killers, achievers, and socializers – and even more according to other authors (Monterrat et al., 2017). That means that

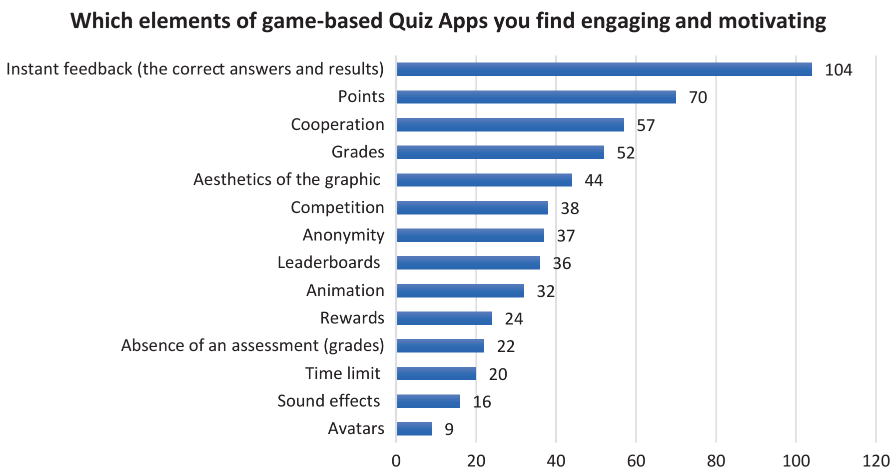

Fig. 10.3 The elements of game-based quiz apps that students find engaging and motivational

each player participates in an activity with different purposes and likes different game elements and mechanics. Games and game-based learning will not always meet the needs and desires of every participant (Vassileva, 2012; Harviainen, 2014).

As shown in Fig. 10.3, 37 respondents marked anonymity, but 36 respondents noted that they find leaderboards engaging and motivating. This contradicts the statement about anonymity. Animation ($n = 32$), rewards ($n = 24$), absence of an assessment (grades) ($n = 22$), time limit ($n = 20$), sound effects ($n = 16$), and avatars ($n = 9$) were also mentioned.

Conclusions

The main conclusion that can be drawn is that the students who participated in this study considered quiz apps as motivational and engaging game-based tools for the assessment and repetition of knowledge in higher education that provide instant feedback about errors. Consequently, they help students to identify their weak spots and the parts of the subject that must be repeated and to which more attention must be paid. For the academic staff, they help to identify the weak spots in the general performance of the students and draw attention toward specific topics or questions that were answered incorrectly. Students find the instant feedback about knowledge that these tools provide (without affecting their final grade at the end of the semester) and the possibility to learn from mistakes made during the activity to be very enjoyable. This is in line with Wang's (2015) opinion that knowledge assessment can be more enjoyable, engaging, and even fun if done via game-based learning tools.

This study has also revealed some consistencies with the theoretical framework of motivation theories. According to the self-efficacy theory, motivation is determined by previous performance and achievements that resonate with game-based student response systems that allow knowledge to be practiced in an engaging way and show students' strengths and weaknesses, and in exams, students' self-efficacy could be higher than in situations where the knowledge is being assessed for the first time. According to Bandura, feedback and positive comments or explanations about the errors students made from academic staff or the student response system can encourage the student in the further acquisition of knowledge.

On the other hand, Ryan and Deci's self-determination theory highlights the external factors that promote engagement and enhance learning motivation like points, competition, time limit, leaderboard, etc. that are offered by quiz apps and provide engagement during the activity. This engagement can lead to an increase in internal motivation that can provide more long-lasting interest in the subject and greater depth to the acquired knowledge.

The negative traits that were revealed during the study and correspond to Gros' work (2006) are that there is a lack of implementation of games as learning tools in formal education and that academic staff do not implement game-based knowledge assessment tools in the lessons as much as they could. Only half of the respondents mentioned that a game-based student response system is implemented in their classes. Academic staff in higher education should consider the possibilities provided by technology-enhanced learning and game-based learning and use them in the future to ensure students' engagement with and deeper understanding of the subject.

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Chapter 11
Reflections on the Application of a Gamified Environment to Foster Young Learners' Digital Competencies

Efi. A. Nisiforou and Charalambos Vrasidas

Introduction

The educational landscape has dramatically changed in times of global pandemic. This situation urges us to search for new solutions and new educational pathways for knowledge and skills development. Digital citizenship is a topic of growing concern, defined as "the norms of appropriate, responsible behavior about technology usage" (Ribble, 2012, p. 10). The global community is now endeavoring to cultivate students into digital citizens, capable of finding solutions for the world's most significant technological advances. Researchers and educational practitioners are increasingly turning their attention toward educational games' effects to support the development of digital skills in primary school students. Digital skills are essential for the next generation to act appropriately in the digitalized and rapidly evolving society. Schools need to extend and embed key skills and concepts into students' lives to ensure they can use digital technology effectively and responsibly both in and out of school context.

The goal of smart education is to foster learners' twenty-first-century skills (such as problem-solving ability) as a medium to confront the challenges encountered in the digitalized society. To keep up with the rapid digital transformation, smart pedagogy (smart teaching and smart learning) must turn its attention to learning how to employ the different digital technologies in a smart and meaningful way (Daniela, 2019). Considering this technological transformation, the idea of "smart pedagogy" was emerging as the driving force of technology-enhanced learning to promote synergy between technology and pedagogy (Daniela, 2018).

The research community lacks a summarized chapter that will introduce the connection between game-based learning and digital citizenship education to support young learners' acquisition of vital digital competencies. Based on these

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prerequisites, integrating GBL in the context of digital citizenship education creates a challenge that must be addressed today. Therefore, this work's overarching goal is to promote smart pedagogy by supporting students and teachers to become members of a digital citizenry and responsible users of digital technologies.

Key Definitions

Smart learning environments are referred to as systems that aim to propose innovative practices of emerging pedagogical approaches and technologies to support effective learning experiences (Pesare, Roselli, Corriero & Rossano, 2016).

The need to establish Innovative Learning Environments (ILE) was also highlighted in the OECD report (OECD, 2017; Borawska-Kalbarczyk et al., 2019). Developing such modern learning environments based on smart pedagogy requires acquiring specific competencies such as digital skills. Smart educational environments can provide tailored and personalized learning (e.g., adaptive content, collaborative and interactive tools, real-time feedback, etc.) to increase student engagement and enhance meaningful learning (Zhu et al., 2016).

The development of an innovative and gamified DRC-Heroes application provides a unique opportunity and pedagogic innovation to teach the various topics related to digital citizenship. Reflections and recommendations are drawn based on the implementation and evaluation of the smart learning environment. In addition to the theoretical part, the chapter gives a practical tone by outlining the reflections and recommendations as emerged through user experience (UX) studies conducted in four different European countries with a sample of primary school teachers and K-12 students. Participant's reflections declare the potential of game-based learning and essential gamification elements to promote smart pedagogy by cultivating young learners' digital skills in the context of digital citizenship education.

The European Digital Competence Framework (DigComp)

To tackle the advanced digital skills gap and promote innovative learning environments, the European Commission's Joint Research Centre published coherent European frameworks such as the Digital Competence of citizens (DigComp), teachers (DigCompEdu), and organizations (DigCompOrg) (Beblavý et al., 2019). Precisely, the European Digital Competence Framework for Citizen (DigComp 2.0) is a reference framework that aims to support individuals' development of digital competence in Europe (Vuorikari et al., 2016; Kluzer & Priego, 2018, p. 12). The framework defines digital competence as using such digital technologies in a secure, critical, collaborative, creative, and responsible way (Vuorikari et al., 2016). Various editions of the DigComp were published since then. DigComp 2.1 is the advanced version of DigComp and includes five digital competence areas, namely, (1) information and data literacy, (2) communication and collaboration, (3) digital content creation (including coding and programming), (4) safety (including digital well-being and competencies related to cybersecurity), and (5) problem-solving (Carretero et al., 2017; European Commission, 2018). The common European Framework for the Digital Competence of Educators (known as DigCompEdu) focuses on expanding the three initial proficiency levels to eight and providing examples of their use. This model was designed to help national authorities guide their policies to implement regional and national tools and training programs and provide a common language and approach, favoring the dialogue and exchange of best practices across borders.

Game-Based Learning (GBL), Gamification, and Educational Games

Game-based learning (GBL) refers to integrating games for educational purposes (All et al., 2016). GBL approach has gained considerable popularity in the last decades, and it remains a fertile area of research in education (Romero & Usart, 2013). GBL is actively driven by games, defined as the process of adapting an educational concept into a game-based structure with clear learning outcomes (Hasan, 2018; Hasan et al., 2018). A more recent term defined by teachers' views is that GBL is learning by having fun, learning by doing, and learning through activities (Avdiu, 2019). It was mentioned that game scenarios could enhance knowledge and competencies acquired through scenario-based, problem-solving, and decision-making processes by engaging students in active learning situations (Prensky, 2001; Klopfer & Yoon, 2005). A recent study declared that GBL implementation composes various teachers' competencies that need to be developed in advance. Understanding these GBL-related competencies supports teacher's professional development (Nousiainen et al., 2018).

Nowadays, the gamification approach has revealed the value of game-based mechanics to create meaningful learning experiences. Gamification is a more recent term than GBL, and although it was first coined by Nick Pelling back in 2003, it was commonly introduced in teaching and learning a decade ago (Jagušt et al., 2018). It has received enormous attention and is defined as a technique that implements game elements and mechanics into non-gamified environments, forcing learner-users to follow specific rules (Deterding et al., 2011). These fundamental elements are given at the beginning of a game, such as rules or progress elements (i.e., avatars, points, badges, leaderboards, achievements, levels, and content unlocking) and users' behaviors-emotions when they receive feedback, interact with others, and build relationships. There are significant research works that clearly illustrate the application of gamified components in education (Christy & Fox, 2014). These studies have introduced a gamified environment concept, which specifies an environment where the gamification characteristics are organized to actively engage users in the learning process (Hasan, 2018; Khan, & Umair, S. (Eds.)., 2017).

Digital Educational Games

Digital games have gained popularity as a new paradigm in education. Games contribute to the active involvement of students in the learning process. The educational value of digital games has been of interest to many scholars (Allsop & Jessel, 2015; Spires et al., 2011; Robertson & Howells, 2008). More precisely, it was affirmed that games introduce students to self-directed learning and develop different skills such as problem-solving, active involvement, critical thinking, and collaboration (Whitton, 2012, 2014; Zsoldos-Marchis & Hari, 2020). Although significant research lies on the positive effects of games on students' twenty-first-century skills development, not much is known regarding how games may explicitly affect students' digital competencies. At this point, many digital games have been developed for educational purposes. However, their implementation into primary classrooms is still in its infancy.

Digital educational games have gained wide popularity over the years, bringing education to a new dimension, which conforms to the habits, needs (e.g., digital literacy level), and learners' interests. It is commonly known that by introducing entertainment in the learning process, a more attractive, pleasant, and engaging environment is stimulated for the learners (Prensky, 2002). When used appropriately, digital educational games can be classified as active learning environments that could enhance children learning and skills acquisition, thus effectively contributing to reforming the educational system (Kebritchi et al., 2010). Nevertheless, digital educational games can successfully enhance student participation and collaboration and foster problem-solving skills (Gros, 2007; Manesis, 2020).

The Context

Digital Citizenship Education to Support Smart Pedagogy

To confront the digital skills gap in Europe, digital citizenship education was introduced as a game-based learning and problem-based learning approach in primary schools within Europe (Cyprus, Greece, Italy, Ireland). These learning and teaching approaches are employed in the context of digital citizenship education to support the development of smart learning environments and further enhance smart pedagogy. Nevertheless, to the best of our knowledge, no case studies nor reviews of the literature exist on incorporating the European DigComp framework in K-12 classes to nurture young learners' digital competencies. To drive this, DigComp was selected as the most appropriate framework to support digital skills initiatives (EU, 2016; Vuorikari et al., 2016).

For these reasons, following the five (5) digital competence areas described in the framework (information and data literacy, communication and collaboration, digital content creation, online safety, and problem-solving), we created an attractive, smart learning environment for students. Henceforth, GBL and essential gamification elements were employed as the most appropriate strategies for the instructional design of the Digital, Responsible Citizenship (DRC)-Heroes application which aimed to engage students in authentic and challenging problem-based scenarios. DRC-Heroes app proposes different game scenarios to master the future workforce's digital skills to meet the challenges of the digitalized society.

User Experience (UX) and Educational Design Research

According to Norman and Nielsen (1998), user experience (UX) encompasses all aspects of the end user's interaction with its services and products. UX research design incorporates a systematic educational design process with target users and their requirements to create products that provide realistic and relevant experiences to end users. On the other hand, educational design research is defined as "a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic setting" (Barab & Squire, 2004, p. 2). Design-based research and UX design joined forces to ground the methodology of this work. The educational design research methodology aimed "to increase educational research relevance for educational policy and practice" (van den Akker, Gravemeijer, McKenney & Nieveen 2006, p. 3). Therefore, user experience (UX) studies with end users (179 teachers and 99 students) from four different EU countries (Cyprus, Greece, Ireland, Italy) were conducted in order to evaluate the application, redesign, and produce the final product. Multiple data sources were used as part of the UX research to ensure triangulation of the collected qualitative and quantitative data. These methods include the following:

(a) Teacher training
(b) Student workshops and observations
(c) Questionnaires

Design, Development, and Evaluation

The DRC-Digital Heroes is a digital game (DRC stands for "Digital, Responsible Citizenship") which is specifically designed to engage and motivate students to acquire digital competencies as formed by the EU DigComp model. The adventurous smart learning environment teaches primary school students (K-12) of all grades (first–sixth) the fundamentals of digital citizenship through a series of dilemmas that take the form of five mini-game-based scenarios. The application is widely available in three languages. It is offered in two formats,[1] as a web-based learning platform and an adventurous gamified application, freely and easily accessible for iOS and Android users. A description of the game elements embedded in the gamified application's construction is presented in a tabular form (see Table 11.1).

Grounded on the concepts of smart pedagogy, the content of the application offers a smart learning environment. The innovative gamified application's design and development were built as part of the "Digital, Responsible Citizenship in a Connected World" (DRC) Project funded under the Erasmus+ program, KA2. The application was developed based on the ADDIE instructional model (Molenda, 2003; Branson, 1978). The five stages of the development process include the *analysis* (i.e., target audience, needs, instructional goals), the *design* (i.e., prototypes, characters, graphics, scenes, and badges) following a design thinking approach (Martin, 2009), the *development* (i.e., instructional content such as rules and aims of the game, narratives structure, scenarios, articulates, level of interaction, usability testing tools, protocols, consent forms), the *implementation* (i.e., student workshops, teacher training, UX case studies), and *evaluation process* (i.e., quality of information, the visual design of the interface, user satisfaction, scoring, real-time feedback, ease of use, language).

Usability evaluations were conducted with primary school students and teachers during the delivery of workshops and training. The UX studies and evaluations were carried out by two researchers per country (a total of eight researchers) to establish the data's validity and reliability. Upon completion of the research process, participants were requested to evaluate the usability of the DRC-Digital Heroes app in terms of its usability (e.g., attributes such as easy to learn, efficient to use, pleasant, content, interface design, etc.). The evaluation tools were:

(a) Observation template
(b) Testimonial template
(c) Evaluation questionnaire

The detailed analysis of both quantitative and qualitative data is beyond the scope of this particular work. As noted earlier, the present chapter reflects on the lessons learned from the evaluation of a gamified application in GBL to promote smart learning and pedagogy. The open-ended questions of all research instruments were formulated to address a wide variety of issues related to UX as a result of users' interaction and overall experience with the application. Participant responses were then reviewed and presented as reflections and lessons learned to illuminate the way for future practices to follow to foster digital skills and promote smart education. Some indicative questions which were embedded in the evaluation templates include but are not limited to the following:

- Give three words that best describe digital citizenship for you?

[1] Web-based, App Store/Google Play

Table 11.1 The architecture of the DRC-Digital Heroes application

Game elements	Description
Language	User language selection (English, Italian, Greek).
Main scenes	Various scenes to cover all five digital competencies as distributed across the different scenes of the PBL scenarios.
Meet the heroes	Game storyboards and instructions related to all six heroes' missions.
Five games	Five mini-scenarios based on DigComp and GBL approach.
Characters	A total of eight (8) characters were designed to count gender equality.
Foxy and Puffy	The two (2) main player characters appear throughout the scenarios.
The creative hero	With the creative hero's guidance, young people learn how to create a digital frame by choosing the background and font and add copyright to an image.
The safeguard hero	With the safety hero's support, young learners acquire knowledge and basic skills on how to use the Internet, create accounts with strong and secure passwords, protect personal information, and decline invitations from unknown people.
The information hero	Together with the information hero, children learn how to evaluate source reliability during online searches.
The problem-solving hero	Children are motivated to use technology for solving an environmental issue and not just apply for active citizenship. The problem-solving hero will help them make the correct decisions.
The communication hero	With the help of the communication hero, children are engaged in producing text messages and comments on social media.
The wizard hero	The wizard hero is the online master of magic and helps young learners to ask a series of easy-to-answer questions to the relevant hero.
Five (5) mini-games	**Description of scenarios**
Puffy & Foxy surf the web	This game aims to help students understand, recognize, and manage e-safety issues in the digital world.
Puffy & Foxy design a birthday card	Through this game, students explore the varied and evolving environment(s) of digital content creation to support the acquisition of critical thinking, reflective and responsible doing and making.
Puffy & Foxy go to the library	In this game, students find useful information on how to use communication and collaboration tools responsively.
Puffy & Foxy research the elections	Through this game, young students acquire basic background knowledge related to information and data literacy.
Puffy & Foxy visit the river	This game presents the concept of problem-solving and aims to foster relevant competence in children.

- How did you navigate through the application? Give an example.
- Describe your experience on the usability and accessibility of the app.
- What have you learned through your interaction with the game "Puffy & Foxy research the elections"?
- How do you find the design of the interface?
- Would you recommend the application to other students?
- Which was the most exciting game for you and why?

- What have you learned from your interaction with the game "Puffy & Foxy surf the web"?
- How would you describe your overall experience with the application?
- What did you like the most?
- What did you like less?
- Is the interface of the app suitable for students? Please describe in terms of language, ease of use, content, feedback, scenarios, self-directed learning.
- Give one example of how to stay safe online?
- Give one example of how to protect your creative commons when creating a digital card.

As obtained through participants' reflections, the evaluation results reveal that students gained a basic level of knowledge on the concept of digital citizenship. Therefore, we assume that digital competencies were acquired at an optimum level through the interaction with the DRC-Heroes application. These initial views will be further examined through the data analytics logs in order to identify trends and accept or reject these assumptions. Both teachers and students found the app motivating to play, revealing a potential impact on learners' engagement and fostering of digital skills. The implications of these findings and the lessons learned are discussed. The application aims to break the illiteracy chain, allowing parents with the lowest literacy levels to explore stories with their children. An impressive result is that besides supporting the official spoken language (English) was also essential to provide a multilanguage system that supports the different local mother languages (English, Greek, Italian). A common outcome of these initiatives is that they demonstrated the value of applying mobile applications to teach children without access to schools. In addition each mini-game scenario embraces a specific learning content related to digital citizenship education (see Table 11.1), which can be horizontally integrated into all subjects areas as part of the school curricula.

Reflections and Recommendations

Game-based learning appears to support teachers in their effort to equip students with the fundamentals of digital citizenship education. The integration of the DRC-Heroes application in the teaching and learning process revealed its potential to cultivate learners' digital skills and acquire the fundamentals of digital citizenship, as these were reflected through their testimonials. The application is an engaging, interactive microcosm with customized, user-friendly, and gamified interactive educational scenarios that give space to the more engaging classroom and home discussions. Overall, students and teachers valued the user-friendly and stimulating environment of the DRC-Heroes app by reporting its ease of use, real time, continuous feedback, and authentic problem-based scenarios that stimulate learners' engagement.

Taking design research and UX approaches was iterative, with multiple feedback loops that informed the app design's subsequent phases. Our lessons learned and recommendations anticipate guiding teachers, and practitioners employ GBL practices to foster students' digital skills and promote smart learning environments.

These steps are based on our views and include the following:

- Review and apply the ADDIE model of instructional design in the teaching practices or other related models.
- Understand the needs of the target group.
- Focus on the required skills relevant to the learning objectives of the class audience.
- Dedicate time for planning the design of the GBL course.
- Use a friendly tone in the scenarios relevant to the target audience.
- Use authentic problem-based scenarios to cultivate problem-solving skills.
- Create a balance of engaging text and images.
- Employ gamification mechanisms to trigger students' participation, motivation, and engagement (such as rules, points, badges, unlocks, ranks, level up, leaderboard).
- Identify potential obstacles, and tackle challenges from a different angle or perspective on overcoming the difficulties and turning those into possible opportunities.
- Understand that a cohort of students requires an iterative education development process that involves planning, testing, and reflective practices.
- Take a student-centric approach, involving a multidiscipline team, to understand what was desirable from the student perspective.
- Redesign the smart learning environment based on the feedback received by teachers and end users (i.e., students).
- Flexibility is a crucial factor to accommodate game-based learning; subsequently, a more radical policy reform would be needed.
- Adjust the teaching content to country-specific curricula, pedagogy, methods, and practice when embedding digital games in the context of digital education.
- GBL needs an extra effort from teachers, and they also need skills in designing different games.
- Implement effective GBL by teaching through play.
- Design the GBL activities by starting building the teaching scenarios having in mind basic gamification mechanisms.
- Ensure that students are learning by assessing their knowledge progression throughout the session to allow the teacher to better-adjust their teaching activity.
- Design learning activities that enable students to uncover their prior knowledge and unfold their capabilities.

Future work will integrate voice-over narrations throughout the entire scenarios and run log analytics. Besides, the analysis of the application based on the TPACK model would reveal interesting research paths. Further UX studies will take place using a more significant number of participants to examine trends and draw conclusions on the application's usability. Finally, it would be interesting to measure the level of interaction and cultivation of digital skills before and after the intervention of teaching and learning practices with the DRC-Heroes application. These data will confirm the application's potential to foster young learners' digital skills and support the development of smart pedagogy.

Conclusion

Our chapter reflects on the usability of the DRC-Heroes application as a smart learning environment in the context of digital citizenship to promote smart pedagogy. The UX evaluations in primary schools in Cyprus, Greece, Italy, and Ireland presented the DRC-Heroes gamified learning environment in primary school settings during the implementation of an Erasmus project. Reflections on its implementation encapsulate innovative ways on how the concept of digital citizenship in school curricula might tackle the digital skills gap.

Primary school teachers must be taught the relevance of game-based learning and training on applying basic gamification techniques in teaching practices to motivate students' knowledge and digital competencies development. Teachers must recognize the importance of game-based learning, digital citizenship, and new teaching and learning technologies. Adequate training on these concepts could support teachers adopt these recent trends.

Teachers' and students' experiences and views on integrating the DRC-Heroes games in the primary classroom call for a dynamic connection between curriculum design, learning culture, and practice when implementing game-based learning. We anticipate that this brief chapter will motivate teachers to embed digital games into their teaching practices and identify innovative pedagogies to teach fundamental digital citizenship concepts.

Transitioning students and teachers to digital citizen mindsets may require much more time and preparation than expected. Henceforth, there is an imminent need to understand how GBL can reinforce students' digital demands and keep up with societal trends. Finally, the chapter envisages guiding educators, students, policymakers, and other education professionals on designing, developing, and implementing digital citizenship pedagogies in the primary school curriculum.

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Chapter 12
Game Design for Adult Learning: Blending Smart Pedagogy and an Andragogic View

Andrea Filatro and Marilene Santana dos Santos Garcia

Introduction

This article aims to expand reflections about new academic research perspectives on digital games with a focus on the following elements: (i) andragogy, (ii) games, (iii) game design for adult learning, and (iv) smart pedagogy.

There are historical records that show that games have been present in human life for a long time, throughout civilizations (Huizinga, 1999). However, there was a long trajectory before electronic and digital games reached the point they are at today, which was made possible by events in informatics and computer sciences, mainly throughout the twentieth and twenty-first centuries. These events are related to the emergence of computers, the expansion of memory and processing speed, the reduction in the size of devices, and the emergence of networked computers and mobile devices, among other examples (Harris, 2015; Arruda, 2013; Luz, 2010; Nagalingam & Ibrahim, 2015; Alvarez et al., 2019).

Among their many aspects, games are directly associated with fun, hobbies, and entertainment, but they have been expanded to other uses, such as training, issues related to health rehabilitation, and the acquisition of soft skills and new knowledge. At the same time that players have fun, games can also demand a high level of cognitive effort through capturing the player's attention and the use of complex problem-solving strategies and decision-making. They can result in satisfaction or

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frustration (Dreimane, 2018; Kapp, 2012; Alvornoz, 2009; Harris, 2015; Resnick, 2004; Neri et al., 2017).

Games arouse a lot of interest and have generated varied research focuses in the educational field. Educational games' construction is based on recent frameworks to achieve quality and playful learning processes. In this sense, it would be expected that they would be able to leave the fields of mere entertainment and fun and start to contain pedagogical practices. The reasons for this are oriented in studies that identify the playful, cognitive, and engaging side of games as a qualitative differential for learning (Aleson-Carbonell & Guillén-Nieto, 2012) to the point of creating a completely new approach: game-based learning (GBL, as defined by Prensky, 2007).

The concept of GBL encompasses board and card games, video and console games, online and mobile games, and games based in other digital devices and services, such as virtual and augmented reality, sensor recognition, holography, and the Internet of Things. It also includes gamification strategies that, to a greater or lesser extent, adopt game elements for educational purposes.

Game design for educational purposes aims to build activities to achieve some intellectual skill or competence, generate engagement and motivation, and trigger results in practical life or in the context of work, in short, in the reality of learners. The most relevant aspects are related to gameplay, friendly interfaces, and direct and dynamic interaction, all based on rules, implicit or explicit, to be respected for the progress of the game. This process emphasizes the experience of playing in the design and also seeks to improve aspects of intuitive navigation, usability, and access in the interfaces, due to the game's ergonomics (Shneiderman et al., 2016).

It is important to highlight that, with the advancement of digital technologies, the growth of the digital games industry has become quite expressive. It stands out for its possibilities of providing simulations and experiences that are not necessarily possible in the real world, in the work or school environment – such as the simulation of a historical period, the evolution of an extremely long or short process, or a natural phenomenon that is difficult to follow, among others – that can use various virtual reality systems: immersive virtual reality (IVR), augmented reality (AR), and serious games (SGs). Important examples are also found in educational games in the area of psychology and the rehabilitation of the elderly (Neri et al., 2017).

Education focused on adults is defined by the concept of andragogy, a term that was based on studies by Malcolm Knowles (Knowles, 1984; Knowles et al., 2005) and started to be disseminated in the second half of the twentieth century. Its main objective was to adapt teaching and learning proposals to the profile of adult learners who are already participating in the labor market and need to recycle knowledge to meet their new professional demands and to feel included in the processes of social change. Andragogy is oriented toward assumptions of lifelong learning and toward permanent education.

Considering the broader social, political, cultural, economic, and historical aspects, Freire's work (1987) focuses on the literacy of young people and adults, with an emphasis on the relationship of the apprentice with the world in which he/she lives so that he/she is aware of their place in society. For the author, in the context of the politicity of education, educational processes cannot accentuate the passivity of adults in the face of reality, but rather stimulate their awareness and their power to change it, based on an active participation based on critical awareness about their place in society (Barros, 2018).

Thus, adult or continuing education programs are structured to achieve different training purposes. They can be official programs of public agencies or private initiatives, ranging from formal courses at the undergraduate and graduate level to professional development actions, programs to increase productivity and sustainability in the labor market, and literacy courses for adults or functional illiterates, among other aspects that are still relevant today.

It should be emphasized that current adult students have already grown up in environments offering electronic and digital games, often incorporating their dynamics into their lives. Likewise, they have assimilated literacies for the use of digital technologies for different forms of productivity and social interaction (Prensky, 2007). Andragogy is supported by the theory of adult learning; it can also be applied to the online environment and to digital games, and as such, faculty members include these learning experiences for their online students (Cochran & Brown, 2016). The social and historical conditions of the profile of these adults and their needs have changed greatly over the years; however, while the principles proposed by Knowles still make sense, they have been adapted to the needs of the present (Knowles et al., 2005; Cochran & Brown, 2016).

In this context of reflection, the concept of smart pedagogy emerges, which incorporates designs aimed at a student who may have different technologies and methods available and be able to learn from them (Daniela, 2020). It seems that there is a voluminous and systematic approach to the theme of games, but when associating it with the educational context of adults, it appears that the field still requires more attention and deepening, even implying, as an adaptation of the term, a possible "smart andragogy," as is discussed below.

Theoretical Background

Andragogy: Adult Education

For Knowles (1984), adult learners demand some important requirements for their learning, including valuing their previous experiences in other learning processes, the recall of their previously acquired professional and life practices, participation in the negotiation of relevant content to be learned, the application of collective and personalized strategies for monitoring and evaluating their evolution, and attention being given to the level of learning achieved as well as the level of satisfaction.

Above all, in this context of adult education in the digital sphere, it is important to address how an interactive interface is presented, which game design frameworks are suitable, how to keep them playful and relaxed, and how they bring valuable information to this type of learner.

The andragogical model emphasizes the centrality of the student's role and is based on six assumptions: (1) the need to know, answering the questions why, what, and how; (2) the learner's self-knowledge, issues related to autonomy; (3) the value of learners' life and work experiences, associated with sources and the mental model; (4) readiness for learning, through the proposed tasks; (5) orientation focused on learning, focus on problem-solving and contextualization; and (6) motivation for learning, intrinsic value and personal reward (Cochran & Brown, 2016; Knowles et al., 2005).

Games in Adult Education

Alves (2003), when reviewing the history of games and describing the playful culture, provides information stating that in many cultures, games, even those aimed at children, were oriented toward the future adult. The author exemplifies this idea with the Brazilian indigenous culture in which, from an early age, children learn to manipulate a bow and arrow in order to be trained in hunting and fishing while still having a sense of play. For this author, even in a game aimed at a child, there is usually support and guidance from an adult on how to play it. Thus, in many ways, the game is inseparable from the adult.

Currently, the construction of games for different purposes and users worldwide is part of a profitable industry, economically speaking, but it also mobilizes research and new developments. Since games broke the barrier of consoles, consumers can be anywhere and can access games on their smartphones at any time, using a wide range of applications. They can play online or offline. This has undoubtedly increasingly stimulated researchers in the field of education to understand the pedagogical potential of games on mobile devices, who are aiming at achieving quality in what is learned and how to make sure that this learning is actually put into practice in the real world.

In the context of adult learning, serious electronic games are usually used for some recognized purposes, including changing attitudes and behaviors and acquiring skills, as well as learning updated content (Nagalingam & Ibrahim, 2015; Aleson-Carbonell & Guillén-Nieto, 2012).

Studies have also shown that educational games can fulfill an auxiliary role when used as a reinforcement to support learning (Nagalingam & Ibrahim, 2015; Nesteriuk & Mattar, 2016).

Out of the practice of games emerges the concept of gamification, which arises from the need to bring more interaction, engagement, and playfulness to education practiced in a live or hybrid environment.[1] In this way, they are constructed from the same base, but in different ways.

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[1] The term was coined by British programmer Nick Pelling in 2003 (see Pelling, 2011).

In his book *Homo Ludens*, first published in 1938, the Dutch historian Johan Huizinga (1999) offers a still very current definition of games. For this author, the game is seen as a voluntary occupation, carried out within time and space limits, with mandatory rules for the players' performance.

Games are cultural manifestations that have their own language, leading the player to interact with them. The experience of the game is both individual and social when it is practiced in a team or against an opponent. They also bring competitive habits, as in tournaments and tests, that evaluate competences, which may be agility in reasoning or different forms of attention, intelligence, or memory, among others.

Games, in their analog format, are related to physical games, board games, and leisure activities, such as chess or backgammon. There are also games such as the magic cube that are made up of an object-device, which challenge the player to manipulate their elements (Harris, 2015).

Observing the learning of adults, gamified activities, as well as the games themselves, can develop a form of immersion, concentration on a challenge, and motivation to receive new knowledge. Thus, the condition of digital games originated from the concept of gamification. This term is widespread and has also formed its own path in terms of research aimed at implemented didactics and methodologies that bet on playfulness associated with learning (Domínguez et al., 2013).

The gamification of activities proposed in teaching plans is guided by active methodologies, which can be applied by teachers in the classroom and/or by SMEs on corporate courses, as long as they aim to involve learners in an engaging way with a permanent point system (Gayer & Mattar, 2019). Badges, trophies, etc. can be used when the activities are carried out successfully.

Kapp (2012) defines gamification with the use of game mechanics and aesthetics to engage people, motivate actions, promote learning, and solve problems. For Dreimane (2018), gamified activities can provide pleasant and competitive interactions with elements that improve concentration while simultaneously offering entertainment.

Game Design for Adult Learning

It can be said that there are several paths that are oriented toward the design of games for adults to achieve some form of learning. There are game design proposals that aim at the professional and social contexts, are oriented toward mobile application interfaces, lead to self-directed learning, incorporate knowledge of the experience of learning in other types of games, or emphasize forms of interaction and use, among other elements.

Resnick (2004) states that experiences of a significant nature for learning are related to the activities that please the learners while they are having fun, which he calls "ludic inclination." In this way, there would be an opportunity to learn while playing for pleasure. It should be emphasized that the author does not align with the term "edutainment," wherein learning is a bitter medicine and the leader would need sweetened games to be able to face it or a way to be attributed a reward. In fact, designs must consider the reality that something is learned in a fun way.

Concerning the design of the learner's experience, user experience design (UXD) can also be mentioned (Alvarez et al., 2019). UXD is related to experiences from which emotions, beliefs, psychological behaviors, and perceptions are derived from the use of a game. Important aspects of the experience design framework are considered for gameplay, including the following six elements:

- Satisfaction: Individual expectations of gaining pleasure or satisfaction from playing the game.
- Learnability: The ability of the player to understand the content of the game and how to handle or play the game.
- Effectiveness: To identify if the objective of the game is achieved.
- Immersion: To engage the player with the game world and indirectly expose its educational aspects.
- Motivation: The excitement that drives the player's need to keep playing the game until the last level.
- Emotion: The player's feeling toward the game they are playing. It is important because a positive feeling toward the game will motivate players to continue to play the game (Nagalingam & Ibrahim, 2015, p. 431).

With the designation of these six elements, it can be understood that the design of a game's experience is centered on the learner and seeks interactions to improve its ease of use and the pleasure gained from playing, based on usability and processes that imply valuing that same learner. The assumption of this design is that what is learned can interact with learning for longer and with better quality from a defined objective.

The learning experience design (LXD) is part of an experience project supported by learning theories that value cognition and the search for applications in reality with strong interdisciplinary support. Floor (2018) states that LXD puts an emphasis on emotional design.

Smart Pedagogy

According to Daniela (2020), the term "smart pedagogy" was first published in an article by Zhu et al. (2016) when they developed a framework that encompassed education in a smart learning environment. Thus, it is a recent theoretical construct, even though it considers technological resources, teacher practices, and a focus on student qualities, such as the need for engagement, elements already discussed in the field of educational technologies.

For Spector (2014, *apud* Daniela, 2020, p. 7), the word "smart" refers to the efficient and effective use of educational technologies, and its goal is also to provide guidance on self-learning in tune with the student's own pace, focusing on personalized learning skills as well as self-motivation.

The emphasis of the concept of smart pedagogy is based on the perspective of the competence of the educator who, based on current knowledge about how students react to and participate in learning, directs their pedagogical work supported by technologies and learning objectives (Daniela, 2020). The author's correction understands that the concept of smart pedagogy is a compound of three main elements: (1) *human developmental regularities*, which include the conditions for the development of cognitive processes, the conditions for sensory development, as well as the conditions for socio-emotional development; (2) *the taxonomy of the educational process*, which includes the goals to be achieved and the regularities of the learning process needed to achieve these goals; and (3) *technological progress*, which entails the need for changes in teachers' pedagogical competence, of which one of the most important is predictive analytical competence.

Thus, smart pedagogy emerges to provide support and pedagogical integration between the existing technological offerings that presuppose active, interactive, collaborative, and engaged students and the competence of teachers in this process. This should demand an educational pedagogy consistent with these students and appropriate to highly technological demands.

In this sense, the principles of smart pedagogy can support the design of serious games; since the need for engagement is also a priority in adult education, games can be considered as intelligent learning environments, and they potentially favor autonomy, self-motivation, and self-learning.

Research Methodology

To verify the most recent publications about games in the context of adult learning, the systematic analysis of articles published in the last 3 years (2018–2020)[2] was chosen as the research method. The Google Scholar database was chosen as the source of publications.

To select the articles for this analysis, Publish or Perish software was used. This is a program that retrieves and analyzes academic citations from a variety of data sources (including Google Scholar). The program searches for raw citations, analyzes them, and presents metrics of bibliometric interest.

Using the search terms "game" and "games" in two separate searches in the Title field, combined with the keyword "andragogy" in the Keywords field, we obtained, respectively, 40 and 27 results.

[2] The 2020 data goes up until November 14, 2020, the date on which the search for articles was carried out.

Table 12.1 Overview of publication years of all 55 articles and the 15 most cited articles

	2018		2019		2020		Total
Total of articles identified	24	44%	21	38%	10	18%	55
Total of most cited articles	10	67%	2	13%	3	20%	15

After an initial treatment,[3] we reached a total of 55 articles. Of these, 15 were selected because of their score in the criteria of absolute number of citations in the period and index of citations per year.[4]

In terms of distribution over the years, the following table compares the total of 55 articles identified in the search with the group of the 15 most cited articles (Table 12.1).

The articles are presented in the table below, organized in descending order by the citation index (citations per year) and year. Note that this group of articles represents 72 citations in the period.[5]

Data Analysis

The initial analysis of the selected articles consisted of the elaboration of a tag cloud based on the keywords collected, with the aid of the WordArt tool, as shown in Fig. 12.1.

The tags understandably reflect the central themes of this research, and it is worth noting that many terms have been used interchangeably by several authors, despite the clear differences between continent and content. For example, gamification was used in some articles as a synonym for game-based learning, and the latter expression was associated with the idea of serious games (a term most used in the corporate context) in contrast to entertainment, commercial, or noneducational games.

Also noteworthy is the status of the term “pedagogy” in the tag cloud due to its weight being almost equal to that of “andragogy.” Although some authors distinguish between the two approaches [8, 9], it can be said that pedagogical and andragogical research and practice are still confused in the set of articles.

Having established this, we then started to analyze the articles in terms of research contexts, types of games, and concepts most presented in the theoretical framework.

[3] The treatment of the data aimed at excluding repeated titles (2), citations instead of original publications (2), complete books (3), slideshows without a date (1), and articles in languages other than English (4)

[4] In Publish or Perish, this index corresponds to the total number of citations divided by the age of the article (i.e., the number of years since publication).

[5] Table exported directly from Publish or Perish. For complete citations, see the References section.

Fig. 12.1 The tag cloud based on the keywords of the selected articles

First, the diversity of the *research contexts* is revealed by the different levels of education and groups of people covered in the 15 articles analyzed:

- *Higher education* – from so-called "nontraditional" students aged over 24 who return to study after a break in the United States (national study) [1][6] to 20- to 60-year-old students at Inland Norway University of Applied Sciences [7] and, in a more focused way, to students of medicine courses at the Unitec Institute of Technology, New Zealand [2], and Keele University School of Medicine, in the United Kingdom [3]; engineering at Ural Federal University, Russia [6]; crisis preparedness and management at Inland Norway University of Applied Sciences [7]; computer science at the University of Minho, Portugal [9]; business at North American University and two British universities [10]; and library and information science in the United States [12]
- *Continuing education* – from people over 60 years old learning about nutrition in residences for the elderly in Vancouver [5] to adults starting programming studies, changing careers, or starting late education in technological areas at the University of Minho, Portugal [9]; to wine aficionados at Keio University, Japan [11]; and to degree programs at the School of Liberal Arts and Business School at a large community college in the American Midwest [14]

[6] The numbers within brackets refer to the articles listed in Table 12.2.

Table 12.2 Overview of titles, ordered by the citation index and year

Titles	Author(s)	Publishing year	Citations per year	Citations in the period
[1] Influence of online computer games on the academic achievement of nontraditional undergraduate students	PE Turner, E Johnston, M Kebritchi, S Evans, et al.	2018	8.00	16
[2] Use of the game-based learning platform KAHOOT! to facilitate learner engagement in Animal Science students	K Cameron, LA Bizo	2019	7.00	7
[3] Evaluating student perceptions of using a game-based approach to aid learning: Braincept	SA Aynsley, K Nathawat, et al.	2018	5.00	10
[4] Integration of Game-Based Teaching in Bulgarian Schools: State of the Art[a]	E Paunova-Hubenova, V Terzieva, et al.	2018	4.50	9
[5] Play, Learn, Connect: older adults' experience with a multiplayer, educational, digital Bingo game	ETW Seah, D Kaufman, L Sauvé, et al.	2018	4.00	8
[6] Effect of using game-based methods on learning efficiency: teaching management to engineers[a]	N Stepanova, V Larionova, Y Davy, et al.	2018	2.50	5
[7] Flipped Gaming-testing three simulation games	T Vold, H Haave, OJS Ranglund, et al.	2018	2.00	4
[8] Investigating retention and workplace implementation of board game learning in employee development	M Wait, M Frazer	2018	2.00	4
[9] Improving game-based learning experience through game appropriation	S Teixeira, D Barbosa, C Araújo, et al.	2020	1.00	1
[10] Cultural influences moderating learners' adoption of serious 3D games for managerial learning	H Siala, E Kutsch, S Jagger	2020	1.00	1
[11] Would you like some wine? Introducing variants to the beer game[a]	C Roser, M Sato, M Nakano	2020	1.00	1
[12] Power Up: Games and Gaming in Library and Information Science Curricula in the United States	AJ Elkins, JM Hollister	2020	1.00	1
[13] Utilizing Digital Educational Games to Enhance Adult Learning	L Cordie, X Lin, N Whitton	2018	1.00	2
[14] Gaming the performance: Massively multiplayer online games and performance outcomes in English and business courses	P Bawa, SL Watson, W Watson	2018	1.00	2
[15] Andragogy and EMOTION: 7 key factors of successful serious games	C Malliarakis, F Tomos, O Shabalina, et al.	2018	0.50	1

[a]The numbers within brackets identify the articles in the following analysis. Only the title, keywords, and summary were analyzed for articles [4], [6], and [11] since they are not available in full without payment or subscription

- *Corporate education* – from retail store employees at various levels of management and with varying levels of experience in Johannesburg, South Africa [8], to adults receiving online training in financial and economic skills or strategic training for the military system [13]
- *Teacher training* – teachers in primary, secondary, and tertiary education in Bulgaria (national study) [4]

There is a prevalence of studies on higher education, with applications in contexts as diverse as library science and management studies. We also see surprising applications outside the university environment, such as "mental training" for the elderly and the appreciation of alcoholic beverages.

With regard to the education of young people and adults with little or no schooling, there is a recommendation to consider the student's literacy level in order to apply the games or their elements that are best suited to their skills [9]. Regarding a typology of approaches to games, the articles are distributed as follows:

- *Digital games* – online computer games [1], digital bingo [5], simulators [8], serious 3D games [10], educational digital games [13], synchronous and asynchronous games [13], and massively multiplayer online games [14]
- *Analogic games* – a card-based RPG [3], board games [8], and a strategy game [11]
- *Gamification* – analysis of the perceptions of students and teachers [4], comparison with traditional teaching [6], and serious games [1, 2, 3, 5, 9, 10, 12, 13, 14, 15]
- *Game tools* – solutions for engagement like Kahoot! [2], solutions for creating scripts and testing scenarios such as RAYVN, Microsoft HoloLens, and interactive simulators [7]
- *Frameworks for studying and developing games* – conceptual structures for creating serious games, such as the andragogical adult game-based learning model EMOTION [15]; customizing the selection of games according to the profile of students according to an ontology, such as OntoJogo [9]; or verifying the integration of games with the curriculum [12]

As for *andragogy*, the articles showed their opposition to pedagogy [8, 9] to the point of considering that (digital) games are a departure from traditional pedagogy [15]. In fact, Malcolm Knowles [1, 3, 5, 7, 8, 12, 13, 15] and David Kolb [1, 7, 8, 10, 15] are the most cited "andragogical" authors.

It is worth noting that although the selected articles are aimed at adult learning, several references emphasize the importance of games for Generation Z [1, 10], the digital generation [4], and the Nintendo generation [15].

As a theoretical foundation, adult learning is connected to the constructivist theory [1, 8, 10, 14], the theory of the reflective professional [7], the theory of social and collaborative learning [1, 2, 3, 7, 10, 13], and the theory of experiential learning [1, 7, 8, 10, 14, 15], as well as to the search for "andragogical efficiency" [10].

Many benefits of using games in adult education are pointed out, including increased engagement [1, 2, 3, 4, 5, 10, 12, 13, 14, 15], motivation [1, 2, 3, 5, 6, 8, 10, 12, 13, 14, 15], and students' confidence in their own learning [1, 5, 8, 10, 14] as a result of games offering significant feedback [1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 15], not to mention the possibility of "learning by doing" and learning in/with practice (mentioned in all 15 articles), all within a fun [3, 13] and secure environment that simulates the "real world" [13].

Among the positive aspects, there is also the increase in social connection [2, 4, 7, 10] and the development of skills such as creativity [1, 3, 5, 10, 12, 14, 15], problem-solving [1, 2, 3, 5, 6, 8, 9, 10], communication and collaboration [1, 3, 5, 8, 14, 15], decision-making [3, 6, 8, 10, 13], critical thinking [1, 2, 8, 10, 12, 14], authentic learning [1, 3, 10], and the students' role in driving, reflecting on, and evaluating games [7]. As a result, the adult learner's self-determination [10, 14], autonomy [14, 15], and independence [15] are valued, something fully consistent with the andragogical perspective.

In contrast, the difficulties are related to devices' interfaces (especially those with small buttons or text) that can be a challenge for adults with low mobility or visual impairment [9], while adults unaccustomed to the world of games or digital tools [4, 6] may demonstrate anxiety and a preference for passive learning, in addition to requiring traditional expository classes. For some students, games can mean excessive "fun" and a lack of seriousness in the classroom [9], a stance that may also be influenced by Rogers' adopter categories [10], as well as by age differences [13], gender, or cultural issues [11].

On the theme of *adult games' designs*, the principles of video games and games in general can also be applied to the design of educational games [5, 14]. In this line, the most cited author is James Paul Gee [1, 5, 8, 9, 13, 14, 15], followed by Mark Prensky [2, 13, 15].

The central thread is that effective games, whether digital or analog, require that learning objectives be integrated into the mechanical core of the game [3]. For example, it is recommended to use concept maps to structure learning and to take care in the design of questions, answers, and feedback [5]. The design process also includes gamification techniques, such as offering rewards and including progression levels [5, 10].

More complex games involve the creation of real-life scenarios, for example, in immersive 3D environments [1, 7, 10] or with characters that simulate the "virtual presence" [10]. The design of social learning experiences is emphasized, including the use of the term "co-playing" [5]. In addition, issues related to human emotion are a critical element of design, as defined in the EMOTION framework [15].

Another design model emphasizes the idea of flipped gaming, in which groups of students are responsible for game design, creating executable scripts for testing and cross-evaluation [7].

Probably due to the recentness of the articles, there is a lot of talk about *learning experience design (LXD)*, an emerging trend in instructional design [1, 2, 5, 7, 8, 9, 10, 12, 13, 14, 15]. This approach unfolds in proposing useful experiences, linked to practical experience and application [1], and in stimulating positive feelings, enthusiasm, excitement, a sense of belonging, comfort in the group, and achievement through learning [5].

In this sense, there are several citations to the *theory of flow*, with explicit references to Mihály Csikszentmihalyi [7, 9, 15]. This is about designing the ideal experience that allows the user to play uninterruptedly and with focus, totally absorbed [1, 2, 5, 7, 8, 9, 10, 12, 14, 15]. To reach this stage, it is necessary to have clear objectives and provide sufficient feedback, offering a level of customization of the game that allows its adaptation to the players' profile by considering either the classic categorization of games into achievers, explorers, socializers, and killers [9] or Rogers' adopter categories – innovators, early adopters, early majority, late majority, and laggards [10].

In addition, the more players are inserted into a narrative and can manipulate characters [9, 10, 14], the greater their identification is with the game, motivating them to continue playing for longer periods [9].

Although it was not expected that references to *smart pedagogy* would be found, due to the search being filtered by the keyword "andragogy," it is surprising that the term "smart game(s)" did not appear in any of the analyzed articles. However, when presenting the OntoGame project, the authors announced the development of a platform in which the data of the players and their actions are recorded and then processed through pattern recognition and machine learning algorithms in order to determine what the most suitable games are for each student [9].

On the other hand, with regard to the main guidelines for the design of educational games, several authors point out the need for direct alignment between the game, the feedback, the learning results, and the evaluation [1, 5, 13]. In this sense, there is a clear approach toward the pillars of smart pedagogy (Daniela, 2018).

Some Final Thoughts

In the research conducted here, we find a diversity of applications of games and gamification in adult education in varied contexts. In most of the articles, we are faced with a cohesive theoretical basis related to the adult learning process and practical reports on the application of the fundamentals of game design for this specific audience.

There seems to be a consensus among the authors that "game-based learning" is an approach aligned with andragogy, especially because it takes into account the adult learner's self-determination and his/her need for the immediate application of their education to practical life.

Thus, in parallel with the principles of "smart pedagogy," we risk talking about a "smart andragogy" based on GBL. This approach corresponds to the state of the cognitive development of the adult – a mature learner in physiological and psychological terms and an increasingly digital one as new generations reach adulthood.

With respect to educational taxonomy, a smart andragogy can benefit from GBL as a strategy for structuring the learning process, with opportunities for remembering, understanding, applying, analyzing, evaluating, and creating new knowledge.

Finally, depending on design decisions, games can play multiple roles in the adult education process: as learning materials, they can provide access to the content of the learning; as technological tools, they can enable active methodologies through the use of computers, smartphones, robots, and so on; as true learning environments, they can bring together content and tools in a single interactive space. They can propose learning activities related to the application of content to everyday life. They can offer scaffolding in a more appropriate way to independent students and promote self-assessment through realistic feedback that values metacognition. Last but not least, games can strengthen social relationships on physical or digital networks, even creating a learning and/or practice community.

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Chapter 13
Serious Film Games (S.FI.GA.): Integrating Game Elements with Filmmaking Principles into Playful Scriptwriting

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Introduction

Smart teaching and learning indicate the necessity to assimilate digital media and technologies to prepare students for the challenges of the digital age (Daniela, 2019). Smart learning is based on active student participation and readiness to learn, innovative pedagogical methods to facilitate the learning process, learning activities that aim to promote students' autonomy, as well as cooperation between student and teacher and their classmates. In smart learning environments, students research and investigate deeper and more extensively for the necessary knowledge, with temporal and spatial flexibility, by processing conflicting information, thinking critically, and focusing on deeper understanding (Spector, 2015). Students express opinions, propose solutions, reach to useful conclusions, share knowledge, and prepare for the next steps. Their personal knowledge is being utilized, personal differences of thinking have to be understood and recognized, and also, their emotions are of a great importance to be expressed (Hogan, 2011). Emotions are integral to learning. Teachers are companions and helpers; they enliven the learning process in a playful way. They do not function as infallible sources of knowledge but motivate their students to explore and work in a proficient, viable, adaptable, and continuous way. Within this scope, the authors are currently developing Serious Film Games (S.FI.GA.), a novel methodology that utilizes smart technology and playful learning for teaching the creation of short films. Besides providing students with the theoretical background on the history and evolution of cinematography, as well as with the technical knowledge for experimenting with state-of-the-art audiovisual techniques,

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S.FI.GA. is largely based on game-based learning (GBL) environments to engage students in the completion of learning objectives through playful educational activities. It functions as an intersection between electronic games and filming techniques aiming to highlight the building blocks of filmmaking and study the artistic practices for their realization, while facilitating students to take up an active, critical stance on the creative process and explore their own authenticity.

The part of S.FI.GA. presented in this chapter deals with the act of scriptwriting through an interactive, educational electronic game. More specifically, the game "Just Ahead of Me" was designed by the authors and tested by students of the Elements of Film Directing & Acting course at the Department of Audio and Visual Arts of the Ionian University in Corfu, Greece, who played the game, filled in an evaluation questionnaire, and participated in semi-structured interviews. The purpose of this research, which accounts for addressing the game to this specific focus group, was to collect data that will facilitate the optimization of the game's design before its incorporation as a module into the S.FI.GA. methodology. The game is structured in seven rounds, which address different stages in creating a storyline. In each round, players must first select one of the available cards, which represent different narrative archetypes, and then develop the plot based on their selection. This level of interactivity between the cards and the final outcome is complemented by a second level of interactivity between players: once a card is selected by one of them, it cannot be selected by another. It was the researchers' main drive for conducting this research to investigate whether students will be able to shift the focus of their script and essentially adjust their creative thought to a different card than the one they had initially counted on.

Theoretical Perspectives and Basic Principles

As a whole the S.FI.GA. methodology works as a kind of social research, based on the students' stories, and attempts to offer answers to the narrative questions "what," "where," "when," and "how" (Tashakkori et al., 2021). However, it is not always so easy to find the "why." Therefore, the main emphasis is on finding useful data elements (Teddlie & Tashakkori, 2009, pp.68–69) concerning the way they structure their stories and how they realize and put together the central dramatic elements. In this context, the creation of the game was based on three basic principles.

First Principle: Respect for the Personal and Private Reality of Each Student

The process of the game is a personal and private reality of each student. Everything that happens during the game represents "reality" at that moment, allowing students to escape from the constraints of everyday life and to experiment with new facts and/or situations (Loh & Sheng, 2015). Players actively engage with the game, as their stories mostly are self-directed. Their involvement intrigues their interests and helps to express the authenticity of their thoughts. They act spontaneously, and this is a mirror of their broader aesthetic, historical, and cultural context and influences (Czauderna, 2018). Their own way of scriptwriting is composed of a cognitive spontaneity, as everyone is involved in a unique, individual way of developing their story, as well as of a social spontaneity supporting specific individual and social characteristics, actions, and behaviors, often with a sense of humor, developing imaginary characters and their actions, usually accompanied by the revelation of various emotions. All student behavior is fully in line with the StoryLab (Knudsen, 2018, 2020) principle of authenticity, which is one of the three basic principles of filmmaking. The filming follows the writing of the script, which is a consequence of the game.

The goal of educational games is to help active participation in the learning process and thus produce learning that extends beyond the gaming context (Zheng & Gardner, 2017, p.2). They cultivate critical thinking, interaction, cooperation in problem-solving, and enhancing of skills (Koltay, 2011). In its whole the S.FI. GA. methodology constitutes an interdisciplinary field. “Just Ahead of Me” acts as a means to inventive description with the purpose of facilitating students to handle various situations, to move within spatiotemporal fields, to acquire the ability to a well-defined self-expression, to seek solutions, and to overcome problems. The essential factors are the parameters that shape the development of their story and make the narrative roles understandable and the ways in which their stories take place in the context of a reality-focused view. It is a card game, in which cards act as milestones creating challenges, it is also an open path that leads to the solution of their dramatic question in their stories, and it can also be seen as a puzzle game. Puzzle games are usually used in the classroom for the cognitive, emotional, and social development of students. Stories created by students are influenced by the given cards in the game rounds. Cards trigger players toward experimentation, exploration, prediction, planning, and interpretation of actions.

Second Principle: Passing Through Character Integrity on Students’ Scriptwriting

The goal of the game is to limit the choice of passive strategies commonly adopted by students, when they are faced with problems and obstacles. It is a challenge for educators to lead students to engage playfully in situations they easily characterize as unfamiliar, arguing that these situations can never happen. When some unexpected or uncommon situations finally come to reality, students become stressed, and they feel unable to confront. They need to become familiar with the possible occurrence of the unexpected and be prepared to face the unpredictable and nonexistent (Papadopoulou, 2018). Besides, predefined series of orderly steps drawn from a current repertoire of actions in order to confront unexpected situations make students run off from any creative process (Papadopoulou, 2019).

Through its mechanics our game helps students reconsider the actions of their characters on a continuous basis. Their stories have to keep going on; on the one pole, the changes through cards are in some way embodied and students' thoughts or suggestions are registered, and on the other pole, students become "competitive" and fight against the proposed change and try to handle the challenge, to transform or overcome it. It is through that duality that the card game aspires to become more interesting and intriguing.

Receptivity to new experiences is characteristic of unconventional, creative, imaginative people who are willing to get involved in a change. The concept of locus of control (Lefcourt, 1976; Marsh, 1986) comes from Rotter's theory of social learning, which he formulated in 1954 (Rotter, 1954). This theory references two categories of individuals in terms of the degree to which they believe that events in their life are under their control (internal statement) or under the control of others, persons or forces (external statement). Thus, dealing with situations is a characteristic of the individual's personality. Internal-statement people are usually willing to take on risky projects as opposed to external-statement people who do not want to engage in risky activities. According to Rotter (Rotter, 1982, 1990), internality and externality are the two poles of a continuum. People with high internal control expect a reinforcement of the outcome of their behavior mainly due to their own decisions and actions (Rotter, 1990). They also have the ability to control their behavior (Zuroff & Rotter, 1995), seek to influence others, and want to know all the information related to the specific situation they are dealing with. On the other hand, people with high external control expect a reinforcement of the outcome of their behavior due to the events determined by powerful others, fate or luck, etc.

Third Principle: Readiness for Change, Openness, and Innovative Mood

Players formulate the information given by cards using their creative mood, try to overcome obstacles, and complete their stories. They can handle the unexpected and find the solution in an imaginative way by making and extending correlations. This way of thinking is generally useful in many situations in which students are not looking for information in an obvious way and in a specific place (Kirriemuir, 2006). In our discussions about the development of their story, we look and discuss why an action or a move of their characters was chosen over another (van der Meij et al., 2020).

It is crucial that any unexpected card suggestion reshapes the development of their story without enticing them to support something, which is not representative of them or their hero's character. Overturning in their script can be characterized as an influence, which means that it is not solely about compliance, but can also lead to innovation. This attitude reflects the genetic model by Moscovici (1976) in the theory of social influence and social change. In the theory of social influence and social change, there are two conflicting models, the functionalist model and the genetic model. In the functionalist model, the individual does not resolve the conflict effectively, and its ability to successfully manage conflict situations is weakened (Moscovici, 2005). In the genetic model, individuals or groups do not conform to the majority view and articulate an alternative argument, manner, or behavior. This means that they are led to unusual correlations or less obvious sideways. It is crucial that they can be detached from preexisting frameworks and evoke new views and perspectives. Students have to consider testing and articulating alternative arguments. Thus, they are open to changes and led to new perspectives.

The purpose of imposing limitations and rules on the card game is to raise discussions in order to invent a strong character. Alternative ways to approach what is a strong, solid, and/or efficient character are mostly found within the wide range of possibilities given by imagination, in the mind level. It is anticipated that the new challenges of the card game awaken the situation awareness. It is a key objective in the S.FI.GA. methodology that students recognize the fact that the ways, in which people interact in situations, as well as the correlation between variables, differ due to the varying context and cannot be practically predicted. The action and reaction have never self-evident consequences.

Storytelling and Creativity Methods

Having the above three principles in mind, we wanted to approach our part of this game from the exact same point of view. Storytelling plays a really crucial role in this game, running through its basic core. The players have to use storytelling and creative writing techniques, in order to create their own characters and stories through the game's process. Therefore, in the storytelling part of the project, we decided to use and connect with StoryLab's (Skills Training for Democratised Film Industries) main methodological tool: ethnomedialogy. Ethnomedialogy is an interdisciplinary approach inspired by ethnomusicology and autoethnography. It involves the active and immersive participation of researchers in the research culture and process, using this active personal engagement as a basis for knowledge generation, data gathering, and evaluation (Knudsen, 2020). StoryLab was created on the notion that filmmaking is not just about cinema. StoryLab is based in the following three core values:

1. Integrity: Integrity points out the fact that the training schemes are mentor-based, in which equality of the relationship between mentor and mentees, professionals and communities, and researchers and participants is an integral part of the nature of discussions and collaborative engagements.
2. Authenticity: Authenticity indicates a commitment to anchoring story development in the feeling, emotional, intuitive, aspirational, dream, memories, and

needs of the individual participants in workshops. No agendas and expectations are set by outside agents, and all stories developed are closely aligned with these core attributes.

3. Openness: Openness signifies the nature of the working space in which professionals, researchers, mentors, participants, mentees, and communities engage with the practical processes of story development. This working space is an open "clean slate" working space in which all participants engage in freshly developed ideation and not predefined narratives or previously ideated projects (Knudsen, 2018).

We believe that this approach can provide all the required tools in order to use these methods of creativity, storytelling, and filmmaking in the educational environment. StoryLab's core values provide us with the necessary tools to approach storytelling from a different and more intimate perspective. They also provide us with more options for our data gathering and evaluation. We also consider that the model that we are developing works as a channel system between the tutors and the students. That is the reason for the development of the card system. The card system allows us to contribute our thoughts and give a "creative push" to the students so that they start developing their stories. Moreover, the act of stating your ideal card with a direct message to the game master can create this environment of integrity between the students and the tutors.

Authenticity is a really crucial part of this pilot experiment. We believe in the power of stories and we believe that the true power of the medium is not trapped in big production companies but inside the ideas and emotions of the writers that do not work following specific motives and requirements of the industry. This idea can help us to research deeper in the true power of storytelling: by analyzing these stories, we can provide a better explanation of the everyday life and emotions of the focus groups we are working with. In an educational environment, this element can be very important for teachers in order to understand the issues and the problems of their students through their stories. Also, the students can use this "open slate" way to create their own stories as a way to release pressure and also to discover their creative side.

The openness point of view that defines the environment of researchers and students working together to create stories is really important especially during the troubled years of the pandemic. This game is designed to work in both physical and digital environments, and its core value is to create an open space for exchanging ideas and thoughts between the students and between the students and the researchers. Even in times of spatial restriction, even such environments, realized on digital platforms, can create a space for creativity and playful improvisation for the students that is really needed.

Game-Based Learning Principles

In the game design part of the project, we implemented game-based learning (GBL) principles to encourage narrative fiction and to structure narrative levels. GBL is differentiated from gamification in that it does not merely utilize game elements, such as progress points and achievement badges, in order to make the task at hand more attractive and thus strengthen players' incentive to engage in it, but rather adopts fundamental game principles, such as rules and structure, or even involves the integration of an intact game, in the learning process, in order to achieve the learning objectives (Plass et al., 2019). In other words, whereas gamification provides the means to embellish nongame activities with compelling game mechanisms, GBL expresses complete strategies to redesign the classroom activities as games.

When redesigning a learning activity to the form and standards of a game, the curriculum is broken down into its basic elements, which are mapped onto game actions and reactions, a system of rules, closed and autonomous, based on choices and consequences (Perrotta et al., 2013). The game mechanics formed within must be carefully chosen to address the intended learning goals. Plass, Homer, and Kinzer refer to the design of such learning interactions within a game as "learning mechanics," which can be effective only when aligned with the learning goals (Plass et al., 2015). In that process, motivation, i.e., the ability of GBL systems to keep learners content and engaged, which is also their most cited benefit, is not the only feature to be considered. GBL can also be seen from a cognitive perspective, which shapes the way content is represented; from an affective perspective, which influences players' emotions; and from a sociocultural perspective, which creates opportunities for social interactions (ibid). The instructor taking up the role of the game designer may move freely along the continuum between gamification and GBL techniques and into the notion of "playful learning" that focuses on the realization of learning experiences as playful tasks designed to include one or more, peripheral or core, game elements (ibid).

We decided to avoid the use of leaderboard-based elements, as they have been sometimes reported to unintentionally produce negative dynamics due to excessive competition between players (Reiners et al., 2014). We also did not want to adopt the full-scale mechanics of a specific game, because it would be too restricting for both students and instructors. Instead we created a hybrid narrative puzzle based on features of two genres: pen-and-paper role-playing games (RPGs) and card games. The former provided the framework for structuring the curriculum into chapters and tasks, whereas the latter added the elements of chance and unpredictability that were responsible for the game's challenging identity.

In the RPG genre, players control a character, who is defined by a set of attributes and a sequence of actions (Miller, 2004). When played with pen and paper, the game is a formalized verbal interaction between a group of players and a referee, with the intention of producing a narrative (Rilstone, 2000). The referee, known as Dungeon Master (DM), controls the fictional world, in which the fictional characters controlled by the players have complete or nearly complete freedom of choice. Both the DM and the players are storytellers: the former is responsible for creating the plot, playing different roles, and providing with challenging tasks, whereas the latter are responsible for pursuing the plot, interacting with the different roles, and carrying out the tasks; the former controls the story in any direction, whereas the latter move in any direction within the story. Thus, the game has no winner or loser; instead players evolve by competing themselves in a dynamic flow of narrative information (Winter & Pickens, 1989).

The instructor acts in a similar way to the storyteller, creating the learning space for learners to explore, providing them with educational tasks, exciting their curiosity, retaining their volition, and ensuring the completion of their objectives (Reiners et al., 2014). Similarly, the game designer is a kind of storyteller as well, a “narrative architect” who sculpts worlds filled with items for players to touch, grab, and interact with (Jenkins, 2004). All possible actions that players can perform in the game world, all possible meanings that game designers imply in their design, constitute the game’s space of possibility (Salen & Zimmerman, 2004). In instructional game design, the game world represents the curriculum to be taught, and the space of possibility ensures that all intended motivational, cognitive, affective, and sociocultural goals are achieved. Educational tasks become challenging quests, and learning progress unlocks the next chapter of the plot. The curriculum units form a chain quest that combines all key experiences of the learning process (Kingsley & Grabner-Hagen, 2018).

Learning Objectives

The basic learning objective of this endeavor refers to overcoming a challenge and furthermore embracing the elements of change, randomness, and unpredictability as the means to creativity and authenticity. “Just Ahead of Me” is proposed as an educational practice of studying characters and their actions. Depending on their content, form, and frame, the narrative elements ignite discussion, raise problematic, and trigger inspiration in the context of a wider classroom attempt to study and understand problems that arise in a world of deep recession, insecurity, and uncertainty about the future. The game-based activity aims to enhance the scriptwriting process by providing students with challenges designed to prevent them from being trapped in narrative biases. The goal is to monitor and study how characters contribute to action but also how action contributes to form characters (Shilomith, 2005). Different categories of acts are identified, such as an order act, an omission act, and a planned act. Motivations, complexes of circumstances, causes, purposes, and impulses are studied (Prince, 1987; Baroni & Revaz, 2016; Bal, 2017).

The card selection system, as the game’s core mechanic, provides the basic nodes of the narration. Players take turns in making the first move. Thus, at the start of each round, a rudimentary guidance is given; however, the story itself is written by the students exercising their freedom within the imposed limits. After completing the game, they are rewarded with supplementary material to study. Time is given for potential additions and changes to their script, triggered by the additional material, which acts as a lever to reexamine their thoughts. The goal for this methodology is to be adopted by students as a creative process, as a generator of activities, which transforms structures, relationships, and behaviors.

Generally, the use of educational games helps students to learn objects and methods and, particularly in our case, to develop problem-solving skills, by using their desire to play (Warren & Dondlinger, 2008). Apart from boosting motivation toward the subject matter, the educational game activities enhance engagement to the learning process by providing students with the opportunity to reinforce previous knowledge, attitudes, and behaviors (Schuch, 2017), representing them in a more comfortable and enjoyable environment (Jackson & McNamara, 2013). In "Just Ahead of Me," a practice is launched that is capable of creating new ways of understanding and acting without the fear of the wrong answer. Through the game we aim to achieve increased students' concentration, attention, observation, as well as the activation of their imagination, curiosity, and critical thinking. The feeling of control is to be alternated with selfless adaptability: acting within one's individual cosmos and unfolding its fate partially due to extrinsic events. The purpose of the cards, of their unexpectedness, is to disrupt, to divert the plot away from its predetermined outcome. The optimal aim for students is to expand their creative thought without being overly influenced by the challenges posed by the cards, i.e., to not completely change their intention and focus on something they do not want to include in their story. On the one hand, they are diverted toward something else that redirects their attention, while on the other they handle the differentiated situation to slightly modify their previously shaped story. It is a kind of experience modeling tool to let the characters and their actions follow the challenging path of the cards.

"Just Ahead of Me" is not a game with narration, but rather a game about narration. We created the setting to be filled with the students' narrations. We divided the curriculum into milestones that represent the key stages of scriptwriting: imagining the main character in a fictional universe; defining the dramatic question, the logline, and the synopsis of the story; formulating the three acts; and adding a turning point right before the end. Milestones were mapped onto game elements: a hero in a specific time and place, equipped with a token and setting off for a quest against an antagonist. These game elements are not just objects for interaction, but rather "lyrical ideograms," sperms of myth, and archetypes acting upon collective imagination (Caillois, 2001). The structure of the narrative is there, waiting to be filled with words, a sequence of symbolic actions waiting for learners to form their own awareness of it.

Kapp defines a vicarious experience through four elements: characters, plot, tension, and solutions. From a pedagogical perspective, these are mapped, respectively, onto learners, narrative, milestones, and learning objectives (Kapp, 2012). In a game system, the activity connecting all these threads is to make choices and to take actions in a way that is meaningful (Salen & Zimmerman, 2004). Constructing meaning does not necessarily depend on a positive outcome. GBL systems provide learners with a safe environment to experiment, try out ideas and strategies, repeat and optimize their actions, and of course fail in the process. In that sense failure is widely considered to be an advantage for the learner and therefore encouraged by the game designers (Reiners et al., 2014). Failure is an opportunity for improvement (McGonigal, 2011). Challenge is also crucial for the game's learning outcome. Researchers of Csikszentmihalyi's flow theory (1990) have argued that the interaction between challenging tasks and applied skills is a predictor of engagement and as such has a both direct and indirect positive effect on perceived learning (Hamari et al., 2016).

We aligned with the GBL principles mentioned above and designed the game so that choice making is a fundamental element of the game's mechanics. We used cards to define the space of possibility and a turn-based selection system to create some competition. In essence, players do not compete with each other, but with themselves: once their intended card is lost to another player, they have to quickly redesign the plot of their story to match a card that is still available on the deck; if they are the last to select, they will need to cope with the only card left. Each encounter with a game object may lead to a radical change of state. The challenge to predict the outcome and the potential failure in keeping everything under control become essential parts of the gameplay.

Research Methodology

A significant aspect of the proposed storytelling approach is the way in which the data was collected and processed. Based on Prof. Erik Knudsen's paper "Research Glossary For Creative Practitioners A Discussion Paper," we based our data collection, outcomes, and impact of this research on a combination of traditional methods such as surveys with audiovisual data collection (Knudsen, 2016). Our experiment was conducted in two phases: the first one comprised playing the game and then filling in an evaluation questionnaire, whereas the second one took place 5 days later and included semi-structured interviews. Qualitative data were collected from both sessions through video and audio recordings that monitored the participants' responses and body language during all stages of the process (see Appendix). The main impact of the research was captured through the questionnaire, which used a 1–5 Likert scale for quantifying the students' qualitative feedback, whereas the semi-structured interviews elaborated further on the preliminary results. Moreover, the stories themselves, the final artistic outcomes delivered by the players when completing the game and in some cases further processed between the two phases, constitute an additional pool of data. This cross-disciplinary approach of data collection provided the necessary information to refine the final design of our game and address it to specific learning groups.

More specifically, the group of research participants consisted of eleven (11) students, 7 male and 4 female. During the first phase, one participant had to leave due to an emergency; thus he was excluded from the process. The authors moderated the sessions by explaining the rules of the game, controlling the sequence of timed events, providing any necessary clarifications in each round, and conducting the interviews. All protocols for processing personal data were followed. In the first phase, the actual game lasted for 2.5 hours, whereas in the second phase, the participants were separately interviewed for 10 minutes each. Both sessions took place online.

The main purpose of the evaluation process was to collect data that will facilitate the optimization of the design process. In the first evaluation phase, the researchers designed the EQ with ten statements revolving mainly around two issues: the emotional response to the game and the completion of the learning objective through its core mechanic. The statements were formulated in a mixed positive and negative way to protect from wild-card guessing. The participants were asked to use a 1–5 Likert scale ranging from "strongly disagree" to "strongly agree" in order to assess their experience in terms of the following statements:

- I enjoyed the game.
- The game was difficult to complete.
- The process was useful for the development of the script.
- The cards did not help to trigger my imagination.
- The card picking system helped my scriptwriting process.
- The cards did not provide enough options.
- The cards addressed enough topics.
- The required time for each round was not enough.
- The online version of this game was satisfactory.
- I would participate again in an interactive scriptwriting game.

The post-evaluation phase consisted of semi-structured interviews aimed at providing clarifications on the EQ results. The questions, which served as the basis for the interviews, addressed the participants' comments and suggestions on the experience, whether they further developed their story, whether they studied the complementary material, and how they would use such a game in the classroom. Depending on the answers, the interviewers dynamically adjusted the course of the interviews and prompted the participants to further elaborate on their thoughts in order to shed light on specific issues in focus.

Game Description

The rules of "Just Ahead of Me," presented to the players at the beginning of the game, are:

- The game is completed in seven rounds.
- In each round players select one card each.
- Only in the first round players select three cards without any restrictions.
- Prior to their selection, players must decide within 2 minutes and send in a private message to the game moderator the card they intend to select.

- The selection process takes place openly.
- The selection order is defined randomly at the start of the game and is shifted one step each round.
- Every card can be selected only once; then it is no longer available.
- Within specific time after making their selection, players must create and send to the game moderator a text subject to each round's specifications.
- The text must be connected to the respective card.
- After completing the game, players gain access to supportive material and fill in an evaluation questionnaire about their experience.
- At a later time, players will participate in a semi-structured interview to discuss their experience.

The order for the selection of the cards was set at the beginning of the game by rolling online digital dices. In the first round, players have to choose three cards to describe the main protagonist of their story. It is only in this round that the players do not have to worry about someone else picking their ideal choices first. The available cards are:

1. Powerful
2. Shy
3. Obsessive
4. Clumsy
5. Cold
6. Reckless
7. Charming
8. Arrogant
9. Stubborn
10. Guiltful
11. Sensual
12. Consistent

For the first deliverable, the players need to complete in 10 minutes a psychological profile for their main hero. This profile is a questionnaire provided by the game masters. When they finish with the psychological profile, they gain access to supporting material that will help them to complete the next round. The first supporting material they gain access is a lecture about Aristotle's poetics in modern screenwriting (see Appendix).

In the second round, the players need to choose the beginning of their story and place their hero in time and space to start their narration. The available options are:

1. Dead end
2. Shopping window
3. Square
4. Basement
5. Office
6. Desert
7. Boat

8. Refuge
9. Cafeteria
10. At the doctor's
11. Hall

After secretly sending their ideal card choice in a direct message to the game master, the card selection process takes place. Every card that is selected is removed from the deck. As their second deliverable, the players have 10 minutes to create a document with the description of their story's universe. They need to contain information of the era, time characteristics, social contracts, and other elements in 1 paragraph of minimum 75 words. When finished they gain access to the new supporting material, which is a lecture regarding Vogler's approach of the "Hero's Journey" (see Appendix).

In the third round, the players have to define the main problematic that drives their narrative forward by choosing one from the following cards:

1. Lack
2. Secret
3. Boundaries
4. Duty
5. Right
6. Conquest
7. Beauty
8. Attention
9. Safety
10. Obstacle
11. Pleasure

Same process takes place here as in all other rounds: the players communicate to the game master their ideal choice via direct message and then select their actual cards according to the selection order. As this round's deliverable, they need to provide the "dramatic question" of their story in 5 minutes. The dramatic question represents the main problem of their hero. When this question is answered, the story finishes. Upon completion of their task, they gain access to a lecture about Carl Jung's collective unconscious and archetypes in (see Appendix).

In the fourth round, the players have to choose one token that will help them to answer their dramatic question. The choices are the following:

1. Keys
2. Bag
3. Cage
4. Book
5. Rope
6. Talisman
7. Picture
8. Pills
9. Clock

10. Glasses
11. Cellphone

The deliverable of the fourth round, for which they have 10 minutes, is a logline. The logline is the shortest description (one or two sentences) of their whole story. They need to refer to the story's protagonist and to the main issue and then provide a "hook" to excite the audience's interest. As soon as they finish, they gain access to a 13-minute tutorial explaining the power of symbols and tokens in the film *Parasites* (2019) (see Appendix).

In the fifth round, the players have to decide for the main feature of the hero's antagonist. This element is really important for the next stages of this game and will help them finish the narration of their story. The card choices are the following:

1. Patron
2. Mask
3. Nightmare
4. Boredom
5. Enigma
6. Contempt
7. Fall
8. Change
9. Coincidence
10. Authority
11. Mirror

After the card selection process, the players have 10 minutes to create the synopsis of their story. For the synopsis we require a much more detailed description of the final story. The minimum length is 1 paragraph of 75 words. After the players send their synopsis, they gain access to three articles regarding Martha Rosler's photography (see Appendix).

In round six the players have to decide for the core element of their hero's final test. The available choices they have are:

1. Pause
2. Letter
3. Dagger
4. Defeat
5. Teddy bear
6. Money
7. Journey
8. Fire
9. Perfume
10. Envelope
11. Jewel

As their deliverable, the players have 20 minutes to create a narrative description in three acts. They need to deliver three paragraphs, each one dedicated to one act of their story. This material provides us with the full picture of their story's beginning, middle, and end. After that the players have access to a 1.5-minute recorded video of a platform-type video game (see Appendix).

In the final round, the players come across something unexpected. They do not need to select a card, since all options are the same for everyone: 11 cards with "turning point" written on them. Thus, the players need to think of the final climax of their story, but instead of ending it, they have to come up with a turning point. They have 10 minutes to write a paragraph describing that unexpected final event added just before the end. The final turning point is quite substantial for a story, since it can intensify the viewers' attention or make them completely lose their interest.

Discussion of Results

Phase 1: Evaluation Questionnaire

The first phase of the result analysis dealt with the data collected from the evaluation questionnaire (EQ) that was filled in by the participants in the first experimental phase right after the completion of the game. The use of the Likert scale to codify the degree of their agreement or disagreement with the statements under examination facilitated the quantification of their qualitative feedback. First, the evaluation scores of the negatively formulated statements were inverted to match the scaling of the positively formulated ones. Then, the mean average score of each statement was calculated. The highest rating (4.1/5.0) was observed in the "I enjoyed the game" and "I would participate again in an interactive scriptwriting game" statements. Particularly regarding the enjoyment indicator, all participants except for one agreed or strongly agreed that they enjoyed the game. Both these statements constitute a finding, which indicates that in general the participants accepted the game very positively as a pleasant experience that would interest them in the future as well. The statements "The process was useful for the development of the script" and "The online version of this game was satisfactory" were rated also highly with a mean of 3.9 suggesting that the methodological approach was successful in terms of the educational goal set by the researchers, whereas the lack of physical presence did not impede the actual process. This finding can contribute to the discussion on utilizing both game principles and online technologies to design efficient educational programs. Further statements that can be interpreted as positive, since they scored a mean of 3.0/5.0 and above, are "The cards did not help to trigger my imagination" (3.7 in inverted form), "The card picking system helped my scriptwriting process" (3.5), and "The cards addressed enough topics" (3.0). These results imply that the core essence of the game's mechanics, i.e., taking alternating turns to select unique cards that serve as the fundamental knots for the narrative structure, did indeed play a beneficial role in exciting the participants' creative skills. Last, three statements, namely, “The required time for each round was not enough,” “The game was difficult to complete,” and “The cards did not provide enough options,” ranked below a mean average of 3.0/5.0 (2.8, 2.6, and 2.6 in inverted form, respectively). A t-test analysis was performed to compare the means of each one of these statements against the respective means from the “enjoyment,” “imagination,” and “scriptwriting process” indicators. No significant difference ($p > 0.05$) was found between any of these data sets.

The basic gameplay mechanism that was utilized by the authors to stimulate the players’ creative thought by forcing them to adjust the predetermined momentum of their story to the dynamically changing circumstances of the game’s unpredictable unwinding is the fact that depending on the selection order of each round, they may not get the card of their choice. The ratio between the amount of times that a player selected the card they initially wanted and the total amount of times that they made any card selection was defined as “successful selection ratio” (SSR) and calculated from the players’ deliverables. It turned out that only 17 out of 50 times (10 players x 5 selections each) did players actually end up with the cards they wanted resulting in a 34% SSR. This rather low percentage combined with the high rating of the enjoyment indicator suggests that the difficulty in controlling all aspects of the storyline does not thwart the positive feelings derived from the experience. On the contrary, it may be interpreted as a contributing factor to the positive evaluation of the statements regarding the card selection process and its effect on players’ creativity. Unfortunately, since the SSR data was collected from the players themselves during the game and not from the anonymous EQ, no further correlations could be explored between the SSR factor and individual indicators. This issue will be addressed in future research implementations.

The scope of this research was not to test the efficiency of a methodology in its whole, but to extract some preliminary results that will help optimize its design. Even though the number of participants and of the involved statements is limited, the findings provide useful insight for refining the game’s aspects. According to the assessment and the analysis conducted, the high-rated elements of the game appear to have had a positive impact on players’ creativity, yet the exact nature of that impact is not clear. Similarly, the low-rated elements seem to have been perceived as exciting challenges rather than frustrating difficulties, yet the data collected from the first experimental phase alone do not suffice to support this generalization. The second experimental phase provided essential qualitative data to further elaborate on the ways that the game’s structure and plot contributed to the completion of its educational goal.

Phase 2: Semi-structured Interviews

The second experimental phase included semi-structured interviews of the game participants. The most salient finding is that all subjects (10/10) referred to the game as a very helpful means to coming up with ideas and structuring them into a narrative. The card selection mechanic seems to have played a vital role in this process. According to the participants' comments, the restrictions posed by the cards' content helped them think in a fast and spontaneous way, whereas losing a desired card to someone else and having to adapt to the content of a new card motivated them and pushed them to find other options, go deeper into their story, and change their plan entirely or build on their initial concept by adding details that they wouldn't have thought of. One student reported that getting a different card than planned proved actually better for her story; another one even stated that he was a bit disappointed when getting the card he initially wanted. Comments like "Every time I have to change my story again and again but I like it! This helps me challenge myself" and "I would never have written something like that if it wasn't for this project, but I am very happy this happened, because I was forced to think of this" suggest that the game's mechanism facilitated the participants to question their limits and transcend themselves to draw their ideas.

Another commonly mentioned issue is the constraint of time. Half of the players (5/10) characterized the game as stressful due to the limited time for completing the tasks at hand, and one of them felt that she did not have enough time to deliver a complete story. However, all these players also claimed that this condition was fruitful, fun, and challenging. They felt motivated to make quick decisions that led them to imagine and finish their story in a short time. Some participants felt this time pressure throughout the whole game, while others only in specific parts of it, such as in building the hero's psychological profile or deciding which card to choose. Time management was mentioned by another player as well, but in a different way: he thought that the game had a slow flow caused by the poor coordination of timed events.

Only one player made changes to his story after the end of the game. He did not change any of his cards, but rather interpreted one of them in a slightly different way. He told the interviewers "This whole time I had the story on my mind." Some of the other subjects made very specific that they felt no need to concern themselves again with the same stories, since they were the outcome of a spontaneous brainstorming in the context of a game, which is now over, and they actually work as they are. Still, three participants are interested in further developing their works in the near future. Four participants studied the complementary material that was provided as reward after the game's completion and said it gave them food for thought about their story. Two participants suggested changes in the game itself: one asked for the addition of game elements, such as more dice rolls for extra cards, and the other for breaking down the game's structure into more rounds. Last, all participants that were asked agreed that the game can be used in formal education, because it is fun, interactive, and well-structured, yet some pointed out that special consideration must be paid to the subject matter, and the long-term commitment required from the players.

Conclusion

The digital game "Just Ahead of Me" was designed to enhance the scriptwriting process through playful learning and then tested for optimization and integration into the S.FI.GA. filmmaking methodology. Principles of game-based learning and film studies were combined resulting in a hybrid narrative role-playing card puzzle, which guides players through the key stages in composing a storyline. A turn-based card selection system was applied as the core learning mechanic aimed to train players in using their imagination to confront the unexpected.

In terms of the game part, subjects agreed that it was a fun and helpful experience that pushed them to quickly come up with ideas. Gameplay mechanisms such as the limited time, the card options, and the interactivity of the selection process did not thwart their creativity, but instead were accepted as challenges that motivated them to elaborate on their thoughts. Regarding the storytelling part of the game, it is really important that all participants managed to produce a complete story as their final outcome. This element is crucial for story ideation, in order to transcend predetermined models or industry trends and develop a narrative through emotional expression and fruitful thought in an open environment.

Based on the results of this research, the authors intend to add more game elements, such as rolling the dice at the start of every round. The rounds themselves can focus in more depth on aspects of storytelling, such as the existence of a strong opponent. Further ways of interaction between players, such as collaborative tasks or attacks on cards, will be investigated. More participants will expand our research sample and allow for more valid results. Last but not least, the therapeutic and social aspects of the project will be explored. We shall attempt to study students' stories that address various addiction issues. Opponents will be created by asking students to assign them with opposed social characteristics to the ones of their heroes. Stories will be created, in which the hero will have to face groups of people and either comply with their own point of view as a necessary choice to invoke social change or decide that the denial of the majority view is a proof of their innovative process of thinking and not simply a misconception of reality.

Appendix

Complementary Material

- Round 1: lecture about Aristotle's poetics in modern screenwriting: https://drive.google.com/file/d/1O1x595rDpZKxnhSvN5TAqFy-b9lE4ZNO/view?usp=sharing
- Round 2: lecture regarding Vogler's approach of the "Hero's Journey": https://drive.google.com/file/d/1wSirgPHZdf3_oewcwTyrx9pAFMw2PLjk/view?usp=sharing

- Round 3: lecture about Carl Jung's collective unconscious and archetypes in scriptwriting: https://drive.google.com/drive/folders/1YE8S1cUMpd2cW8KW6VL8yLeUao4eSUw6?usp=sharing
- Round 4: tutorial on the power of symbols and tokens in the film *Parasites* (2019): https://drive.google.com/file/d/1Vn4UEz29MfSOBTyP75md6Q8Q4qq4LCti/view?usp=sharing
- Round 5: articles regarding Martha Rosler's photography: https://drive.google.com/drive/folders/1LsSEqj3QP_19DYlxCEai66wnI1ajd4zN?usp=sharing
- Round 6: video game: https://drive.google.com/drive/folders/1H5xZcptOulVUkLmnlvlEVlZgVIxoRYXP?usp=sharing

Video Recordings

- Session 1: Game https://vimeo.com/500553092/9bf81f33b9?fbclid=IwAR1evD3HHY7PUAhPicoAHARpHNR3Tl5us2_oeejEYM3ZDuW8lxVyoTECELI
- Session 2: Interviews https://vimeo.com/500603307/289397a41b?fbclid=IwAR0pmu2pTb5qSrStX65ogFAtieTRmfGDMhalkaC9AKsAbFonz_ntsHtnlOI

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Correction to: The Role of Instructional Activities for Collaboration in Simulation-Based Games

Kirsi Syynimaa, Kirsi Lainema, Raija Hämäläinen, Timo Lainema, and Tiina Lämsä

Correction to:
Chapter 2 in: L. Daniela (ed.), *Smart Pedagogy of Game-based Learning*, Advances in Game-Based Learning, https://doi.org/10.1007/978-3-030-76986-4_2

This book was inadvertently published with author information instead of abstract online in Chapter 2.

This has now been updated online as follows:

The success of today's society and work life depends on possibilities to create novel procedures to forward workplace learning. In this chapter, we examine the role of instructional activities facilitating collaboration in game-based learning (GBL) and discuss the role of instructional activities promoting collaboration in the context of simulation-based game environments. In collaborative learning settings, such as GBL, the teacher's role is associated with planning and organising learning circumstances in which collaborative and inspiring group work may arise. The study at hand presents analyses of real-time audio and video data collected in an authentic GBL setting. Our qualitative content analysis points out several noteworthy pedagogical aspects regarding game-based teaching and learning. The findings indicate that pre-game instructional activities promoted collaboration in relation to adopting roles and responsibilities, building a common understanding, expediting decision-making processes, initiating meaningful communication and increasing knowledge sharing and co-creation. Furthermore, during game instructional activities promoted

The updated version of this chapter can be found at https://doi.org/10.1007/978-3-030-76986-4_2

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participants' game collaboration by directing the participants' attention to important aspects, by facilitating team members' equal participation, by fostering and maintaining rich and dialogical communication and by reflecting on team performance in comparison to other teams. The study concludes that simulation-based games in work contexts have potential to serve both as an environment in which to learn work life skills (such as collaboration) and as a platform for illustrating the concept of sustainable learning. In the future, studies need to focus on GBL as a possibility to create and proliferate sustainable approaches to workplace learning.

Correction to: Serious Film Games (S.FI.GA.): Integrating Game Elements with Filmmaking Principles into Playful Scriptwriting

Agnes Papadopoulou, Emmanouel Rovithis, and Iakovos Panagopoulos

Correction to:
Chapter 13 in: L. Daniela (ed.), *Smart Pedagogy of Game-based Learning*, Advances in Game-Based Learning,
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This book was inadvertently published with incorrect spelling of the author's name in Chapter 13 and the preface of the front matter. We have now updated the author's name in Chapter 13 and in the preface as 'Emmanouel Rovithis'.

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