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Xiaowen Fang (Ed.)

HCI in Games

First International Conference, HCI-Games 2019
Held as Part of the 21st HCI International Conference, HCII 2019
Orlando, FL, USA, July 26–31, 2019, Proceedings

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Foreword

The 21st International Conference on Human-Computer Interaction, HCI International 2019, was held in Orlando, FL, USA, during July 26–31, 2019. The event incorporated the 18 thematic areas and affiliated conferences listed on the following page.

A total of 5,029 individuals from academia, research institutes, industry, and governmental agencies from 73 countries submitted contributions, and 1,274 papers and 209 posters were included in the pre-conference proceedings. These contributions address the latest research and development efforts and highlight the human aspects of design and use of computing systems. The contributions thoroughly cover the entire field of human-computer interaction, addressing major advances in knowledge and effective use of computers in a variety of application areas. The volumes constituting the full set of the pre-conference proceedings are listed in the following pages.

This year the HCI International (HCII) conference introduced the new option of "late-breaking work." This applies both for papers and posters and the corresponding volume(s) of the proceedings will be published just after the conference. Full papers will be included in the *HCII 2019 Late-Breaking Work Papers Proceedings* volume of the proceedings to be published in the Springer LNCS series, while poster extended abstracts will be included as short papers in the HCII 2019 *Late-Breaking Work Poster Extended Abstracts* volume to be published in the Springer CCIS series.

I would like to thank the program board chairs and the members of the program boards of all thematic areas and affiliated conferences for their contribution to the highest scientific quality and the overall success of the HCI International 2019 conference.

This conference would not have been possible without the continuous and unwavering support and advice of the founder, Conference General Chair Emeritus and Conference Scientific Advisor Prof. Gavriel Salvendy. For his outstanding efforts, I would like to express my appreciation to the communications chair and editor of *HCI International News,* Dr. Abbas Moallem.

July 2019 Constantine Stephanidis

HCI International 2019 Thematic Areas and Affiliated Conferences

Thematic areas:

- HCI 2019: Human-Computer Interaction
- HIMI 2019: Human Interface and the Management of Information

Affiliated conferences:

- EPCE 2019: 16th International Conference on Engineering Psychology and Cognitive Ergonomics
- UAHCI 2019: 13th International Conference on Universal Access in Human-Computer Interaction
- VAMR 2019: 11th International Conference on Virtual, Augmented and Mixed Reality
- CCD 2019: 11th International Conference on Cross-Cultural Design
- SCSM 2019: 11th International Conference on Social Computing and Social Media
- AC 2019: 13th International Conference on Augmented Cognition
- DHM 2019: 10th International Conference on Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management
- DUXU 2019: 8th International Conference on Design, User Experience, and Usability
- DAPI 2019: 7th International Conference on Distributed, Ambient and Pervasive Interactions
- HCIBGO 2019: 6th International Conference on HCI in Business, Government and Organizations
- LCT 2019: 6th International Conference on Learning and Collaboration Technologies
- ITAP 2019: 5th International Conference on Human Aspects of IT for the Aged Population
- HCI-CPT 2019: First International Conference on HCI for Cybersecurity, Privacy and Trust
- HCI-Games 2019: First International Conference on HCI in Games
- MobiTAS 2019: First International Conference on HCI in Mobility, Transport, and Automotive Systems
- AIS 2019: First International Conference on Adaptive Instructional Systems

Pre-conference Proceedings Volumes Full List

1. LNCS 11566, Human-Computer Interaction: Perspectives on Design (Part I), edited by Masaaki Kurosu
2. LNCS 11567, Human-Computer Interaction: Recognition and Interaction Technologies (Part II), edited by Masaaki Kurosu
3. LNCS 11568, Human-Computer Interaction: Design Practice in Contemporary Societies (Part III), edited by Masaaki Kurosu
4. LNCS 11569, Human Interface and the Management of Information: Visual Information and Knowledge Management (Part I), edited by Sakae Yamamoto and Hirohiko Mori
5. LNCS 11570, Human Interface and the Management of Information: Information in Intelligent Systems (Part II), edited by Sakae Yamamoto and Hirohiko Mori
6. LNAI 11571, Engineering Psychology and Cognitive Ergonomics, edited by Don Harris
7. LNCS 11572, Universal Access in Human-Computer Interaction: Theory, Methods and Tools (Part I), edited by Margherita Antona and Constantine Stephanidis
8. LNCS 11573, Universal Access in Human-Computer Interaction: Multimodality and Assistive Environments (Part II), edited by Margherita Antona and Constantine Stephanidis
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21. LNCS 11586, Design, User Experience, and Usability: Practice and Case Studies (Part IV), edited by Aaron Marcus and Wentao Wang
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23. LNCS 11588, HCI in Business, Government and Organizations: eCommerce and Consumer Behavior (Part I), edited by Fiona Fui-Hoon Nah and Keng Siau
24. LNCS 11589, HCI in Business, Government and Organizations: Information Systems and Analytics (Part II), edited by Fiona Fui-Hoon Nah and Keng Siau
25. LNCS 11590, Learning and Collaboration Technologies: Designing Learning Experiences (Part I), edited by Panayiotis Zaphiris and Andri Ioannou
26. LNCS 11591, Learning and Collaboration Technologies: Ubiquitous and Virtual Environments for Learning and Collaboration (Part II), edited by Panayiotis Zaphiris and Andri Ioannou
27. LNCS 11592, Human Aspects of IT for the Aged Population: Design for the Elderly and Technology Acceptance (Part I), edited by Jia Zhou and Gavriel Salvendy
28. LNCS 11593, Human Aspects of IT for the Aged Population: Social Media, Games and Assistive Environments (Part II), edited by Jia Zhou and Gavriel Salvendy
29. LNCS 11594, HCI for Cybersecurity, Privacy and Trust, edited by Abbas Moallem
30. LNCS 11595, HCI in Games, edited by Xiaowen Fang
31. LNCS 11596, HCI in Mobility, Transport, and Automotive Systems, edited by Heidi Krömker
32. LNCS 11597, Adaptive Instructional Systems, edited by Robert Sottilare and Jessica Schwarz
33. CCIS 1032, HCI International 2019 - Posters (Part I), edited by Constantine Stephanidis

34. CCIS 1033, HCI International 2019 - Posters (Part II), edited by Constantine Stephanidis
35. CCIS 1034, HCI International 2019 - Posters (Part III), edited by Constantine Stephanidis

http://2019.hci.international/proceedings

First International Conference on HCI in Games (HCI-Games 2019)

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The full list with the Program Board Chairs and the members of the Program Boards of all thematic areas and affiliated conferences is available online at:

http://www.hci.international/board-members-2019.php

HCI International 2020

The 22nd International Conference on Human-Computer Interaction, HCI International 2020, will be held jointly with the affiliated conferences in Copenhagen, Denmark, at the Bella Center Copenhagen, July 19–24, 2020. It will cover a broad spectrum of themes related to HCI, including theoretical issues, methods, tools, processes, and case studies in HCI design, as well as novel interaction techniques, interfaces, and applications. The proceedings will be published by Springer. More information will be available on the conference website: http://2020.hci.international/.

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Game Design

A Design of Multifunctional Interfaces to Control Game Screens

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Abstract. Due to the great potential that technological games have regarding interactivity, motor and cognitive development, as well as the notable advances of the technological society, traditional games have been replaced. It was analyzed how object design can connect with new areas like multimedia to create a higher level of interactivity in the games through tangible interfaces to support learning processes based on sensory development. For this study, the researcher has developed games based on multimedia for an audience from six to nine years of age. The games seek to teach the concept of competitiveness.

Keywords: Interactivity · Multimedia · Playability · Children · Interfaces

1 Introduction

According to Paredes (2003), playing games is considered to be a very important activity in the development of human beings in all stages of their lives. It is also considered to be an activity connected with entertainment that uses intelligence while skills are being developed. For this reason, it has become a means of socialization, expression, communication, and development.

On the other hand, Bravo (2005) affirms that multimedia, from a didactic viewpoint, is a surprisingly potential resource, considering it allows interaction with all the currently existing communication systems. For this reason, it contributes to the learning process and knowledge construction. Similarly, Morón and Aguilar, in their Multimedia in Education article (1994) argue that multimedia elements facilitate and strengthen the dissemination of information through the high level of interaction with users they generate.

This research presents the process of designing multimedia toys, so as to improve the level of interaction with users by incorporating multimedia elements through tangible interfaces which may support a kind of learning based on sensorial activities, besides looking for teaching users the concept of competitiveness. By using a microcontroller board called Makey Makey, which simulates direction and selection commands that allow you to take these commands to a screen it is connected to, tangible interfaces can be generated. The use of these open interfaces allows users to both increase their motivation for learning in a more active environment and improve their interaction with toys.

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2 Concept

Considering we belong to a technological society which keeps moving forward, being able to introduce new ways of interaction with objects has become indispensable in the field of toy design. For this reason, the incorporation of multimedia in toy design is an alternative to increase interaction with users.

This project's aim focuses on designing toys using multimedia as a support element for children's learning and development by working on their senses and letting them experience new ways to play. This work proposes a type of control which may both adapt itself to different kinds of games and let users change the level of complexity depending on how the remote control is used.

To exemplify this, two proposals of toys which strengthen children's physical and cognitive skills have been developed. In the first case, the idea is to provide users with more command options so that the game activity be more interactive and may adapt itself to as many games using basic commands as possible and, at the same time, may vary and project new game ideas. In the second case, the command options are limited to two buttons which users can control with swinging movements as required by the game on screen.

3 Development

3.1 User

In order to develop these toys, it was necessary to determine the age of the user for whom the products were intended, this being the reason that a field study was carried out and an analysis of both how the game activity occurs in the different stages of human beings' lives and which its main characteristics are was made. It was then determined that an estimated age range of children who would use these proposed products was 6 to 9, considering the fact that at this age users meet certain characteristics that may be strengthened by using the products that have been proposed, Besides, they are in a stage of their lives in which they have to develop their empathy with other children of their age, this being the reason that it is important they learn the meaning of winning and losing through competition games.

3.2 Multimedia Learning

Bedolla's writings about Human Senses and Product highlight the importance of senses in learning. She states that senses are the basis of all knowledge. She also affirms that all information is firstly perceived by the senses and then it is changed into the paths of access to the understanding of the surrounding environment. On the other hand, multimedia is one of the most interactive means by which users may experience the integration of all forms of expression in a coordinated and dynamic way. After analyzing all these concepts, it was decided that it is convenient to take advantage of these characteristics of multimedia and make them work together with the users' senses, so as to generate their learning and development.

4 Materials

4.1 Makey Makey

This is a microcontroller board which functions as an electric closed circuit. It allows, through electrical contacts, to control selection and direction commands in a computer this is connected to. With the purpose of improving interactivity, it was decided to vary the ways of playing with toys by developing two command options which may adapt themselves to different games that are available to the user's imagination.

4.2 Buttons

The material used to build this toy's structure was wood with a 4 mm layer of MDF. The buttons were made of two 10-mm wide Eva rubber plates separated by an acrylic plate. The necessary wiring was installed in the interior of the toy in a way that it allows the receiver to operate. Led lights were placed on each corner of the buttons. These lights turn on when in contact with the Eva rubber plates. In the interior of the toy we find a signal transmitter connected to the led lights, the button, and a copper antenna located to the sides of each button (Fig. 1).

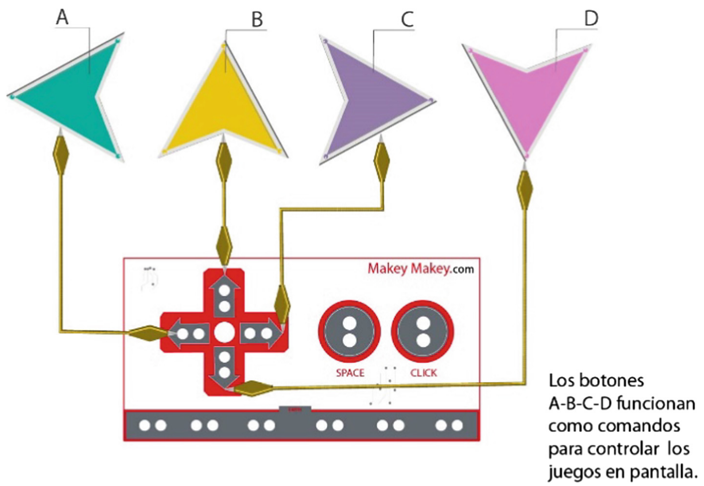

Fig. 1. Conexión de los botones al Makey Makey

4.3 Rocker Arm

The materials used to construct this toy were a 12-millimeter acrylic plate for the rocker arm; the base was a 9-millimeter MDF board covered with Eva rubber to protect the wires which are directly connected to a computer and the Makey-Makey (Figs. 2 and 3).

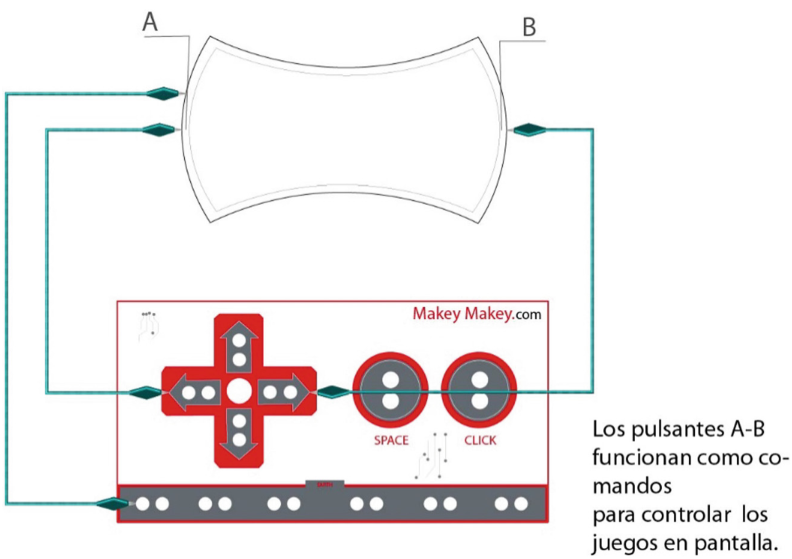

Fig. 2. Conexión del Balancín al Makey Makey

Fig. 3. Interacción Usuario Objeto

5 Aplicaciones

The applications of each control have been designed by considering the users' characteristics and skills and taking into account their physical abilities at school age. Each toy may be connected to an Android mobile device through a USB OTG adapter, which provides more versatility of use and more game options. To exemplify each toy's applications, a Friv Games platform has been used. This offers more than 250 online games which use basic and simple commands for their actions. Besides, users can decide which controls to use, as well as the arrangement and complexity of the game (Fig. 4).

Fig. 4. Online Friv games

5.1 Application 1 - Buttons

The buttons developed are based on 4 buttons that may control any game that uses direction, selection, and, among other options, keyboard commands. In order to improve this interaction, a wireless-button option was proposed. A transmitter which, when pressed, sends a signal to both the receiver connected to the Make Makey plate and the computer was placed in each button (Fig. 5).

Fig. 5. Arrangement of buttons

Each button has an antenna that amplifies signals and allows a range of distance from the receiver of up to 5 m. For this reason, users may play in different ways, change the arrangement of the pieces and, in turn, change the level of complexity of the game. All this has been developed by taking into account the users' skills and favoring the children's cognitive and physical development (Fig. 6).

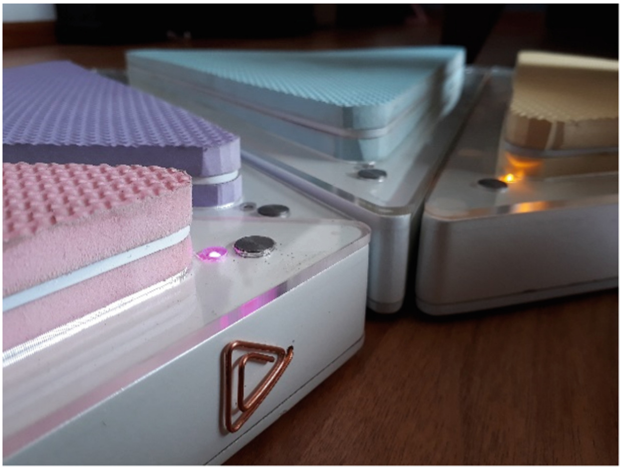

Fig. 6. Signal amplifier antenna

5.2 Application 2 - Rocker Arm

For the development of this toy, a similar concept was applied; that is, the users' skills were considered, as well as the idea that the toy can be used to help children improve their coordination, concentration, and attention. In this case, the command options are limited to two buttons which are directly connected to the computer and the Makey Makey. This toy allows children to activate buttons and control the screen game with body movements.

Fig. 7. User-object interaction

Fig. 8. Rocker arm

6 Results

The results of this research have shown that the proposed multimedia toys increased the users' interactivity. Besides, it was confirmed that the incorporation of these multimedia elements into conventional toys may be beneficial for children's development and learning.

The incorporation of open interfaces has allowed us to realize that the creation of a game platform for the use of these products is not necessary, but rather has shown us that these products may adapt themselves to different types of existing games and to users' characteristics and skills, leaving the use and distribution of toys and the complexity of interaction that users may be able to get at their convenience (Figs. 7 and 8).

7 Conclusion

Playing games is extremely important in all stages of a human being's life. It implies having not only physical activity but also mental activity. Consequently, it is an excellent means for people's physical and cognitive development. On the other hand, taking advantage of the great potential multimedia has to offer as a didactic tool, it may be linked to a type of game activity that can lead to the development of much more active toys.

This research project has allowed us to develop multimedia toys which may offer a much more dynamic and interactive experience through the multiplicity of toys that are available to users. These kinds of toys offer many other benefits, like for example the development of skills, creativity, imagination, and learning through the senses, among others.

The design of these two products is centered on the user-toy interaction design, not on the design of game platforms. But it is important to state that this interaction may be applied to other different fields of education, like for example medicine, therapy, among others.

Acknowledgments. We present our gratitude to the people who shared their knowledge with us and helped us do this research. We specially thank Designer Danilo Saravia for all the support he gave us.

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Who Is at the Center?: Designing Playful Experiences by Using Player-Centered Approach

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Abstract. In this article, I examine the player-centered design philosophy and how it is suitable to create playful experiences. Many scholars and designers employ this approach to enhance the user experience by incorporating game-like characteristics into their design. By getting help from the concept of implied player, I argue that the player is not at the center, but the designers who envision how the players play their game occupy that space in the player-centered design approach. I believe the player-centered design approach is suitable for playful experience design. However, the designers must give users the freedom because, without it, the center of the design that is reserved for the player becomes their prison. Playfulness is an attitude that flourishes when the user has the freedom to express themselves and interact with the design without limitations. To restore the original purpose of the player-centered design philosophy, I get help from sandbox games that offers an open-ended experience to the players. By using the sandbox game characteristics as the starting point, I propose to make playful experiences by removing the implied user from the player-centered design and leaving the center empty so that people may have the freedom to interact playfully.

Keywords: Playful experience · Player-centered design · Implied user · Sandbox games

1 Introduction

We shape technology to assist us, help us, and take care of the things that we don't want to waste time on. We use computers for our works and daily lives, we have our smartphones with us, they are more than portable computers, they are our companions. Playfulness is the attitude that allows users to connect with the activity or object emotionally, although the designed thing is functional or goal-oriented experience [26, p. 27]. The experience that contains playful elements motivates the users more because it is not only about achieving something but having fun during the activity.

Many scholars and designers add game elements to their design to make it more playful. The resulting experience that they want to achieve is transferring play characteristics into nonplay activity, which will lead to a play-like activity but not play. Playfulness is neither the subset of play nor the weaker version of it. As a user experience designer in the gaming industry, I have witnessed many times people using

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playfulness as the carrot on the stick to motivate players with the activity and to make the mundane task fun. Playfulness is not a simple design characteristic that a designer picks from games and transplant into other objects and activities to make them fun. Playfulness is an attitude towards people, objects or activities, whereas play is an activity itself. We need to understand playfulness in its terms to design playful experiences.

2 Designing Playful Experiences

Before talking about designing playful experiences, it is important to clarify what is a playful experience. The definitions of play, playfulness, and games are always messy and often insufficient. Because of this, I will describe them instead of defining them with an example, playing chess. If two players play chess, they are playing the game, but it is not possible to say whether they are playful or not. Both players may engage with the activity, yet their intentions may be not playful. If it is a tournament game, the players may focus only on winning. Or their attitude can be more playful which may lead to different player actions. For example, one of the players can start making sounds as they move the chess pieces or eat the opponent's chess piece. These actions are not necessary to play chess, but they emerge as the result of the playful attitude. The playful attitude contests and sometimes expands the boundaries of play; it sometimes adds different possibilities into the game.

Playfulness is not only an attitude to seek playthings and games to engage with, but it may also challenge the original goal and the designer. In the previous example, the chess players who have playful attitude may stop playing traditional chess at some point and start playing with the chess pieces because giving voice to the chess pieces and roleplaying is how they want to engage with chessboard instead of working towards a goal, which is winning.

History of video games may also help us to understand the similarities and differences between play and playfulness. In the 1970s, a computer was rare and expensive, which made it a valuable resource, and developing *Spacewar* on oscilloscopes was wasting that valuable computer time [7, p. 7]. However, the military who owns the tech facilities tolerated such playful engagements with computers because fooling around the technology allowed developers to find new uses of the technology [7, p. 8]. Thus, the playful attitude towards the productive device – computers - lead to the invention of early video games. In today's world, the designers similarly use playfulness; they let players explore new motivations to engage with the activity through the playfulness.

According to Arrasvuori et al. [2], Playful Experience (PLEX) framework is a tool to approach playfulness systematically as the designers create playful experiences in different fields. PLEX framework provides an exhaustive list of possible playful experiences without explaining how to design them. This framework contains 22 different categories (Table 1) that the designers can use as a control list if they want to make their design playful to elicit an emotional response from the users. Playfulness is not the goal of the design, but it enhances the product experience by contributing to aesthetic pleasure, attribution of meaning, and emotional response [2, p. 11].

Table 1. Playful experiences

Captivation	Fellowship
Challenge	Humor
Competition	Nurture
Completion	Relaxation
Control	Sensation
Cruelty	Simulation
Discovery	Submission
Eroticism	Subversion
Exploration	Suffering
Expression	Sympathy
Fantasy	Thrill

This framework is a useful checklist. For example, if someone wants to design a productivity software that also reduces the user's stress level, this designer can incorporate humor, relaxation, sympathy and even eroticism into their design to achieve this. PLEX framework makes the playful experiences that the researchers identified so far visible to create a guideline. By using the iterative design process, a designer can refine the experience until the users have the desired playful experiences. Although there is a list of categories that make the experience playful, it is ambiguous how to create an experience that encourages the user to have a playful attitude. There are several design frameworks such as user-centered, learner-centered, culture-centered, human-centered, and player-centered, and so on. All these examples are different approaches to design experiences by paying attention to the person who interacts with the design in various contexts. On the other hand, the main purpose of each design approach is the same, not designing for the technology or the designers, but the users.

2.1 Problems with the Player-Centered Design Philosophy

According to Don Norman, human-centered design is a philosophy "that puts human needs, capabilities and behavior first, then designs to accommodate those needs, capabilities, and ways of the behaving" [20, p. 8]. By using the human-centered approach, a designer minimizes this emphasis on utilitarian aspects of the experience and genuinely pay attention to the person who experiences. Human-centered design is a broad term that encompasses other design philosophies such as user-centered design, learner-centered design, and player-centered design, which narrows down the scope by paying attention to different activities; using, learning, and playing respectively.

There are several studies that the scholars who study games underline the necessity of having player-centered approach instead of user-centered philosophy because they claim it is not accurate to treat the players of games as users [4, 8, 16]. The main reason to emphasize the difference between players and users is the playability of the game, which is different than the usability in other activities. These studies echo Kücklich's [16, p. 22] explanation of the difference between playability and usability:

> While increasing the usability of a media technology usually means making its functionality as accessible as possible to the user, playability often depends on withholding certain options from the player. It is quite crucial in many games that the player does not have access to the full range of options the game offers initially, but only after the player has invested some time in the game. The playability of a game is actually increased by this strategy of deferral, because it challenges the player to spend an increased amount of time playing the game.

According to this statement, not having access to all the options is unique to games and this characteristic results in challenging activities in games, which makes people play the game. However, I believe many other designs don't present its full content to the users. For example, PEZ candy dispenser only gives one candy at a time when the user pulls the head of the object. In order to have access to all the candies, the user needs to keep using it until they get all the candies from the dispenser or they can dismantle the system to have access to the candy package directly. Similarly, a player can continue playing to have access to the full content, or they can hack the game instead of following the intended way to engage (Fig. 1).

Fig. 1. PEZ candy dispenser. Image retrieved from https://en.wikipedia.org/wiki/Pez, February 28, 2019.

There are two issues about this explanation.

Considering the challenge as a unique characteristic of video games that makes them playable is one of the major problems of using a player-centered approach to design games or playable experiences in current practices. I claim that people may seek challenge in non-game experiences too. For example, some viewers may enjoy movies with complex narrative structure, which challenges them to interpret the movie. As another example, if someone buys a bench press machine to their house, they expect to be challenged by the weights during their weightlifting training, instead of looking for an electric jack, which does the lifting for them.

In the examples above, a viewer's goal is to watch the movie, a player's goal is to play the game, and the weightlifter's goal is to work out, and all of them are the combination of the interface and activity[1]. Usability targets to improve the interface. On the other hand, the activity itself may not be compatible with usability heuristics. Thus, I claim human-centered design philosophy is compatible with designing games and playful experiences, which is similar to and probably the same with the player-centered design approach. In video games, a designer aims to design a game's interface (input devices such as a keyboard, mouse, and gamepad and output devices such as monitor and speakers) challenge free as much as they can. The designer's goal is to ease people's access to the content. On the other hand, the quality and type of content shape the activity, in which the user may or may not seek challenge. Because of this article's scope, I use the term the player-centered approach, even if I believe calling it the human-centered approach is correct as well.

2.2 Who Is at the Center?

In these studies, the emphasis on balancing the player's skill and the game's challenge to make the game playable also points to another problem of player-centered design philosophy. By sharing challenge as the factor that leads to playability, a designer assumes that every player seeks challenging experience in video games. On the other hand, according to the communication studies researchers, other video game motivations are pastime, entertainment, companionship, escapism, social interaction and relaxation, in addition to challenge, competition and achievement [22, 24, 25, 31, 32].

Fron et al. [9] describe that the Hegemony of Play, who consist of cisgendered heterosexual white males controls the discourses of what is a game and who plays it to normalize heteronormative and Western values. The communications studies researchers identify the dominant motivations to play video games, and I believe there are many other motivations that people seek, especially the ones that are preferred among other demographics such as women, people of color, LGBTQ, people with disabilities and other minority groups. Some scholars who study HCI also state that "games are designed to appeal to a rather narrow, already existing player demographic" [8]. The video game developers seemingly put the player at the center, but they only target young cisgendered heterosexual white male players (whether consciously or not) when they design playful experiences and video games.

This very same power structure that surrounds game technologies, game studies, and gaming communities also affect how we perceive the notion of playfulness. Instead of giving the tools and space for users to encourage them to be playful, current player-centered design practices function more like training the users to engage with the activity playfully as how the designers imagine. Playfulness is the possibility of expressing ourselves, showing who we during the activity. However, if the designers force the users to re-experience the playful bits in the designer's intended way the user

[1] Traditional HCI approach studies the interaction between human and computer as the name of the field proposes. Kaptelinin and Nardi says "people are not interacting *with* computers: they will interact with the world *through* computers" by using the activity theory [14, p. 6]. I claim we must include both the interaction with the computer and interaction with the activity to study the experience.

may choose to reject engaging with the experience, it also hinders the other possible unintended playful experiences due to the designer's limiting attitude.

2.3 Playfulness and Transgressive Play

Based on the literary theorist Wolfgang Iser's [12] model of "implied reader", Espen Aarseth coined the term "implied player", which "can be seen as a role made for the player by the game, a set of expectations that the player must fulfill for the game to 'exercise its effect'" [1, p. 132]. Since the notion of implied player only gives insight about the game from the developers' perspective, it is not enough to understand what players actually do. Players actively make meaning out of the game instead of deciphering it by passively consuming the content. That's why players have the freedom to interpret video games independent from the developer's expectations.

Similarly, I think the playful experiences suffer from the expectations set by the implied playful user. As a result of this, player-centered design approach operates as the implied player-centered design, which allows designers to pick a model user represents the designer's expectations from the user to engage with the experience as they envision. In other words, they design for the implied user by using the implied player-centered design. Although playfulness is a resistance to the seriousness of the activity, the designers try to control the playful possibilities and funnel them into another serious system, which violates the carnivalesque nature of the playfulness. As a result of this, many playful experiences in today's world incorporate game mechanics such as badges, achievements, and scoring systems, but not pay attention to other possibilities that may make the design more playful. In other words, although there are 22 different playful categories in PLEX framework (see Table 1), many playful designs have a challenge, competition, and completion, because narrow target demographic seeks these playful experiences.

Politics play a part in both game and playful experience design, and the designers circulate and reinforce the values of the Hegemony of Play consciously or unconsciously by using the normalized definitions of play, playful and games. Although the dominant definitions of play, playfulness, and games align with the Hegemony of Play, no one has the full power to control people's opinions on these subject matters.

Hall [11] identifies three modes of interpretation: dominant, negotiated, and oppositional. Within the gaming culture, the developers and dominant groups determine dominant interpretations and the implied players subscribe to these interpretation strategies. According to Hall, someone needs to identify the dominant values that normalize certain interpretation strategies, to negotiate with them. Playful experience designers must identify that challenge and competition are not the experiences that everyone seeks but the normalized ones that engrained to the design heuristics to practice more genuine human-centered design philosophy.

Instead of suggesting and even forcing the users to seek challenge and competition to have a playful experience, we should let them find their purposes. Playfulness "frees us from the dictates of purpose through the carnivalesque inheritance of play" [26, p. 29]. Video game players often search for different possibilities to pursue their goals even if the designer tries to limit them. Aarseth calls these people "transgressive players," who use the game mechanics to do things differently than what the designers intended [1, p. 132]. As playful experience designers, we should study and learn from these rebellious user moments to understand where we fail to give freedom to our users, instead of patching the experience to prevent the activities that don't support the objective of the designer.

3 Getting Help from Sandbox Games for Playful Experience Design

Analyzing the instances of transgressive play in any genre can be fruitful for designing playful experiences. In this article, I look at sandbox games because they are open-ended; in other words, have no explicit goals assigned by the developers. That's why a player doesn't need to resist to the authority in sandbox games because of the freedom that is the result of open-ended nature of this genre. The player agency allows players to express themselves through the gameplay. In a goal-based system, it is not possible to give fully open-ended experience, but adding sandbox-like open-ended pieces may enhance the user's playful attitude. As a result of this, through playfulness, a user not only expresses themselves within the boundaries of the activity but also appropriating the open-ended pieces in the design. Because of this, I claim we can design better playful experiences incorporating sandbox game characteristics into playful experiences.

3.1 Sandbox Game Characteristics

Before implementing sandbox game characteristics into playful experiences, it is important to examine and identify the sandbox game characteristics. It is a challenging task because "sandbox is a term often used but rarely defined" [13]. Moreover, the scholars don't agree on the sandbox game characteristics. Based on the discourse analysis, I identify that three characteristics make a game sandbox: freedom in open-world, depth in game systems, and optional in-game goals.

Freedom in Open-World. The scholars emphasize the freedom in an open-world, but how they describe freedom change from person to person. Deen [6] consider sandbox games as the genre that "[the] player moves freely throughout the game world and chooses the order of the challenges." In other words, a player not only has access to the whole game world but can also determine the sequence of the events. Sergio Ocio and Jose Antonio Lopez Brugos [21, p. 70] emphasize the size of the game world of sandbox games by mentioning sandbox games have "big open full of life worlds where [the players] have a high degree of freedom to choose what they want to do to progress through the game". They imply that the size of the game world is an important factor to provide freedom to the players.

On the other hand, Jenkins [13] criticize the necessity of big game world by saying "I've used the term sandbox to refer to any game world—regardless of size and scope—that offers free-roaming, open-ended gameplay." Larger game world means more real estate that the game developers can use to add more options. That's why, scholars, developers, and players usually consider large virtual worlds a good feature to make a sandbox game. As Jenkins mentions, designing large virtual worlds can be a development strategy to allow free-roaming in an open-ended game, but free-roaming can also be available in small-sized game worlds. Rafet Sifa, Anders Drachen, Cesar Ojeda and Christian Bauckhage supports Jenkins perspective on open-world games by emphasizing the "large degrees of freedom in player navigation, in world interaction, and narration" instead of underlining the game world size [27, p. 1].

Depth in Game Systems. Depth in sandbox game systems[2] is another characteristic that Jenkins mention in addition to the open-world design. Depth in-game systems allow players to use a mechanic as they wish. Consequently, this feature highlights that sandbox games allow multiple play styles based on how players engage with the game. The game systems such as building, construction, and logic design are some of the popular ones that many sandbox games have. For example, the block placement system and Redstone logic design system in *Minecraft*, and the space rocket design in *Kerbal Space Program* are good examples of such systems that are deep enough to allow players to interact with them differently. In these two examples, the type of material used, placement order, and connection between parts change the outcome each time. Different than the examples that I gave above, Jenkins considers *Metal Gear Solid*—and many stealth games in general—sandbox games [13] because the stealth games allow multiple and improvisational play styles due to depth in these game's dynamics.

Merrick and Maher [18] argues the development strategies to make sandbox games such as *The Sims*, and *Creatures* more open-ended. According to the authors, a key issue of developing video games with open-ended environments is the design of autonomous non-player characters that can respond to unpredictable changes in the environment. I infer that an autonomous, self-sufficient gameworld makes the game less predictable, which gives more depth to the game and reduces the designer's control over players via non-playable characters. Parallel with Merrick and Maher, Ocio and Lopez Brugos addresses this characteristic of the sandbox games by calling the games that have autonomous non-player characters as "full of life" [21, p. 1]. Thus, according to both studies, self-sufficient non-player characters in open-world is a sandbox game characteristic that provides more freedom to the players, consequently, makes the game open-ended.

Optional In-Game Goals. A player may choose their paths and use the game systems to follow their personal goals in sandbox games. As a result of this, different gameplay experiences are possible in sandbox games, and one of them is not more important than others because the game rules don't valorize the outcomes because "there is no single, correct pathway" [29, p. 170]. In sandbox games, the player is the only decision maker that can evaluate something good or bad, and the labels the player attaches to the certain outcomes might change during play.

Maybe there is no correct pathway in sandbox games, but I argue there are desired pathways that influence player play styles. According to this perspective, a video game is a sandbox as long as the game supports multiple play styles as the result of no correct way to play. For example, Gee explains that there are in-game goals in the video games

[2] A game system is a group of mechanics that work in harmony.

such as *The Elder Scrolls III: Morrowind*, *Arcanum*, *The Sims*, *Grand Theft Auto*, but "players also make up their goals, based on their desires, styles, and backgrounds" [10, p. 178]. In other words, in-game goals function more like optional playable content in the game. Designing playful experiences by applying sandbox game characteristics.

Sandbox as a genre not only gives information about the level of freedom and open-endedness, but it is also the designers' permission to the players to play transgressively because the sandbox game developers don't give importance to how they imagine players use their mechanics as long as the players engage with the mechanic. As the transgressive play, designers can't predict the users' playful attitude. Sandbox games are useful to study for designing playful experiences because the designers don't actively try to predict or control how players play the game. In other words, their implied player is someone who doesn't rely on in-game goals and pursues their self-assigned goals by using the game's mechanics.

I think the sandbox game characteristics that I identify don't give information about which mechanics to incorporate into playful experiences, but it is useful to understand how to present playful bits to the user. The three sandbox characteristics, freedom in open-world, depth in game systems, and optional in-game goals can give insight on playful experience design in three ways.

Let the User Choose When to Be Playful. Playfulness is personal; we express ourselves through it, as for how we want to express. That's why players should have the freedom of choosing when to engage with the parts that function more like toys or playthings to evoke playful attitude. The advantage of having an open-world in a game is to give players enough freedom instead of forcing them to play in a specific area to do the in-game tasks. Trying to control playfulness within the design may lead to creating minigames, instead of playthings that the user can playfully engage. If a user engages with a minigame without a playful attitude, they may resist playing the minigame. Moreover, if the designer forces the user to play the minigame, the user may perceive them as tasks and complete the minigame unwillingly, which may hurt not only that instant but the user may go defensive towards other playful pieces in the experience.

Allow Multiple Playful Characteristics. The possibilities of being playful are as important as when to be playful. Since playfulness is personal, certain playful experiences may be more appealing to someone. Instead of introducing the playful parts of the experience as the fun challenges, it is better to let the user decide what it means to them. In the PLEX framework, 22 playful experiences are identified, and the list may get longer in the future. It may not be possible to cover all 22 playful characteristics in a single playful experience, but the more is, the better.

Encourage a Playful Attitude. Similar to how the transgressive players play the game different than its intended design, the users may playfully engage with certain parts of the activity that the designer doesn't intend to make them playful. In such cases, the players shouldn't be discouraged by design. As long as a user engages with the experience playfully, the designer shouldn't prevent playful behavior. If the activity doesn't help the user to achieve their goal, the designer should improve the activity instead of getting rid of the playful bits.

4 Conclusion

I believe understanding transgressive play is crucial to design successful playful experiences, because playful experiences have their original goals, and these goals are not optional. Playfulness is the attitude to challenge the original goal and the authority who assigned the goal. Similarly, but not same, a transgressive play is rejecting the game's goal and playing for the new goal that is assigned by the player. Playfulness can lead to transgressive play if the user's playful actions lead to or inspired by a new goal that the user assigns. However, the designers should not limit the users to focus on the original task, because it is what prevents the playful attitude flourish. The designers biggest challenge is to make the goal more interesting than the playful possibilities in the experience. It may or may not speak to all the users, but such freedom will encourage playfulness in the experience. That's why sandbox games are the best examples to study and incorporate freedom into playful experiences. Thus, I propose that successful player-centered design is adding playful elements into the experience but leaving the center empty for the user instead of placing the implied user as a role model.

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Developing Design Frameworks and Applications for Future Technologies Through Video Game Representations

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Abstract. Video games offer conceptual examples of future technologies and provide interactive contexts in which these technologies can be designed, tested, and evaluated. Human-Computer Interaction (HCI) has been an integral part of video games since their inception, as it offers interface designers and technology developers a platform by which they can build scenarios and interactive prototypes to engage players. Real-world and game-world technologies draw from each other and lend themselves to evaluation through the lens of human-computer interaction paradigms. This paper seeks to provide further evidence supporting the relevance of HCI principles for evaluating general video game and in-game world technologies, and to establish a set of frameworks through which technologists can examine future technology concepts in video games, often in the form of science fiction artifacts and systems.

Keywords: Video games · HCI · Science fiction · Human computer interaction · Interfaces · Future technology

1 Introduction

Science fiction gives us visions of the future and shows us stories of people using technologies that are yet to exist or enjoy widespread use. Due to the dependence of science fiction upon existing technological progress and human imagination, science fiction media are inextricably linked to contemporary culture. Science fiction media, including video games, are inexplicably tied to the temporal context of their creation [1] with depictions of technology in science fiction works following contemporary, real-world trends in research and development, featuring technologies that parallel the prevalent attitudes and interests of the time [2]. Sci fi influences the design of technology by inspiring development of real-world parallels, fulfilling predictions and expectations for the evolution of similar technologies, providing a social context in which novel technologies can be placed and observed, and introducing new form factor and user behavior paradigms in existent and future interfaces [3].

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1.1 HCI Relevance in Generalized Science Fiction

Science fiction often involves interactions between human (or otherwise intelligent) beings and new forms of technology and thus affords itself to HCI speculation. Pop culture and academia have acknowledged this opportunity, with HCI research citing science fiction more than ever [4]. Researchers are increasingly cataloging examples of technologies in science fiction and real life, gleaning information from fictional case studies for application to real-world case studies of novel interfaces, such as gesture recognition [5]. Scientists affirm the close relationship between science fiction works and real-world technology research and development, with scientific communities drawing inspiration and learning from science fiction examples [6].

Much like science fiction draws from and contributes to real-world technologies, HCI theories of practice in science fiction works can influence and be influenced by the study of real use cases. Science fiction media challenges HCI researchers and practitioners to imagine possible interface schemes and interaction methods that may accompany future technologies, and to consider the ethical implications of such developments [4].

1.2 HCI Relevance in Video Game Science Fiction

Most science fiction research appears to focus on film, television, and literature examples, but the same principles used to evaluate these sci fi phenomena are highly, if not more so, applicable to video games, as they offer interactive demonstrations within situated contexts and provide opportunities for active exploration of technologies and their interactions with people [7]. Design fiction, as described by Joseph Lindley and Paul Coulton, creates a fictitious, yet plausible environment within which ideas can be built and tested, and thus opened for discussion and consideration [8]. This same definition can be applied to science fiction and technology representations in video games. Since their inception, video games have brought an interactive dimension to the science fiction genre, offering players the opportunity to experience future technologies in simulated worlds. Video games provide immersive spaces where players can experience technologies through a digital agent (such as a character, avatar, or camera view) and use these technologies to achieve game-defined goals in designed user contexts while exploring the game environment. Players experience "spatial presence" when interacting with a game world, suspending their disbelief and perceiving objects in the virtual space as "real" [9]; thus, the experience of the player as a user in a game world is comparable to a user experience outside the game in a similar context.

The player actions involved with fictitious interfaces and technologies in these game spaces are analogous to the user tasks of technologies in the real world. Video games can act as testbeds for novel interfaces and emergent technologies, and demonstrate models for effective user-centered design. Many games explore different designs for addressing the same problem and together provide a more comprehensive view of possible avenues for new technology and the design of human interactions with said technology. Video games can be held to the same HCI principles and expectations of other interactive systems, such as ease of use and learnability, and have had to solve

HCI-related problems to become as successful and prolific as they are today [10]. Like all science fiction, video games both inform and are products of their cultural context, and thus apply themselves just as well to real-world technological study as other types of science fiction media [11, 12]. The types of fictional technologies that emerge in game worlds over time reflect to the progression of technological capabilities, the proliferation of emerging technologies, and the cultural values of people associated with certain technologies.

Based on our understanding that science fiction influences real-world developments and vice versa, and that science fiction in video games is demonstrative of this relationship, a pre-existing model for the influential relationships of science fiction film ideas and real world technologies can be appropriated for use in the context of video games [13]. Video games can provide high-fidelity, interactive mockups of technological systems, and artifacts; by recognizing science fiction media, including games, as a means to design, build, and test future technologies, such media can be incorporated into real-world design processes and be examined using the same standards [14]. Video game design can act as a vanguard for the development of novel interactive technologies [15] (Fig. 1).

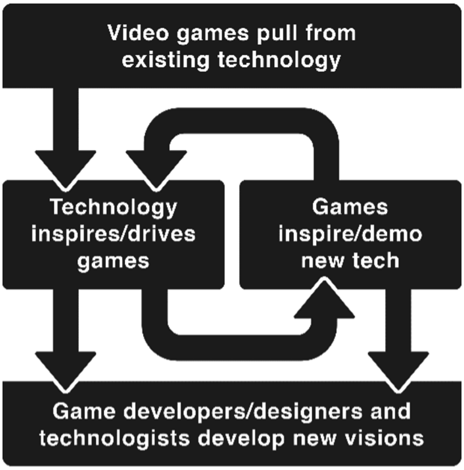


Fig. 1. Model describing the influence of science fiction in video games on the development of real-world technology counterparts, and how collaboration between technologists and designers of fictional technologies can influence both domains. Based off of the model described by Schmitz, Endres, and Butz (Schmitz et al. [13]).

Fictional, interactive environments like game worlds can be designed to share commonalities with the real world - so players can bring with them their mental model of the world and its technologies - while providing plausible contexts that currently do not exist but could in the future. To make these fictional aspects more plausible, media producers often consult with domain experts and technologists to make informed decisions when designing the technologies and associated interactions in a given context [6].

Although current research examines various science fiction technologies using HCI principles, a set of base criteria for applying HCI principles to science fiction that accounts for the reciprocity and real-world relevance of this relationship, appears to be missing [6]. In order to more effectively describe and understand science fiction as it pertains to HCI and vice versa, specifically in the powerful medium of video games, this paper seeks to formally categorize the dimensions of technologies and human-computer interfaces presented in games over past 40 years, and to formulate a taxonomy for classifying video game representations of future technologies that can be analyzed and applied to real-world designs. This set of frameworks would refer to contemporary understandings of human-computer interaction and lend itself to applications in conceptual analysis and user testing of emergent technologies. The following is a sample of the proposed design frameworks, using augmented reality as an applied example.

2 Definition of the HCI Framework

In order to apply these principles, we must determine working definitions for whom we regard as the "human" and for what we consider the "computer" in Human-Computer Interaction in fictional, yet real-world applicable, contexts. A real-world, human player is always involved in an HCI relationship with a video game, but the role and manner of interaction between the user(s) and technology can vary based on factors such as degree of separation or level of abstraction. The following subset of our frameworks can provide a means by which real and virtual users are described and the technologies they interact with are defined (Fig. 2).

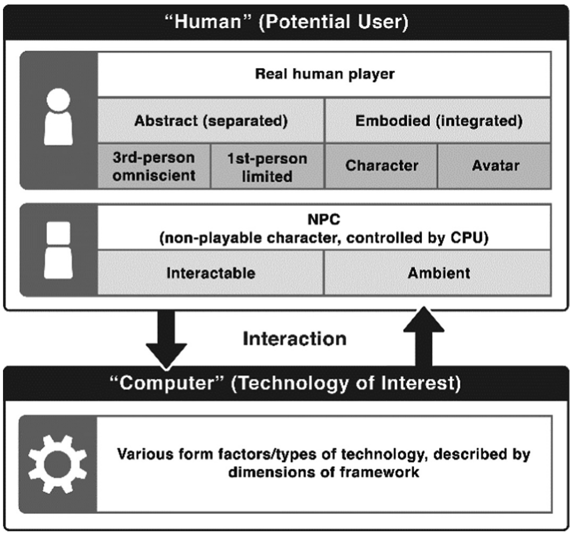


Fig. 2. Visual representation of the proposed framework defining the "human" and "computer" aspects of HCI in the context of video game world technologies, and the bidirectional relationship between them.

2.1 "Human" or Potential User – The Player

The "human" aspect can refer to any potential user of the technology: the player (real user, character/avatar, abstract representation in virtual space) or to a diegetic entity that belongs to the game world of interest. Real, human players are an inherent component of video game interactions but can interact with games as abstract entities, which have a greater degree of separation from the fictional game world, or as embodied entities, which are immersed in the game world. An abstract player entity does not have a virtual "body" or inhabit a virtual, "physical" manifestation in the game world. Abstract player entities are typically represented by cursors or other non-diegetic GUI elements, and can adopt either or both of the following viewpoints:

Third-Person Omniscient Point of View
Referred to colloquially as "God mode", this perspective provides the human player with a wide viewing angle and ability to see the game world with the least visual restriction. This method is commonly used for simulation and strategy games, where the player's view is not unlike that of a military strategy map.

First-Person Point of View
This "on the ground", more limited view frame trades a bird's eye view for a more immersive experience, allowing the player to gain a perspective that is up close and personal. This point of view is usually tied to a character or entity that is more situated in the game world.

The player can also interact with game-related elements by embodying a virtual form, adopting the perspective and capabilities of a diegetic being. The virtual manifestation of the player can vary based on the player entity's relationship to game narrative or integration with the game world. An embodied player may be able to choose between first- or third person point of view, and often navigates the virtual world as one of two virtual physical forms:

Character
This type of player entity is predetermined by game designers (ex. Mario, Master Chief) or limited customizability, this entity is usually tied more closely to game's narrative structure, where an actor fills a role. Games vary in how many characters a player can embody and the level of customization a player can apply to the appearance or performance statistics of their character.

Avatar
An avatar is more customizable, thus having the potential to more closely reflect the appearance of the human player, or conversely to be more abstract than other in-game entities. This type of entity is typically less integral to the game's narrative.

2.2 "Human" or Potential User – Non-Player Entities

The user of a fictional video game technology can also be an agent besides the player; NPC's, or non-playable characters, are native inhabitants of the game world and are controlled by the game through artificial intelligence or other game system protocols.

These entities cohabit game worlds with players and can vary in their level of interactivity and responsiveness:

Ambient
Ambient NPCs occupy the game world but do not interact with the player in any meaningful capacity, similar to "extras" in film (ex. background crowds in *Persona 5*). These entities usually serve as aesthetic elements that provide context or plausibility to the game world.

Interactable
These NPCs are able to interact with the representation of the player in a meaningful capacity (ex. Team members in *Mass Effect*, "Sims" in *The Sims*, combat enemies). These types of entities can be narrative characters or otherwise significantly impressionable or intelligent. Interactable NPCs are more likely to act as users of technology than ambient NPCs because they can use said technology as a means to interact with the player/player character.

2.3 "Computer" – Technology of Interest

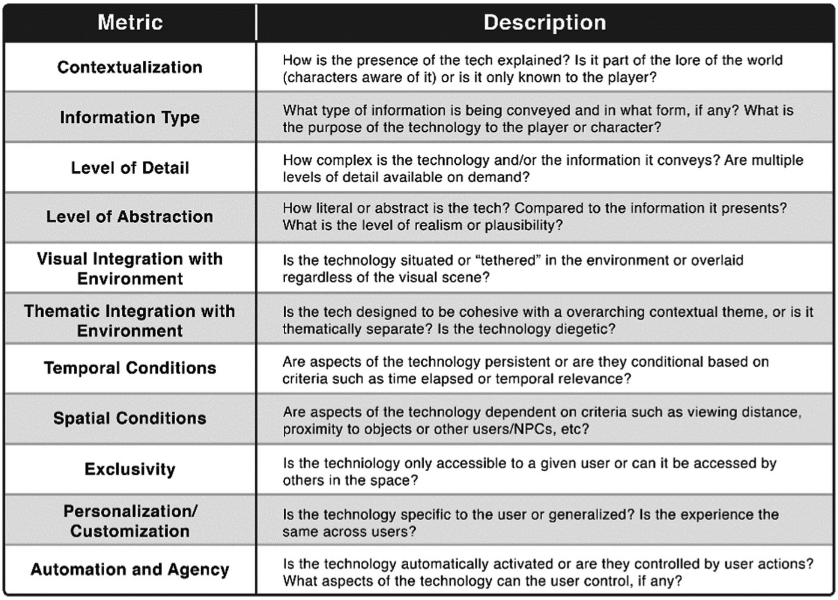
The "computer" can be any technology artifact or system that is related to the game world, whether it's diegetic (situated in the world of the game where virtual entities like player characters or NPCs can perceive it) or non-diegetic (only the player can see it with a third person omniscient viewpoint). Artifacts and objects are usually diegetic and "physically" situated in the game world, whereas GUI components are often non-diegetic or separate from the game world. Diegetic elements lend themselves to more concrete representation while non-diegetic features tend to be abstract. In-game technologies can afford players different capabilities, facilitate game mechanics, serve as narrative devices, convey information, or serve as the primary means through which players interact with the game system as a whole.

2.4 Interaction

Interaction can refer to the real, human player's interplay with the hardware and software of a game system, but for the scope of these frameworks, "interaction" will pertain primarily to the relationships between players, player characters, and NPCs with fabricated manifestations of technologies in or relating to fictional, simulated game worlds. The means, method, and flavor of these interactions are heavily influenced by the aspects outlined in the following technology framework.

3 Definition of the Technology Framework

These categorized dimensions of design choices draw from extant HCI descriptors and can be populated with examples from a large variety of games. The following is the proposed framework through which in-game future technologies can be understood, but derivative frameworks could be developed for specific examples of technologies, such as wearables, human-robot interfaces, artificial intelligence and personal assistants, volumetric projection and telepresence, and body augmentation using prosthetics and cybernetics, all of which have unique affordances, real-world inspirations, and ethical considerations (Fig. 3).



Metric	Description
Contextualization	How is the presence of the tech explained? Is it part of the lore of the world (characters aware of it) or is it only known to the player?
Information Type	What type of information is being conveyed and in what form, if any? What is the purpose of the technology to the player or character?
Level of Detail	How complex is the technology and/or the information it conveys? Are multiple levels of detail available on demand?
Level of Abstraction	How literal or abstract is the tech? Compared to the information it presents? What is the level of realism or plausibility?
Visual Integration with Environment	Is the technology situated or "tethered" in the environment or overlaid regardless of the visual scene?
Thematic Integration with Environment	Is the tech designed to be cohesive with a overarching contextual theme, or is it thematically separate? Is the technology diegetic?
Temporal Conditions	Are aspects of the technology persistent or are they conditional based on criteria such as time elapsed or temporal relevance?
Spatial Conditions	Are aspects of the technology dependent on criteria such as viewing distance, proximity to objects or other users/NPCs, etc?
Exclusivity	Is the techniology only accessible to a given user or can it be accessed by others in the space?
Personalization/ Customization	Is the technology specific to the user or generalized? Is the experience the same across users?
Automation and Agency	Is the technology automatically activated or are they controlled by user actions? What aspects of the technology can the user control, if any?

Fig. 3. Visual representation of the proposed framework for classifying technologies in the context of game worlds, derived from HCI paradigms.

Contextualization. How is the presence of the technology (in the game world or more generally) explained? Is the technology part of the lore of the game world (are characters aware of it), or is it only known to the player?

Information Type. What type of information is being conveyed and in what form, if any? What is the purpose of the technology to the player and/or character(s)?

Level of Detail. How complex is the technology and/or the information it conveys? Are multiple levels of detail available on demand?

Level of Abstraction. How literal or abstract is the technology generally? How literal or abstract is it compared to the information it presents? What is the level of realism or plausibility of the technology, in the game world or otherwise?

Visual Integration with Environment. Is the technology situated or "tethered" in the environment, or is it overlaid regardless of the visual scene?

Thematic Integration with Environment. Is the technology designed to be cohesive with an overarching contextual theme, or is it thematically separate? Is the technology diegetic (belonging to the game world) or non-diegetic (set apart from the game world)?

Temporal Conditions. Are aspects of the technology persistent, or are they conditional based on criteria such as time elapsed, temporal relevance, etc.?

Spatial Conditions. Are aspects of the technology dependent on criteria such as viewing distance, proximity to objects or other users/NPCs, etc.?

Exclusivity. Is the technology only accessible to a given user, at a given time or circumstance, or can it be accessed by others in the space? Do different users have different permissions or affordances?

Personalization/Customization. Is the technology specific to the user or generalized to a wider user base? Is the experience of interacting with the technology the same across users? Does the technology change depending on personal user data?

Automation and Agency. Is the technology or its features automatically activated, or are they controlled by deliberate user actions? What aspects of the technology can the user control, if any, and how?

4 Example Application of the HCI and Technology Frameworks

To demonstrate how these frameworks can be applied to understanding technologies in game worlds, we will examine the design, employment, and human-computer interaction of augmented reality (AR) in a popular video game. Augmented reality is a common mechanic in video games that manifests in a variety of forms and addresses a multitude of user tasks and needs. AR congeners are arguably some of the oldest examples of tech in game worlds, as they primarily serve as the GUI and informational overlays the player uses to understand and navigate the game world. Aspects of augmented reality in video games can be classified by metrics used to categorize AR systems in the real world. The following table and example utilize the aforementioned technology framework to classify and provide a lens through which we can understand real-world augmented reality systems and its in-game counterparts (Fig. 4).

4.1 Augmented Reality and the "Sheikah Slate" in *the Legend of Zelda: Breath of the Wild*

The Legend of Zelda: Breath of the Wild (Nintendo, [16]) is an open world, action-adventure game that takes place in the fictional kingdom of Hyrule: a game world that is not unlike the real, physical world, in physical likeness and behavior. In this game, the player controls the character Link as he completes quests and solves puzzles, using his physical abilities and arsenal of equipment, to save the land from dark magic.

Metric	Description Related to AR
Contextualization	How is the presence of AR explained? Is AR part of the lore of the world (characters aware of it) or is it only known to the player?
Information Type	What type of information is being conveyed and in what form? What is the purpose of the augentations?
Level of Detail	How complex are augmentations and the information they convey? Are multiple levels of detail available on demand?
Level of Abstraction	How literal or abstract are augmentations compared to the information they present? What is the level of realism or plausibility?
Visual Integration with Environment	Are augmentations situated or "tethered" in the environment or are they overlaid regardless of the visual scene?
Thematic Integration with Environment	Are augmentations designed to be cohesive with a overarching contextual theme, or are they thematically separate?
Temporal Conditions	Do augmentations persist or are they conditional based on criteria such as time elapsed or temporal relevance?
Spatial Conditions	Are augmentations dependent on criteria such as viewing distance, proximity to objects or other augmentations, etc?
Exclusivity	Are augmentations only accessible to a given user or can it be accessed by others in the space?
Personalization/ Customization	Is the information user specific or generalized? Is the experience the same across users?
Automation and Agency	Are augmentations automatically added or are they controlled by user actions? Can users manipulate augmentations?

Fig. 4. The proposed technology framework adapted to specifically examine augmented reality as a future technology, as executed and experienced in a game world setting.

Applying the HCI Framework

In this example, the "human" or user(s) in the HCI relationship is the human player embodied as an in-game character (Link), with some degree of third-person perspective looking inwards on the game via the screen. The player-controlled character is narratively tied to the game world and uses the technology in this context. The "computer", or technology example, is the "Sheikah slate," a handheld tablet device that allows the player (through the character) to manipulate aspects of the physical world and perceive information by means of augmented reality features.

Applying the Technology Framework

Contextualization. The technology exists as part of the lore of the game world. This technology was developed by Sheikah people of Hyrule, as explained by the game's narrative and by design clues incorporated into the technology: the name "Sheikah slate" harkens to its creators and is emblazoned with the Sheikah people's symbol.

Information Type. The purpose of the technology is to provide information to Link (and by extension the player) and provide a means of interacting with items in the physical game world through abilities like magnetism, ice formation, and time stopping. Information is conveyed on the device screen (which doubles as the general game GUI for human player) and augmented reality artifacts (with are overlaid and integrated with environment).

Level of Detail. Set levels of detail are available for most features (such as placement indicators for ice blocks and arrows showing force applied to time-stopped objects). Some features support more detail on demand and the ability for the player to add/remove detail (the map feature shows more detail as the zoom level is increased, and the player can set or remove waypoints that appear on the map).

Level of Abstraction. The physical form of the Sheikah slate in the game world is fairly literal (a tablet object with a screen). The augmentations produced by the Sheikah slate vary in level of abstraction, from arrows depicting degree and direction of an applied physical force, to holographic representations of objects showing where they can be placed.

Visual Integration. Some AR elements are situated in the environment (overlays, highlights in relation to objects being manipulated, and environmental effects) while others are overlaid as general GUI elements (a weather indicator, item shortcuts, icon for which feature is currently equipped). Screen elements, such as the map and photo album, are overlaid on the player's screen but understood to be viewed by Link on the Sheikah slate in-game.

Thematic Integration. The device and its features are designed to coincide thematically with the other Sheikah technology in the game world, primarily in aesthetics like color, shape, and iconography.

Temporal Conditions. Passive information, such as the weather forecast and item shortcuts, are present continuously during gameplay unless actively disabled by the human player via the in-game menu system. These pervasive elements are primarily AR overlays. Contextually-relevant information such as a selected object of interest while using a feature (for example, a visual force field around a time-stopped object) appears as long as the current feature is actively in use. If the augmentation is not tied to the Sheikah slate but is an environmental indicator of state, it persists as long as the object is in close interaction range and viewing distance.

Spatial Conditions. Passive information is shown on the sides of the screen regardless of spatial criteria. Feature-specific indicators are restricted to the operable space in which said feature can be used (for example, only objects that can be manipulated with the magnetism feature are highlighted while the magnetism tool is active).

Exclusivity. The technology can be used by whomever is currently in possession of the device, but is primarily used by Link, who is controlled by the player. Information and features appear only to be accessible to the immediate user unless deliberately shared (for example, showing the Sheikah slate's screen to another person in the vicinity). All augmentations are accessible by the player, but not all are presumed to be perceived by Link.

Personalization/Customization. The device and associated interface appear to be designed for a general audience, but some features allow for the user to create custom content, such as photos or map markings.

Automation and Agency. Pervasive augmentations displaying general information such as the game world clock appear automatically but can be turned off by the player in the game's settings menu. The user of the Sheikah slate can control when and how most features are used, but augmentations associated with the active feature appear and disappear automatically (Fig. 5).

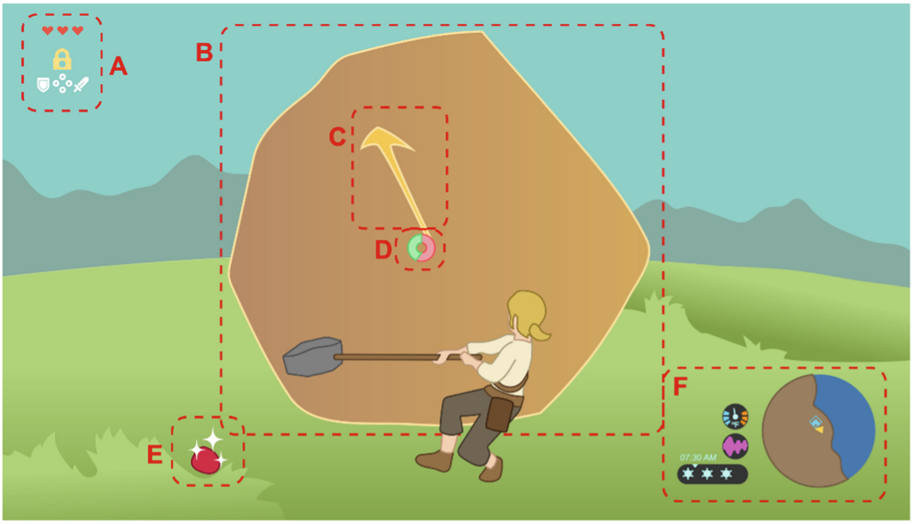


Fig. 5. Examples of AR elements in the game space are outlined. A, D, and F are perpetual, non-diegetic HUD elements, while B, C, and E are situated in the environment, temporary to context, and visible to the playable character. Situated augmentations vary in level of abstraction, from halos around objects (B) to sparkles reflecting sunlight that draw attention (E). A–D are presumed to originate from the Sheikah slate technology, while E is an example of a thematic environmental cue that can also be considered AR in the holistic scope of the game world.

5 Conclusion

These categorized dimensions of design choices can be populated with examples from a large variety of games. Frameworks could be developed for other types of technologies such as wearable technology, human-robot interaction, artificial intelligence and personal assistants, volumetric projection and telepresence, and body augmentation using prosthetics and cybernetics, all of which have unique affordances, real-world inspirations, and ethical considerations.

The nature of technologies in games is heavily influenced by gameplay and artistic choices that may not prioritize practicality nor accurately reflect real-world constraints; however, these interfaces are designed to engage players, convey information, and provide players with resources and information to meet an appropriate challenge. Game designers and technology developers identify the same needs in their respective users. Technologies modelled in games are designed within a given context and carry affordances and limitations analogous to their real-world counterparts. These parallels and a unique interactive quality lend video games to the use of human-computer interaction research methods and frameworks - such as heuristic evaluation and contextual inquiry - that can be used to evaluate theoretical designs and apply findings based on this research to real-world analogues.

Video games are artifacts of their real-world context and reflect the values and current technologies of a given culture and time period; designers are pushed to imagine what future technologies will be like, how they will be used in given contexts, and what ethical considerations are involved based on contemporary knowledge and best practices. Video games serve as compelling test cases for new technologies and provide the means for interacting with them in environments and contexts beyond the present, empowering us to make informed design decisions and proceed with technological development in an effective, accessible, and ethical manner as advancements in human-computer interaction continue to progress.

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Benevolent Deception in Exergame Design

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Abstract. Exergames are becoming increasingly popular as a way of motivating people to exercise. How to use games to increase personal exercise motivation has become an important issue both for HCI researchers and interaction designers. While many exergames can attract users, not all of them have the ability to sustain high levels of motivation over time. The incentive effect of exergames can not only rely on freshness and gameplay, but should adopt other long-term effective means. In most cases, exergames truly reflect the user's status of exercise, as time, speed, heart rate, calorie consumption, etc. In the field of sports psychology, existing research shows that people's cognitive bias in the process of exercise can be manipulated artificially, thus affecting the behavior and exertion of the athlete. However, it has not been found that the designer deliberately integrated benevolent deception into the case of exergame design. As a design concept, benevolent deception has not been widely discussed. We investigate how to apply benevolent deception on exergame design, to verify the possibility of using benevolent deception as a fitness incentive in gym. We developed a set of basic design principles, as promoting fitness by lies is an unusual and dangerous design attempt. Taking the spinning cycle game as an example, we try to introduce benevolent deception into the interactive game design of aerobic exercise. After the design process, we discussed the key impact, main challenge, necessary of drawing on expert opinions.

Keywords: Benevolent deception · Exergame design · Exercise motivation · Spinning cycle game · Design principle

1 Introduction

1.1 Background

Exergames are becoming increasingly popular as a way of motivating people to exercise. Yoonsin Oh and Stephen Yang proposed definition of exergaming as an experiential activity in which playing exergames or any videogames that require physical exertion or movements that are more than sedentary activities and also include strength, balance, and flexibility activities [1]. According to this definition, exergames includes both games designed for fitness purposes, as well as those for entertainment or education, but also allows users to perform physical activities above sedentary levels. Exergames make the fitness process no longer boring. As a means of promoting fitness, exergames with enough exercise intensity can help the weight control effectively.

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Playing active video games significantly increased heart rate (HR), oxygen consumption (VO2), and energy expenditure (EE) from resting. The effect sizes of playing active video games on HR, VO2, and EE were similar to traditional physical activities. Active video game type and the player age were significant moderators for the effects of active video games [2]. Exergames can also play a role in psychological regulation and improve people's mental health. Psychosocial and cognitive impacts of exergames play may include increased self-esteem, social interaction, motivation, attention, and visual spatial skills [3]. Exergame can also be used as a tool for sports assessment. Through the collection of physical activity information in sports through hardware devices, scientific screening and the multi-angle analysis, the computer can evaluate the user's sports indicators to further guide the fitness. Many exergames have the capability to measure activity levels unobtrusively through monitors built into game equipment, and preliminary analysis indicates that exergame measures are significantly correlated with external measures of caloric expenditure, duration of play, and balance [4]. Some exergames are designed for specific people, such as the elderly, children or the blind. The MoveCare Project develops and field-tests an innovative multiactor platform that integrates a robotic system with environmental sensors, smart objects, a virtual community and an activity center to provide assistance, transparent monitoring and activities to the elder at home. Different game modalities, such as playing alone, in competition, or collaboration with other elders of the virtual community will be available [5]. It also needs to be recognized that the potential of exergames in field-based settings might have been underestimated because of a variety of limitations inherent in many published studies. Future research and practice should take into account these limitations to unravel and exploit the maximal efficacy of exergames [6]. With work pressure increased drastically, people are facing the lack of time and energy for exercise. Although the traditional gyms basically meet people's fitness needs, mechanical fitness is still not attractive enough. Sarah et al. identified six superordinate themes contributing to non-participation in a workplace physical activity (PA): self-efficacy for exercise; attitudes towards PA; lack of time and energy; facilities and the physical environment; response to the PA programme and PA culture. Barriers occurred at multiple levels of influence [7]. With the hope of health benefits, exergames began to be introduced into the gym as a serious training method, not just as casual games.

1.2 Need to Improve

While many exergames can attract users, not all of them have the ability to sustain high levels of motivation over time. Those which do show increases in light intensity exercise which although valuable, do not increase the proportion of moderate to vigorous activity required for optimal health benefits. Furthermore, longitudinal studies to date have encountered a plateau effect in physical activity as the novelty of the game wears off [8]. Contrary to intuition, the effect of exergames on user fitness is not always positive. In the long run, it is possible that the interest brought by the game gradually weakens until it disappears, at which point users may become less autonomous for exercise. For example, elementary school children's situational interest during exergame-themed physical education classes declined significantly between the beginning and the end of instruction [6]. In addition to enough exercise time, sufficient exercise intensity is also important for achieving fitness goals. The incentive effect of exergames can not only rely on freshness and gameplay, but should adopt other long-term effective means.

2 Benevolent Deception as a Motivation Skill in Exergames

Social and competition have been widely used as incentives. Paw et al. implemented a dance exergame and compared the level of participation in the game between two different social groups. It was found that the multiplayer group (playing with peers) played approximately twice as many minutes as the home group (playing alone), and dropout was significantly lower in the multiplayer group [6]. Lindsay et al. concluded that the virtual competitive trainer elicited a greater distance travelled and caloric expenditure, and was rated as more motivating than the cooperation trainer, in a study of virtual trainer designed for competition and cooperation in bicycle riding exergame [9]. Soumya et al. put forward an interactive adaptation of the feedforward method: a psychophysical training technique achieving a rapid improvement in performance by exposing participants to self models showing previously unachieved performance levels and evaluated their method in a cycling-based exergame [10].

In most cases, exergames truly reflect the user's status of exercise, as time, speed, heart rate, calorie consumption, etc. In the field of sports psychology, existing research shows that people's cognitive bias in the process of exercise can be manipulated artificially, thus affecting the behavior and exertion of the athlete. Actually, benevolent deception has been widely used in human computer interaction. Eytan et al. [11] presented the notion of benevolent deception as deception aimed at benefitting the user as well as the developer. A user's interaction with a system is mediated by perception, attention, comprehension, prior knowledge, beliefs, and other cognitive activity. From these, a class of HCI deceits, behavioral deceptions, emerge that take advantage of, and occasionally "fix", the physical, sensory, and psychological limits, capabilities, and learned behaviors of the user. Certain Nintendo Wii games give the user "the benefit of the doubt", however, it has not been found that the designer deliberately integrated benevolent deception into the case of exergame design. As a design concept, benevolent deception has not been widely discussed. Another possible explanation is that even there are such cases in practice, developer rarely disclosed them, in order to maintain user beliefs or avoid moral criticism. We investigate how to apply benevolent deception on exergames design, to verify the possibility of using benevolent deception as a fitness incentive in gym.

3 Related Work

Since there is no existing exergame design case as a reference for benevolent deceptive exergame design, we investigated related research in sports psychology fields as a reference. Many studies have used deception to investigate the theoretical underpinnings of pacing and performance.

Golf players put more successfully to the perceptually bigger hole affected by the Ebinhas illusion. A downward-facing projector displayed a ring of 11 small or 5 large circles around each hole to create an Ebbinghaus illusion. For each hole and illusion combination, participants stood at a computer approximately 1.7 m from the hole and used MS Paint to draw a circle that matched the hole's size. Then, researchers attempted 10 putts from a distance of 3.5 m, and recorded how many balls dropped into the hole. Thirty-six participants put to two different-sized holes, 5-cm and 10-cm. The illusion influenced perceived size of the 5-cm hole, and subsequent putting performance. Participants made more successful putts when the 5-cm hole was perceptually larger. The surrounding circles did not influence perceived size of the 10-cm hole. A likely explanation for this effect is that an increase in the apparent size of the target increased participants' confidence in their abilities, which in turn improved performance [12]. This visual-illusion paradigm could be used to induce the perception that a target looks bigger, which have the potential to be applied in the throwing exergame.

The main contribution of Yuki et al.'s research is to develop a method for alleviating fatigue during handling medium-weight objects and augmenting endurance by affecting weight perception with augmented reality technology. In this paper, researchers propose an augmented reality system that changes the brightness value of an object in order to reduce fatigue while handling the object. They conducted two fundamental experiments to investigate the effectiveness of the proposed system. Their results suggested that the system eliminates the need to use excess energy for handling objects and reduces fatigue during the handling task [13]. In another study, researchers investigated whether this powerful weight illusion could influence real-lift behavior—namely, whether individuals would perform more bicep curls with a dumbbell that felt subjectively lighter than with an identically weighted, but heavier-feeling, dumbbell. Participants performed bicep curls until they were unable to continue with both a large, light-feeling 5-lb dumbbell and a smaller, heavy-feeling 5-lb dumbbell. No differences emerged in the amounts of exercise that participants performed with each dumbbell, even though they felt that the large dumbbell was lighter than the small dumbbell. Furthermore, in a second experiment, researchers found no differences in how subjectively tired participants felt after exercising for a set time with either dumbbell. Researchers did find, however, differences in the lifting dynamics, such that the small dumbbell was moved at a higher average velocity and peak acceleration [14]. These studies demonstrate the feasibility of using benevolent deception to reduce subjective fatigue in weightlifting. But some limitations exist, for example, as it is difficult to really improve the user's muscular endurance performance.

Optic flow on the retina creates a perception of a person's movement relative to their surroundings. A study investigated the effect of optic flow on perceived exertion during cycling. Fifteen participants completed a 20-km reference cycling time trail in the fastest possible time followed by three randomly counterbalanced 20-km cycling trials. Optic flow, via projected video footage of a cycling course, either represented actual speed (TTNORM) or was varied by –15% (TTSLOW) and +15% (TTFAST). During TTSLOW, power output and ratings of perceived exertion (RPE), measured every 4 km, were lower during TTSLOW compared with TTNORM and TTFAST. There were no differences in heart rate or cadence. This study is the first to show that different rates of optic flow influence perceived exertion during cycling, with slower optic flow being associated with lower RPE and higher power output [15]. In fact, research on deception in the riding process is the most extensive. Pacing strategy is said to be influenced by feedback information from both internal and external cues. Environmental conditions such as gradient, terrain, weather, oxygen content of inspired air, knowledge of the event (e.g. distance or duration), previous experience and competition all equate to external cues. Manipulation of pre-exercise expectations and external feedback during exercise both effect pacing strategy [16].

From these studies, it can be found that deception can really change the user's athletic performance in different exergame condition. The limitation is that these experiments are often one-off behaviors that are carefully designed in the laboratory environment and do not meet the needs of long-term fitness incentives. These deceptions are not all surely beneficial to the user, so it is doubtful whether they can be considered benevolent. For the exergame design, a fun game mechanic is also necessary because the user is not equivalent to the subject.

4 Design Principle

It is necessary to develop a set of basic design principles, as promoting fitness by lies is an unusual and dangerous design attempt. (1) Deception must be beneficial to the user, serving the scientific way of exercising. Eytan et al. proposed that there is a distinction between "successful" and benevolent deception. While each is necessary for use in HCI settings, neither alone is sufficient [11]. For designers, it's important to know the ultimate purpose of using fraud and always consider the core needs of users. For exergame design, it is necessary to ensure that the direction of deception-induced user behavior is in line with the sports science theory. (2) Deception must be sufficiently concealed. Eytan et al. proposed the inevitable risk of being caught by users. When a user will not be able to tell the truth from the deception, there is a chance for benevolent deception [11]. For the exergame using benevolent deception, this is even more important because it is about user confidence in feedback. If the user suspects that the system is cheating, the incentive will disappear. (3) Deception can't reduce the quality of user experience. It is not the ultimate goal to trick users into high-intensity or long-term exercise. The designer must ensure that users can get pleasure and satisfaction from the exergame.

5 Design Process

Spinning cycle exergames, a very universal and typical template, have a great effect in motivating users to insist on aerobic exercise and improving user satisfaction. Researches on deception in the riding process in sports psychology provided enough deception examples for reference. Taking the spinning cycle game as an example, we try to introduce benevolent deception into the interactive game design of aerobic exercise. Riding in a virtual scene is the basic framework for this type of exergames. Typically, gaming devices include a screen (in some cases a VR head-mounted display) that displays a scene, a sensor that captures the user's riding speed and physiological signal detecting device (in order to obtain physiological indicators, such as heart rate). The game experience is abundant. Some spinning cycle exergames can provide interesting scenery, such as glaciers, deserts or underwater world, from virtual modeling or real-life shooting. Other can achieve multi-player speed competition, just like a real bike tournament. A part of them drew on the traditional parkour video game, in which the user needs to avoid obstacles or hit a specific object to get a score reward. These existing design models have been widely used in homes and gyms and have been proved to be effective incentives. We don't want to overthrow the existing design template, but hope to enter the game design process by combining benevolent deception.

5.1 Investigate Existing Products

In July 2018, we first visited a professional exergames development company in Beijing. Here we experienced exergames designed for spinning bikes, rowing machines, treadmills and aerobics. In particular, we focused on the experience of the VR spinning exergame and recorded the process in the process. Two experiencers each performed two repetitive games.

The user of this exergame plays a motorcycle rider and aims to complete a 3-km ride. In the process, the user needs to control the direction and speed, hit the gold coins and bypass some obstacles such as trees and fences (see Fig. 1). In the left front of the user's perspective, there is a small spherical robot flying to accompany the user. After the game is over, the time of the user's ride and the total number of coins will be displayed on the interface.

Fig. 1. A designer was experiencing the VR spinning exergame

The first play is very immersive and challenging. On curved roads, when attention is focused on trying to control the direction and speed to complete the goal of avoiding obstacles or hitting gold coins, the experiencers can feel the challenge, and get a sense of pleasure when we successfully complete the goal. But the second experience is not as good as the first time. Repeated scenes and roads are no longer attractive and do not provide a sense of freshness or excitement. The location of obstacles and coins is also known to the experiencer, making it easier to achieve goals. This means that the game loses the frequency of stimuli, which causes the experiencer to begin to focus on the ultimate goal of the game. At this point we found that the game has two goals that are parallel but conflicting, to increase the speed of the ride, and to hit more gold coins. Taking time to hit the gold coin leads to a slight decrease in the speed of riding.

5.2 Further Requirements

Reflecting on this game, we found the lack of incentives, and proposed the requirements for improved design. Firstly, designer must consider the effectiveness of exergames as a long-term incentive to provide a sufficiently varied and always challenging experience. Secondly, the exergame should set appropriate game goals, provide users with enough challenge and stimuli. Finally, the direction of short-term incentives should be consistent with long-term goals.

5.3 Expert Interview

We visited a professional fitness instructor with three years of work experience to seek advice on improved design. We focused on two aspects. One is the practicality of the spinning bike game mentioned above, and the second is how the coach motivates the trainee in his daily work.

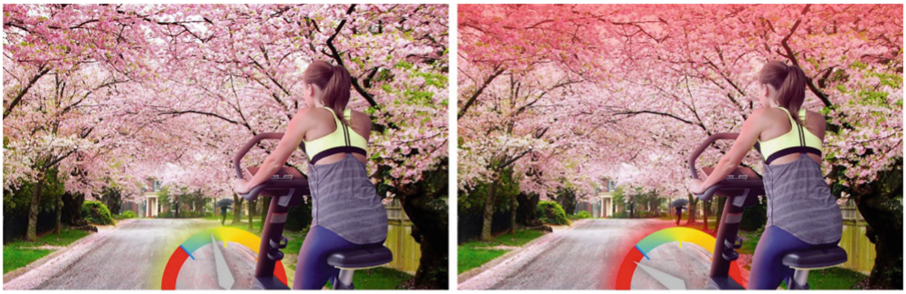
7 open-ended questions were used for collecting more detailed information:

- Do you think this exergame can attract fitness people?
- What do you think of the fitness effect of using exergame?
- What is the difference between using this exergame and training under the guidance of a coach?
- How do you usually guide and motivate the trainees?
- How to make a trainee who lacks spontaneous motivation adhere to fitness?
- How can you help him build confidence when the trainee lacks it?
- What do you think can be improved in this game?

Overall, the coach evaluates the exergame as positive and interesting, although he suspected whether it can improve the fitness efficiency and help users build lasting interest. The coach mentioned that he would use frequent encouragement to help trainees build self-confidence, and even deceptive language skills. Due to the lack of subjective confidence and the neurological self-protection mechanism [17], trainees often find it difficult to persist before they reach the physiological limit. The coach will flexibly adjust the timing to help the trainee improve the duration. Frequent positive feedback is also important. When a trainee made small progress, he will praise in time, using some exaggerated languages. His advice to our game design is to exaggerate the user's performance, such as speed and calorie consumption. This feedback must be frequent enough to ensure that the user is given enough encouragement.

5.4 Primary Version

We first removed the gold coins, an antiquated and useless game prop, because users can't get more fun or improve the efficiency of exercise through it in this exergame. In the new exergame, the only task the user needs to achieve is to maintain different speeds in different scenarios. For example, in a glacier scene, users need to ride at high speed to avoid falling from the melted ice. The dashboard provides the speed feedback and warning in the form of flash color changes (see Fig. 2). We set up richer scenes in order to solve the problem of scene duplication. At the beginning of the game, the user is told to experience cycling in different environments. In each round of the game the user can select any four scenes. Two scenes require high speed (high-intensity) and other two require medium speed (medium-intensity). At the end of each scene, the user was provided a short one-minute break. Although the user is informed that the distance to ride in every scene are same, in fact, the system estimates REP (Rating of Perceived Exertion, HR [bpm] = 69.3 + 6.23*RPE [18]) based on the user's HR (Heart Rate), and terminates the previous scene when the user's fatigue reaches the set limit. In the user's view, a short break is a reward for completing a phased goal. When the user feels tired, the expectation of the next break will support him. At the end of the game, the user will know the time and calorie consumption of the ride.



In proper speed In low speed

Fig. 2. Visual speed feedback

5.5 Upgraded Version

Although primary program basically satisfies the design principles and further requirements, we still find obvious defects. Maintaining the position of the dashboard pointer does not give the user a sense of accomplishment. Although failure leads to immediate frustration, this incentive creates an increase in psychological stress. Although the scene brings a sense of freshness for a short time, it does not take up the user's attention for a long time. Since the task of maintaining speed does not need to be fully focused at all times, and lacks continuous challenges, users are likely to still focus too much on fatigue. This is obviously not conducive to the cultivation of long-term interests. Although the number of scenes is sufficient, the user may still use the same scene repeatedly, and the deception on the distance may still be recognized.

In the upgraded version, we removed the dashboard to ease the psychological pressure, and designed a new form of speed feedback. Without additional information provided by the dashboard, such as heart rate, mileage, speed, etc., users will judge the distance and speed with the reference given by the visual image, such as character avatars, objects (such as trees, obstacles) or road markings. We simplified the content of the scene so that the user can only judge the speed from a specific object, in this case the road marking.

The task of the game is to control the speed to hit the target, called “wormholes” (a wormhole can be visualized as a tunnel with two ends, each at separate points in spacetime [19]) in this game. The route is fixed and the user cannot change direction autonomously. The end of the ride is a visible point in the distance. The challenge is to determine when the “wormhole” (see Fig. 3) will be on the road marking and control the speed to reach it at the right time. The user gets a short acceleration visual feedback after hitting the “wormhole”, which leads to the pleasure of completing the phased goal. In fact, this is benevolent deception provided by the system, the user’s speed will not be really improved. Because there is no stable distance reference system in the scene, the user cannot find the truth. In the process of passing through the “wormhole”, the user can slow down or stop riding, but still feels accelerated in the visual sense. This provides users with a short break as a staged reward. This challenging task, focusing on estimating the speed of the “wormhole” movement and controlling the speed of riding, takes most of the attention, resulting in that the user ignore the slight fatigue. The total distance of each round of the game will not be explained in advance. At the end of the game, the user will know the time of the ride and the calories consumption.

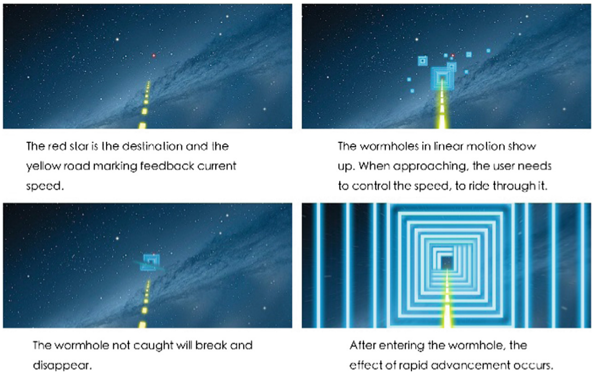


Fig. 3. “Wormhole”, a new game mechanic

The system estimates REP based on the user’s heart rate. When the user’s fatigue is high, the movement speed of the “wormhole” is slowed down, leaving more time for the user. Conversely, when the user does not exert enough effort, the wormhole moves faster and the user needs to speed up the ride as much as possible. Due to the uncertainty, the user will focus on the estimation of the speed of the “wormhole” movement, instead of fatigue and boredom. This game mechanics maintains fatigue at a moderate level and flexibly regulates exercise intensity and time.

6 Conclusion

Through literature research, expert interviews, and design practices, we found the key impact of user predictions on user's performance. The conclusions of psychological research verify this. Highest or most difficult goals produced the highest levels of effort and performance. Performance leveled off or decreased only when the limits of ability were reached or when commitment to a highly difficult goal lapsed [20]. But the particularity of exergame is that fatigue and dynamics change of body perception will affect the user's difficulty prediction. As the exercise progresses, the fatigue increases, the body becomes painful, and the user becomes more and more inclined to lose confidence. The rate of change varies depending on individual physique differences and tasks. Therefore, the aim of benevolent deception in exergames design is to maintain or even enhance the user's confidence during the whole process of sports. Based on the summary of existing sports psychology research and this design practice, we believe that benevolent deception is effective in maintaining and improving user confidence and has the prospect of promotion in different exergames.

7 Discussion

Through an improved design of an existing spinning exergame, we explored the possibility of using benevolent deception to enhance the incentives of exergames. During the design process we found the challenge of using benevolent deception. (1) Avoiding inconsistencies in sensory information. Since human motion perception is direct and sensitive, especially for transient changes, it is not easy to deceive users in motion. (2) Avoiding losing interest. Although the results of sports psychology can be directly applied to exergames, a single, simple task is difficult to bring enough challenging and interesting experiences to users. (3) Considering long-term effective. Deception must not be discovered by users when game is repeatedly played. Taking the primary version as an example, the user is likely to find inconsistencies in the distance between different scenes after several rides. (4) Limitations of equipment form. The form of the device limits the form of interaction.

Drawing on expert opinions has improved our design efficiency, as it increases the speed of data collection and provides key design ideas. Expert experience has a high guiding value due to the rich experience and deep understanding of user behavior. The design of the benevolent deception exergames is a whole new challenge. It is necessary to involve sports physiology, motor psychology researchers and professional coaches in the design process.

The above discussion can provide guidance on the exergame design based on different fitness methods. Further, in the future, it is necessary to explore the limits of the user being deceived and the psychological reaction of the user if deception is found. With the deepening of emotional computing research, the assessment method of emotions, fatigue, and motivation also needs to be considered.

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Unfathomed Voyager: The Design of Real-Life Cooperation Game

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Abstract. Unfathomed Voyager is a real-life cooperation game. Three guests are in a group, and each guest has a control panel with different functions. Unlike most collaboration games appearing on the AppStore, Steam, or other platforms in which players get the same information from an instruction and try to solve the problem together, our guests will receive different instructions that may or may not belong to their own control panel from their monitors, so they need to share the instructions they have with their teammates rapidly in an intense game environment. Information exchange is the key point in this game. There is also some physical cooperation in the game, such as switching stations. By doing it, they can complete the mission and find the blobfish in the deep ocean.

Keywords: Transformational playground · Real-life game · Cooperation game

1 Introduction

There are millions of people who play video games every day on PCs or smartphones. It seems that playing video games with each other makes them get closer. However, the truth is that they rarely talk to each other after the gameplay. It's a significant problem of video games that players are actually isolated with their friends and the real world by the screens. It is a common agreement that the goal of a good game is to let guests reinforce the relationship between each other and also have fun in their real life. So, Unfathomed Voyager aims to reinforce the relationships between players in the real world and let them have fun. As for reinforcing the relationship in the real world, we strongly agree with the idea that people can learn how to communicate and collaborate with others in a game which is also the instinct of human beings. In daily work, people always have different information and ideas, so how to share the information they have with others efficiently is essential to a team. Also, people always have a better relationship with people who communicate more with them. People also choose to trust the people who share the correct information with them. So, our guests can actually get closer through continuously talking and responding to each other. As for letting our guests have fun, we provided a pretty intense game environment so that the whole gameplay is in chaos! We designed to show instructions to our guests just for 15 s each. So they need to respond quickly and then yell out the instruction or operate the

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panel as soon as possible. Through the observation, every play-tester got more and more excited during the gameplay.

2 Related Works

People have often compared Unfathomed Voyager to Spaceteam [1], a popular mobile game with a similar gameplay system. In Space Team, players work together to fly a spacecraft. To do so, they all have a unique set of buttons and switches along with one instruction. The instruction tells the player to set one button or switch to a desired value, but that button or switch may or may not be their responsibility, and therefore they must communicate to make sure that instruction is followed quickly. Buttons in Spaceteam don't make sense. Although each button has a different name, but the name has no connection to the game scene. There is no end state to Spaceteam; there are only ends to stages, giving players some sense of progress and reward.

To research more possibilities of physical interaction, we also played Spaceteam Card Game [2], a card game version of Spaceteam. In Spaceteam Card Game, besides exchanging cards, interactions like switching positions, pulling one player back to table and muting one player were actually inspiring for us.

3 Design Method

3.1 Brainstorm

From the start, we knew we wanted to use Phidgets as our platform, mostly because our team was lacking in programmers compared to other teams, and knew Phidgets were simpler to work with than AR, VR, or the like. Phidgets are simple pieces of electrical hardware, like buttons, switches, dials, and keypads, which can detect real-time input and feed that into a computer. There are dozens of different kinds of Phidgets, ranging from simple ones like switches and touch sensors to more complicated ones that can measure ambient temperature or infrared reflective sensors. We wanted to use a variety of different types of Phidgets, so as to make as lively a gameplay experience as possible, but figuring out a good way to put those Phidgets to work was more tricky. Ultimately, we found that a gameplay experience like the one presented in Spaceteam would translate best to a variety of Phidgets.

Spaceteam was definitely a starting point for much of our design, but we wanted Unfathomed Voyager to have an endpoint, since the play experience is different for the two games; Spaceteam, as a mobile app, may be played any number of times, but Unfathomed Voyager, as a game existing only in a festival, would likely only be played once or twice per person. With Spaceteam, players can keep playing and see themselves last longer and longer the more they played, but if we did the same with Unfathomed Voyager, players would be less likely to know if they did well or not after leaving the game. It wouldn't be immediately apparent to them whether the average team made it to stage two or five or ten, and so it would be harder for them to feel a sense of triumph as they left. Thus, creating a state of success and a state of failure would be much better at communicating to the guests whether or not there truly was cause for celebration.

Another key differentiation from Spaceteam was the input. In Spaceteam, most of the input comes in the form of buttons with a handful of sliders and dials thrown in. We knew that if we wanted Unfathomed Voyager to really be successful, we'd have to embrace the Phidgets, which suggested more varied and engaging input, even if all the symbolism and teamwork were stripped away. Therefore, we gave each player a wide variety of different types of input with no more than two controls using the same device per player, and no more than three with the same device across all players. We also decided not to give every player the same set of Phidgets so the game would feel different depending on which set of Phidgets they received. Also, many of the input devices in Spaceteam would follow the form of an instruction saying something that ordinarily wouldn't be solved with a button, yet there is a button somewhere with a label that makes sense. For example, one instruction in Spaceteam is "Entertain passengers," which requires one player to find a button labelled "passengers" emblazoned with the word "entertain." This input wouldn't work in Unfathomed Voyager, since the Phidgets are too small to write on, and thus the verbs in the instructions would have to be much more indicative of the relevant input device, like push, set, or change, not entertain.

We also wanted Unfathomed Voyager to tell a story, and we considered many options, like that of a barista taking complicated coffee orders or a mad scientist bringing a monster to life. Eventually, we were set on using a submarine to fetch something. We settled on fetching a blobfish because two of the team members who worked together previously meant to use a blobfish in a prior game, but had to cut the blobfish due to scope. Thus, the two felt compelled to avenge the blobfish species by bringing one here. This also fit the fun, silly tone of the game, but it presented a potential issue: what if the players felt bad capturing a blobfish and taking it from its home? The story would have to be constructed in such a way that players would feel like capturing the blobfish was a win-win scenario, so the dialogue was written to portray that the blobfish was bored of living in the sea and eager to start a new life as a crazy oceanographer's companion.

3.2 Player Transformation

According to The Transformational Framework [3], there are some types of transformation, such as knowledge, skill, behavior, belief, relationship and so on.

Unfathomed Voyager focuses on the relationship between players. Can they have a stronger connection after playing Unfathomed Voyager? Do they communicate more? Are they in a better status after playing the game? How can we achieve the transformation? These were questions we asked ourselves when we developed and playtested the game. One of our main purposes in building Unfathomed Voyager was to incentivize guests to communicate more so that they were able to have a good relationship with each other. The basic requirement of the game we designed is that players need to communicate and exchange the information, and by doing that, they can win. There are two kinds of communications in the game: the first is talking about the strategies to win, the second is sharing the instruction. We created a platform to let our guests talk to each other and change their relationship. Through observation of players during the ETC festival, we found it was interesting that nearly all of the guests couldn't stop talking after playing the game. Some of them talked about how to cooperate, and some of them talked about the strategies. Nearly thirty percent of them wanted to play again. And also, our guests could be divided into two different kinds, the first kind of guests were strangers, and they didn't know each other before playing the game; another kind of guests were friends, and they were familiar with each other. In the beginning, we hoped that our design could let them trust each other and strengthen their relationship. But how can they trust each other? Sharing the one hundred percent correct information is the key. Every guest in the game needs to follow the instructions from other guests, even though they don't know each other. During the gameplay, nobody doubted that the information from others was wrong, and they all chose to trust. We designed the mechanic to transmit the information secretly, so that everything people said was correct.

3.3 Storyline and Interest Curve

What's more, to design this game, we created a clear storyline that an old oceanographer needs three warriors to achieve his dream: catching a blobfish. The interest curve [4] was also considered (see Fig. 1).

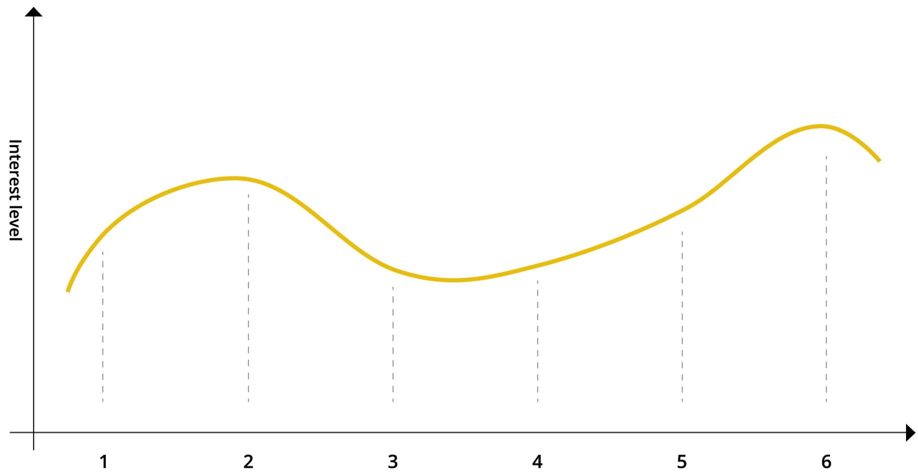

Fig. 1. Interest curve

1. We designed to let the oceanographer tell the background story to our guests by using funny animations and a humorous script. This is the first impression we deliver to our guests and raise their interest in the coming gameplay.
2. After guests choose their avatars, they need to create a team name which aims to let them know that they are a team from now on.

3. According to the playtest, we found that at the beginning, most of the playtesters were overwhelmed by the complicated control panels. So, we designed to give them some time to get used to their control panels before the instructions show up.
4. The difficulty of the game is from normal to advanced. In the beginning, the interface is very clean and polished, but if the players make too many mistakes, the screens become cracked and red and water starts to seep in.
5. We designed a common task which needs to be done simultaneously: Switching the stations. At the transition between the first and the second plot, guests need to switch the stations and get familiar with another control panel as quickly as possible. Switching stations and the melting interfaces push the game to its climax.
6. Finally, they find the blobfish and return her to the oceanographer, and that is the end of the interest curve.

3.4 Playtesting and Iteration

In very early versions of Unfathomed Voyager (see Fig. 2), players had different roles; some would see instructions but not be able to carry any out, and others would never see instructions, but be able to follow instructions.

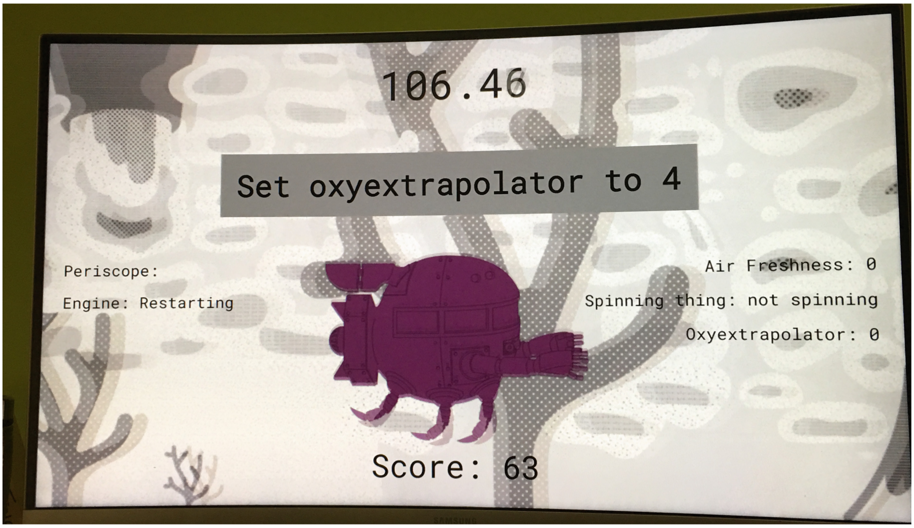

Fig. 2. Initial version/Playtest

We quickly found that depending on each player's personality type, there would be one role they'd enjoy, and one role that would either bore them or make them anxious, and it wasn't apparent to players before starting which role would appeal to them more. Since this led to half the players having a bad experience, we redesigned the game so that every player could both see and follow instructions (see Fig. 3).

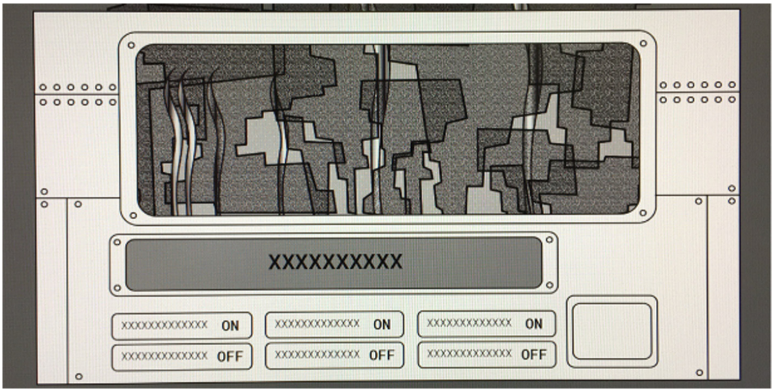

Fig. 3. Iteration

Another problem we had noticed was that many players either didn't realize that not all instructions they saw applied to them or that not all players saw the same instructions. We altered some instructional text to mitigate these issues.

Players also weren't noticing the vast majority of their screens during the main gameplay, because they were so focused on the instruction bar. They were so focused to the point that if they saw the game when they weren't playing it, they'd barely recognize the main gameplay screen, aside from the one instruction bar. This meant that they didn't notice the indicators of the current values of all their controls or the bar that showed the current health state of the submarine, which can provide great clarity during the game (see Fig. 4).

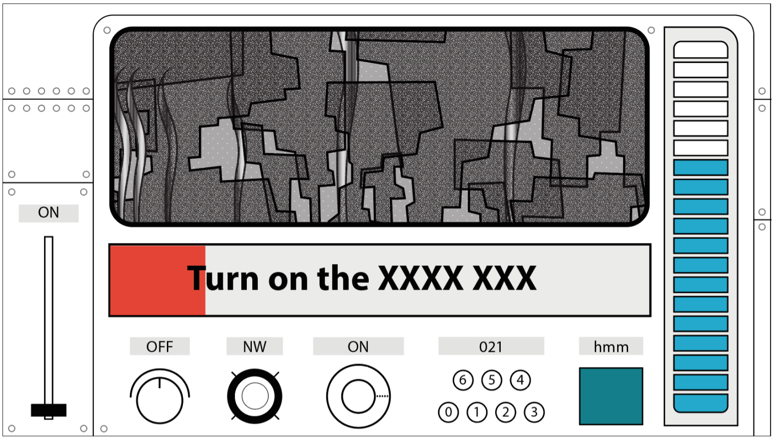

Fig. 4. Iteration (Health bar)

To solve this, we added a period in the beginning of the gameplay when players are encouraged to explore their controls and the interface without consequence, which solved the problem.

We realized that during the gameplay period, the interest curve was getting a bit flat halfway through, which prompted the inclusion of the intermission period in the middle and the station switching, which gave players a new station to look at, keeping the gameplay fresh. We also liked the collaborative tasks of Spaceteam, but felt like a task that required everyone to act should feel more impactful, which is why we made sure that starting the autopilot (which triggers the intermission and the end state) was a collaborative task, asking all players to do one thing that everyone had on their control panel: press the zero button, representing the amount of work they'd have to do in the next 15 s. Not only did this create more variation in the gameplay, but also the act of running to a new gameplay was often a source of smiles and laughter, which was very refreshing after a minute of players screaming at each other to set the piezogauge to 0.7, push the life support, or spin the spinning thing.

4 Implementation

We used Phidgets as the input and combined all the elements in Unity3D with three monitors for guests and one big screen for the audience. The monitor for guests shows the status of the control panel and the instructions. The audience screen shows the real-time score and the whole process of gameplay, which can let the audience engage in the gameplay. We also used laser-cutting to make the control panels. Each control panel contains five or six phidgets.

The main game uses a list of scriptable objects, each representing one task. Each task object contains a task message, corresponding Phidget, type of variation (range of values, cardinal direction, list of words), and all the variations possible (e.g. integers between 0 and 3, the eight main cardinal directions, or minimum/average/maximum). For example, a task may have the message "Set the exhaust gas temperature to _", Phidget slider 2, variation is a list of words, and those words are minimum, average, and maximum. Tasks are chosen semi-randomly (tasks that were completed via operating a Phidget shaped like a box that had to be rotated to a correct orientation came up twice as often as any others, since we learned that this was the most fun Phidget to operate), and the game checks for their completion by storing Phidget input as a variable showing the value of the control, and compares the value of that variable to the value the task demands. For example, if the task from earlier required the exhaust gas temperature to be set to average, the program would first take in slider 2's value, which is a float between 0 and 1, 0 being all the way down and 1 being all the way up. It would convert that to an enum for relative exhaust gas temperatures (0–0.03 → minimum, 0.03–0.4 → low, 0.4–0.6 → average, 0.6–0.97 → high, 0.97–1 → maximum), and checks to see if the resulting enum is average, as the task requested. If it was, the task would be completed, the submarine would get a temporary speed boost, and a new task would be chosen. If the task wasn't completed within 15 s, the submarine would shake, the instruction bars for the player who was supposed to operate the exhaust gas temperature and for the player who was supposed to communicate that the exhaust gas temperature needed changing would flash red, showing they did something wrong in the one part of the screen they're most likely to look at.

The reasoning behind the names of the different controls was twofold: firstly, they had to make the players feel like they were really piloting a submarine, and secondly, they had to contribute to the humorous tone of the game. Most of the controls have names that sound like very technical pieces of equipment, but are actually fake words. The piezogauge is one example of this. In reality, there's no such thing as a piezogauge. However, piezo - as a prefix means pressure, and the suffix - gauge means measure, and a device that measures pressure would likely be right at home in a submarine. This also created some fun moments for players who didn't speak English as their first language, who would often remark that their English wasn't good enough for this game, but when they found out these names weren't words in any language, they'd usually be very surprised and amused. Also, every control panel had at least one control that didn't appear particularly useful, such as attitude, paint color, and the 'spinning thing'. These were added mainly to break some tension that may be caused by three players shouting at each other; having your two teammates scream at you to carry out different tasks can be stressful, but if they're screaming at you to "change your attitude to freaking out," the absurdity of that demand took away some of the anxiety. Overall, the names of all the controls were made to make the game seem real, but still make the journey feel more humorous than hardcore.

To emphasize the game experience, we focused on the word "submarine" and integrated game content, user interfaces (see Fig. 5), control panels (see Fig. 6) and the decorations of the game room.

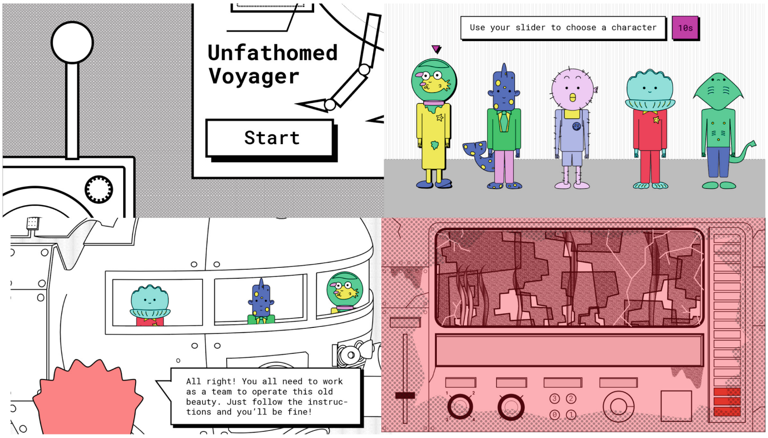

Fig. 5. User interfaces

The story happens in an old submarine, so that all the elements we put into this game have the sense of a submarine. To simulate and amplify the feeling of being in the submarine, the interfaces we designed look like the windows in the submarine. And

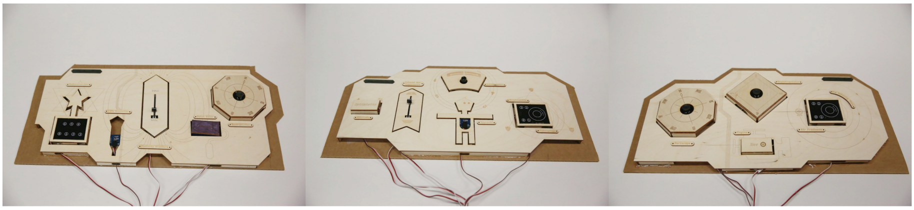

Fig. 6. Control panels

also, we used the same windows to decorate the game room. All the decorations, game interfaces, and animations have the same art style. As for control panels, all of the functions are related to operating a real submarine. We linked the operations with the interfaces by showing the status of control panels on the players' screens, which also makes the game more like driving a submarine in real life.

5 Conclusion

We followed a rigorous pipeline to design Unfathomed Voyager, through research, brainstorming, paper prototypes, iterations, and final presentation. We refined the interaction in gameplay and gave all the operations meanings. During the process, we did a lot of playtests. Playtests are always the most helpful tool to let us know the details which need to be improved.

After three rounds of playtests and iterations, we brought the unconventional and innovative experience to nearly 200 people at ETC festival 2018. For ETC Festival, we introduced experience design methodology and location-based entertainment theory into our game and decorated an ETC office as an submarine (see Fig. 7).

Fig. 7. Room decoration

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Fostering Interactivity Through Analogue Principles Applicable to Design of Virtual Reality Games

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Abstract. This contribution presents interactive art model, introduced and tested in the art practice by J. Vančát with respect to the tradition of Czech school of structuralism. In principle, this model attempts to visualize the interaction of larger groups (8–12 persons) in a pluralist environment through a symbolization process with real objects. This model might offer an alternative view of a game in virtual space alike. Social impact of such a project might have a potential in visualization of the social roles and interests in a group. Authors briefly investigate also the potential this model might offer to the design of virtual reality environments and computer gaming in general.

Keywords: Czech school of structuralism · Virtual reality design · General interactivity principles · Structuralism and collaborative design · Art-based interaction design practice · Playful experiences

1 Introduction

We argue that virtual reality (VR), although currently speeding up its development on the technological level (hardware and software), is in its implementation limited in the level of the imagination of the users.

The imagination of the VR user must be reconfigured from the modus of reception that has been constructed by the previous visual structurations. We understand such a structuration from the position of the general visuality development (see Fig. 1).

Current generations do still meet the meaning of art education in the frames of visual model Nr. IV in Fig. 1. The majority of the population is successfully decoding the visual model of Renaissance as these recipients are already trained by daily processing of the cinematographic image and this includes a perception and understanding of mutual interrelations of visual objects, although related only to the stable position of the viewer. Introducing the viewer to the perception and understanding of the visual substance in VR is then not only simple utilization of natural perception but an instruction in the decomposition of the Renaissance model in dependence to the movement of the own body. Here must be emphasized that the imagination in the frames of model Nr. V in the relation to the movement of the own body is applicable only to the small minority of the recipients. The vast majority of the recipients is still

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dependent on the understanding of the Renaissance model and not trained in the comprehension of abstract art model.

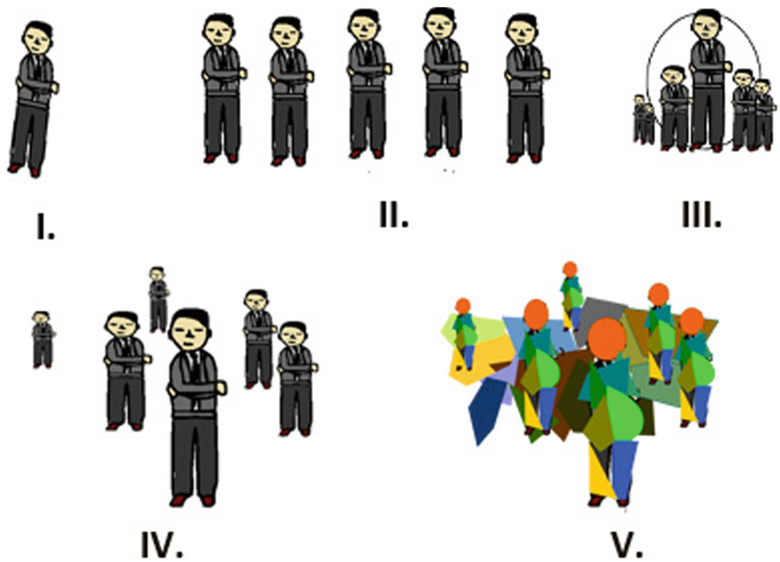

Fig. 1. In our model, we understand the development of visual expression as an instruction of the viewer in the comprehension of gradually increasing number of relations between displayed objects and particular elements: I. Paleolith, II. River Civilizations, III. Art of Christianity, IV. Renaissance, V. Modern Art.

In such a virtual interaction model, any collaborative activities among large number of persons lead to the loss of overview over the corpus of interaction. These days, the developers still design computer interfaces more or less in the face-to-face mode, so in the art where the mutual understanding of collaborative virtual interface is problematic and limited. The user of computer games might swap between different roles in the game, but in principle is still impossible to associate the roles in real time with the taking the roles by the others. In virtual reality computer games, the option to swap the roles is not identical with a requisite to hold a gross overview about the co-location of the other players as the essential prerequisite of pluralistic discussion. Although recent rapid developments in the area of game design for collaborative virtual reality keep the promise of such an environment, currently is the visualization of pluralistic communication still easier in the analogue physical situation settings.

In this contribution, we present the potentials of original art project model that might open new pathways in the process of virtual reality design. During the interactive sentence, this model enables the users to gain a gross idea about the background of virtuality and overview of the particular interactive situation as such.

2 Legacy of Structuralist Approach in Arts

Paving the way to the structuralism, this became, as may be seen today, one of the great contributions of Czech culture to the world heritage in the interwar period, when Czechoslovakia became surrounded by totalitarian regimes. During their study of language and art, the members of the Prague Linguistic Circle proposed a different model for understanding of large corpuses. Especially, uncovered how this model applies to organizing a supernumerary quantity of individuals, components or elements.

Cézanne's invention of how to fine-tune 'the relationships of various tones' [1], so as to achieve a 'perfect' picture is activated by Mukařovský's definition as the 'effect of transformations of parts to transformations of content and the dynamization of wholes, through which, by the nature of this dynamic, transformations, and the growth of their relations' [5], we can attain an entirely new *structural approach to the world* 'We refer to the mutual relationships between a structure's components, relationships that are intrinsically dynamic, as a specific characteristic of the structure of art. According to our conception, we can consider as a structure only such a set of elements, the internal equilibrium of which is constantly disturbed and restored anew and the unity of which thus appears to us as a set of dialectic contradictions. That which endures is only the identity of the structure in the course of time, while its internal composition and the interrelationships of its components are in constant change.' [5].

Dialectical contradictions still retained some residue from Plato in the concept that only one or the other contradiction might be sustained in the structure after such a 'duel of dialectical contradictions'. However, if we view the elements of the structure entering such an interaction also as structures at their subordinate level, also composed of elements one structural level lower, their interaction is not necessarily a duel of A versus B, but rather a structural modification of each of the interacting elements.' [5].

It is outside the scope of this contribution to provide more detailed evidence of how the concept of structure was enriched and further developed by French postmodern philosophy, which emerged from a critique of the static interpretation of structure by Levi-Strauss, who – as opposed to Mukařovský's interpretation – sought in it a solid, timelessly stable network of mutual relationships.

Levi-Strauss sees the meaning of structure as a set of stable parts 'Probably there is nothing more than that in the structuralist approach; it is the quest for the invariant, or for the invariant elements among superficial differences.' [3].

For a purpose of analyzing visual works, we can understand postmodern philosophy and art theory as an elaboration of Mukařovský's synthesizing dynamic definition of structure in details, which had been known far earlier from the efforts to resolve the question of organizing a painting – by comparing, for example, one of Derrida's fundamental discoveries 'The play of difference supposes, in effect, synthesis and referrals which forbid at any moment, or in any sense, that a simple element be present in and of itself, referring only to itself.' [2], with Cézanne's description of his method for building the picture 'The secret of drawing and modelling resides in the contrasts and relationships of tone'; 'There is no such thing as line and modelling. Drawing is a relationship of contrasts or simply the relationship between two tones, black and white' and 'There is no light painting or dark painting, but simply relations of tones.' [1].

In our research approach, we understand and promote the study of the visual representations that characterize postmodernism not only as an undeniable visually mediated fact, but as a *method for organizing structure from a supernumerary quantity of elements,* Mukařovský's approach thus still might offer very clear, valid and understandable criteria.

3 Postmodern Echo

If we can therefore understand modernism – as we can see with our own eyes from the pictures it produced – as a deconstruction of the preceding solid, objective world through sharpened attention to its parts, postmodernism can show what this is good for: to be able to investigate more deeply and thoroughly how the world functions in motion and change, in growth and transformation.

The new Grand Narrative that postmodernism offers, despite the currently predominant skepticism, builds the whole not from stable parts determined by their sole purpose but also from individual active agents cognizant of their unique potential and capable of using it in their interactions with other equally free agents, thus forming unprecedented wholes with as yet in-credible possibilities.

Consequently, many established positions must be re-evaluated from their very foundations so as to arrive at the new Grand Narrative: thus the notion that vision copies reality has suffered the same fate as the 'realistic' nature of pictures. Cognitive neurologist Vilanayur S. Ramachandran interprets vision as a strong back-projection, with the brain checking which visual images that the brain created earlier and has available for a given situation are best suited for an incoming percept. The earlier order of 'percept – image' proceeds in the opposite sequence, and thus in a new hierarchy – 'The imagination controls perception'. In the end, it is the imagination that guesses what solution best applies to the given situation. These suitable solutions, interpreted as 'true vision', are accompanied by an active reward, thus creating preferred visual fields of our experience in the world.

'In a sense, when we look at the world, we are hallucinating all the time. One could almost regard perception as the act of choosing the one hallucination that best fits the incoming data, which is often fragmentary and fleeting.' [8].

Authoring visual images – models for 'hallucination' as described above – is evidently the purpose of art. Experimental art constructs images that, for now, are not at risk of being incorrectly applied. If such a defective model occurs in art, the worst-case scenario means then only that a particular person doesn´t like the picture. But, if we do, they become visual images that will subsequently have a major impact on our real life orientation in the real world.

In this way, we can use pictures to create daring visual images that we have not yet encountered in our everyday lives but that we sense may suit us in situations that have yet to happen and in places that we have yet to reach.

4 Interactivity as a Design Principle

4.1 Idea

The difference in interaction between the objects, invented by Dadaism, and also by Surrealism in the 1930s, in this the objects had a metaphorical effect and focused on feelings of individual, personal levels - such as subconscious contents, dreams, erotic content.

On the other hand, in postmodern situation, these originally sensational interactions are outdated, they are visible everywhere, they became to be trivial. Their effect is being manifested in social trends (at a structural level higher than the level of individual existence that are the result of interactions of these individual interests (see Fig. 2).

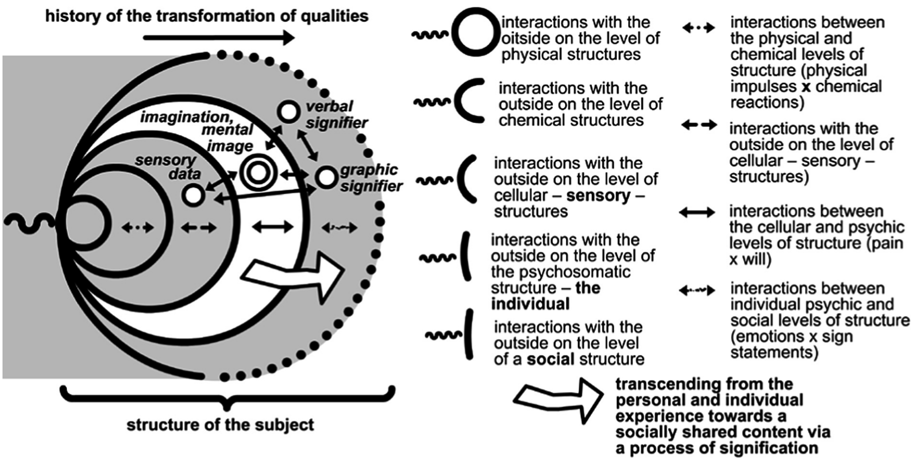

Fig. 2. J. Vančát – Structural Model - Visual Reception [7].

4.2 Interactive Approach

Interactive media have at their disposal a power to set the designed environment and objects into various relations and are so an ideal medium for the expression of the multiplicity of ideas. A commonly shared experience offers a prerequisite of any sort of a fair communication.

We would like to establish such a communications in the frames of interactive media experience we have experienced during our research and pedagogical activity at the Creative Arts Department at the Faculty of Humanities, Charles University in Prague.

Part of the department's primary research focus is a current state analysis of creative arts from the point of view of gnoseological and communication impacts. At the core of our research is the development of a methodology for collaborative visual design that facilitates the understanding of the pluralistic character of these gnoseological and communication processes for both students and researchers.

According to this methodology, our students operate with design objects (inspired by Dadaist and Surrealist artistic techniques) and set these objects in mutual relationships according to their personal preference.

Complex structures might be designed in the case of the implementation of a higher number of included elements (see Images 1, 2, 3). The interpretation varies according to the algorithm given to the user, and these users must act according to this algorithm without having the option to communicate with the others about joint design. Such poly-valence in designed structures is then a stimulating source of inspiration for the following interpretation, discussion and evaluation. The configuration and composition of objects, while not plain in logical descriptivism, expresses visually experienced approach. Such an intuitiveness has been enabled by the alteration of various set-ups of designed object formations, the alteration of a single object's positions carries with it the alteration of a network of relationships alike.

4.3 Design Workshop

While the surrealistic acts of avant-garde are modeled by interactions of individual objects with one another[1], the postmodern approach is modeled as follows:

Approximately 12 students and the objects (e.g. boxes of cigarettes, pencils, apples, etc.), it is good to agree that two or more listeners do not have the same subject, as then it would appear a problem with identifying their involvement in of the corpus. Gradually one by one, they each place one object on a defined area (tabletop, bounded on the floor). The same procedure has been reiterated in the further cycles.

The main feature of the workshop is to define the instruction that becomes the way to gradually add its objects to the surface. The most common instructions are:

a. try to guess what tendencies are taking place in the collaborative work and try to support them. During the process, you must not talk to anyone;
b. try to stand out by the composition of their sequentially folded items. Here we usually severely limit the area so that, in the absence of space, individual projects have to intersect and compete. This way we add a rule that a participant can remove one of the already placed objects in the highest layer instead of placing their own instead of inserting their own item when it comes to it.
c. arrange with a couple and their subjects to try to excel - without further co-ordination;
d. find someone whom you will complement and support by submitting your subjects without any mutual support;
e. one half of the participants in the first part of the game can, if they come in line, place three objects (it has so much influence on the foundation structure); in the second part, three objects have the second half (it has the possibility to influence the final shape of the structure).

[1] Comte de Lautréamont, who inspired the surrealists, quoted: 'It is beautiful as a random meeting of the sewing machine and the umbrella on the autopsy table!'.

In our research practice, we have learned and tested that it is possible to alter much more instructions performed by the participants of the design project in a mutual interaction.

Image 1. The configuration of structures has become established in the various sets of even objects chosen by the users, while not being aware of the intention how the objects will be further implemented. (In the concept of pluralistic approach, introduced in the frames of interactive process, is the option interpreted as the unique determination that has been personally introduced into any type of interaction. The participants do learn how to utilize the potentials of the selected object towards enforcing the original features in the totality of the corpus structure.)

In the final phase, the participants draw their object-placement strategies, and the intended situational placement and the one that really appeared on the scene. Other drawing then attempts to visualize what the participants consider as dominant in the structure, valid creation elements, or objects representing the success of the concept. Further, our participants may watch the video-documentation of the running project and so identify milestone in the structural design. These positions identify the point when their plans have become fulfilled. Such a structure by its versatility in the process clearly demonstrates transformational impacts of these interactive design procedures.

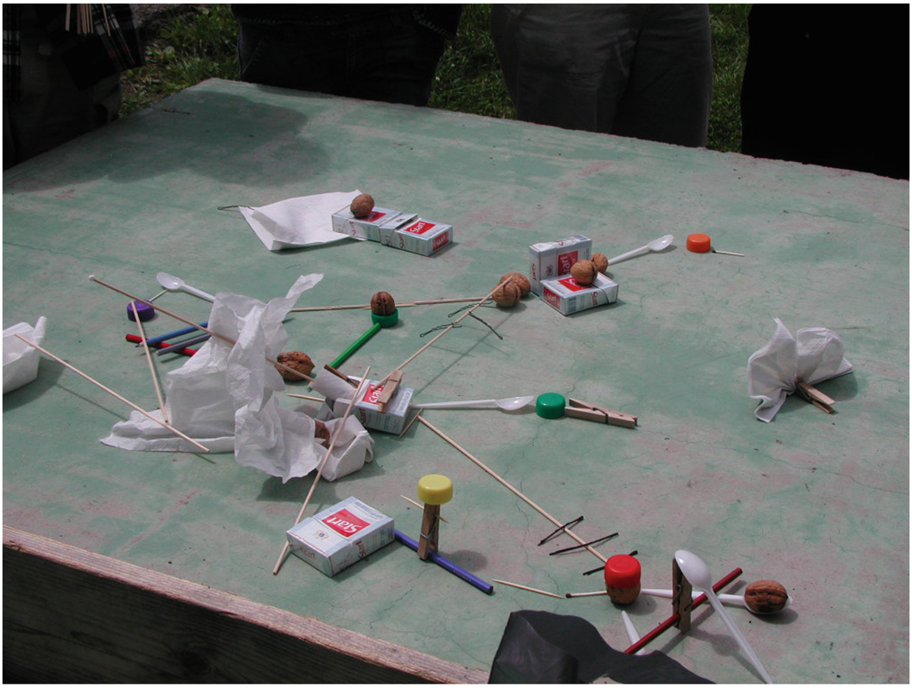

Image 2. The results of instruction: attempt to uncover what tendencies develop within the structure and try to promote them with own object-types. Such a structure in this period mimics a picture style by Kandinsky and so evokes its relationship to the structured reality closer than expected.

All these and other similar tasks, which the students are called upon to do, aim at studying processes in structure growth and its interactions, which I consider, this has become an innovative qualitative feature of postmodernism. Students are free and active to participate in the structure and its development. On the contrary, their inventions are being welcomed both in the creation itself and in the analysis of the results.

You often plot in drawings and compare how these sketches often present different views of the same structure according to the position the listener tracks from the structure - usually he notices more relationships about the part of the structure he himself has created.

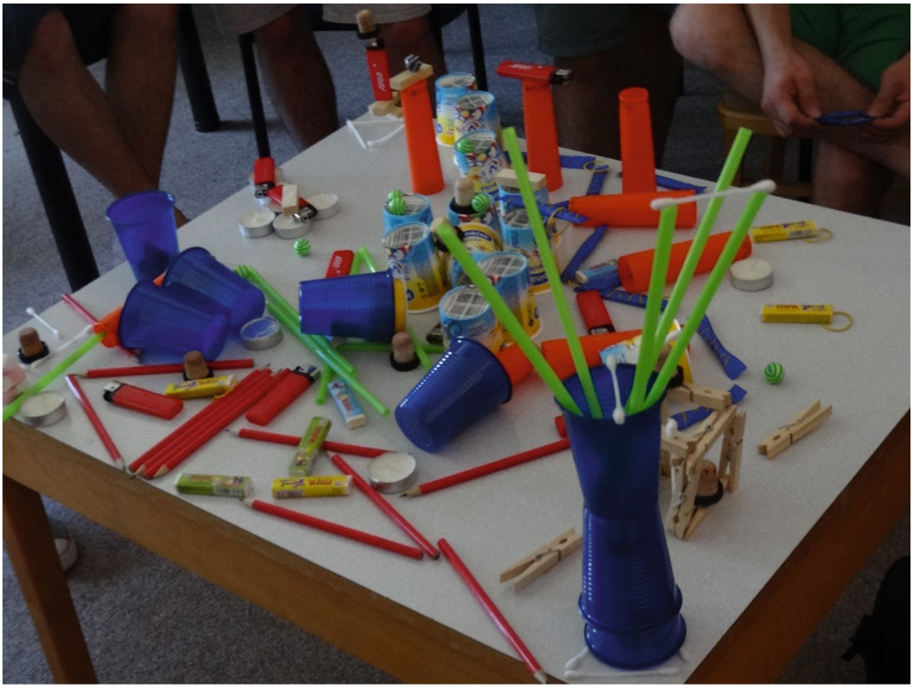

Image 3. The result of interaction with the instruction: ‘attempt to surpass others’. With the exception of objects positioned with aspiration to be above other, normally comes to higher condensation in the frames of single type of object. The participants often attempt to design a shape isolated from the other participant’s objects.

5 Conclusion

Our understanding of the principles of interactivity learned in the research and daily educational practice in the frames of creative arts department might bring the following impacts in the area of virtual reality design:

1. The participants do profit from learning about the process of relational structuration of spatial object and cultivate their virtual imagination.
2. The participants might become able to visualize their spatial situation in its gradual dynamics and so perceive virtual reality not only in its full sensory 3D position but also in its time-space transformation.
3. The participants get an idea about the principles of visual structuration of their senses much closer to the abstract model of art (Nr. V in Fig. 1) and so implementation of the achievements of (post) modern art in the visual perception.

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"Naughty AlphaGo": Transforming the Game of Computer Go into an Emotional Tangible Playground

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Abstract. The game of Go is a traditional board game originated in ancient China and has long been viewed as the most challenging of board games for artificial intelligence. In 2016, AlphaGo defeated a human professional player in 19 × 19 game with deep neural networks. The ground-breaking advance in computer Go brought artificial intelligence into public view and raised discussions on how to interact with machines in the future. However, AlphaGo is still a highly intelligent computer program without emotion and personality. This paper presents a novel game design of "Naughty AlphaGo", which is an emotional Go robot player based on AI algorithm. Result shows that the emotion expression approach based on behavioral and kinematic characteristics can support human players' perception about the AI player's emotional states through interaction.

Keywords: Computer Go · Emotional design · Human-robot interaction

1 Introduction

The game of Go is a traditional board game originated in ancient China. There are two players in the game, *Black* and *White*. Two players take turn to place their stones on an empty intersection of a square grid-patterned game board, the size of which is 19 × 19 in most official games. The game ends when both sides agree that there will be no more moves. At the end of the game, the winner is determined by counting stones and points in Chinese Rules [1].

The game of Go has long been viewed as the most challenging of board games for artificial intelligence owing to its enormous search space and the difficulty of evaluating board positions and moves. Before 2016, there were no computer Go programs that can challenge a human professional player in the full-sized game. AlphaGo is the first computer program to defeat a human professional player in 19 × 19 game. It combines Monte Carlo simulation with value and policy networks to achieve a 99.8% winning rate against other Go programs [2]. In 2017, AlphaGo Zero achieved superhuman performance and winning 100-0 against AlphaGo [3].

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The ground-breaking advances in computer Go brought artificial intelligence (AI) into public view and raised discussions on how to interact with machines and robots in the future. However, AlphaGo is still a highly intelligent computer program without emotion and personality. Although previous study raised emotional expression issues in the game of Go [4], it only aims to make Go beginners enjoy watching or playing Go game rather than personalize AI Go program as an individual with emotions. This paper aims to enable emotional expressions for the game of Computer Go, through which the human player views the AI player as an independent individual with identity, personality and feelings.

This work presents a novel game design of "Naughty AlphaGo", which is an emotional Go robot player based on AI algorithm to support human players' perception about the AI player's emotional states through interaction. The system is implemented as an emotional tangible playground and was brought on public exhibition for validation. Result shows that the emotion expression mechanism based on behavioral and kinematic characteristics can support the perception of AI player's emotions.

2 Related Work

The design and implementation of emotional robots have been widely discussed. In 1995, Rosalind Picard [5] first brought up Affective Computing to refer to the study and development of systems and devices that can recognize, interpret, process and simulate human affects. It views emotions as a kind of information and has been the mainstream of emotional artificial intelligence. For example, Suzuki implemented an intelligent agent system for human-robot interaction through artificial emotion [6], which expresses emotions through LED lights and music. However, this emotional design paradigm has been criticized as fake for its mathematical view of emotions [7].

In 2007, Boehner [8] brought up a new perspective of viewing emotions: emotions are expressed and perceived through interaction, which are dynamic, culturally mediated, and socially constructed and experienced. In this view, the design of emotional robot should aim to support human users in understanding, interpreting and experiencing emotions during interaction. A simple artwork *Useless Box* designed by Marvin Minsky is a representative of such design [9]. When the human user toggles the switch to open the box, the box will close itself by toggling the switch again. Through simple interaction, this box expresses a wide range of possible emotions such as lazy, capricious, negative or angry. This paradigm is also widely adopted in the emotional design of games [10].

The design and augmentation of the classic game of Go also draws much attention. In 2013, Lee proposes a soft-computing-based emotional expression mechanism for computer Go [4], which supports Go beginners to enjoy watching or playing Go game. However, its mathematical-model based design only enhances the enjoyment of human Go player but fails to build the AI player as an independent individual with identity, personality and feelings. Besides, this research is based on the video game of Go, which loses the tangible interaction to game objects in board games. Therefore, human player cannot observe the movements and duration spent for an action, which is important for one player to get an idea of what the other player was thinking [11].

Therefore, our study focuses on enable emotional expressions for the game of Computer Go, through which the human player views the AI player as an independent individual with identity, personality and feelings. Besides, the game is designed in 3D physical world with a serial robot arm representing the AI player, which enhances the AI player's identity enables tangible interaction for better emotional perception (Fig. 1).

Fig. 1. Concept design of "Naughty AlphaGo"

3 Design Process

The design of "Naughty AlphaGo" is carried out under the Chinese rules of Go [1] with a 19 × 19 chess board, which is in accordance with AlphaGo to give human player the first impression of a serious Go match. The human player plays black stones to trigger the reaction of robot as it is a rule in the Go match that the player who owns black always takes first move.

3.1 Emotion Expression Mechanism

The emotions of Go robot can be expressed through both behavioral and kinematic characteristics, which are the key design goals in this research.

Behavioral characteristic is defined by how the robot behave towards certain input. This is further explained in Sects. 3.2, 3.3, 3.4. Kinematic characteristic is how the robot arm moves in kinematic way, which is illustrated in Sect. 3.5.

Besides, contrary to myriad possible inputs during the game play of Go, it's too complicated and nearly impossible to recognize human player's intentions for every possible input and response accordingly. Therefore, the personality of Go robot is firstly set to balance between various inputs and limited response patterns.

3.2 Personality Settings

Considering that AlphaGo is a master in the game of Go, we set the personality of our emotional robot to be naughty and proud. This personality is expressed through the following behavioral characteristics:

(1) If the human player is good at Go, the robot will play Go game seriously and try to make best decision.
(2) If the player has little knowledge in Go and makes a series of bad moves compared with the knowledge of our Go robot, the robot will tease the player by playing the Snake game or finishing patterns.
(3) If the player makes a series of invalid moves, the robot will get mad and clear the chess board.

Bad moves are defined as the moves with low winning chance (<0.3) in Go mode. Invalid moves are the moves that violate pre-defined rules, which will be specified in Sect. 3.3.

Another factor affecting the game experience is the number of bad/invalid moves leading to mode switching, referred as to N. If N is too large, the interaction process before mode switching will be too long. If N is too small, no reliable judgment can be made upon the player's Go level or understanding of current rules. In this research, N is set to be 3.

Through such personality settings, not only is AlphaGo's highly intelligent identity strengthened, but also the possible inputs can be simplified by categorizing invalid input as a whole.

3.3 Game Design

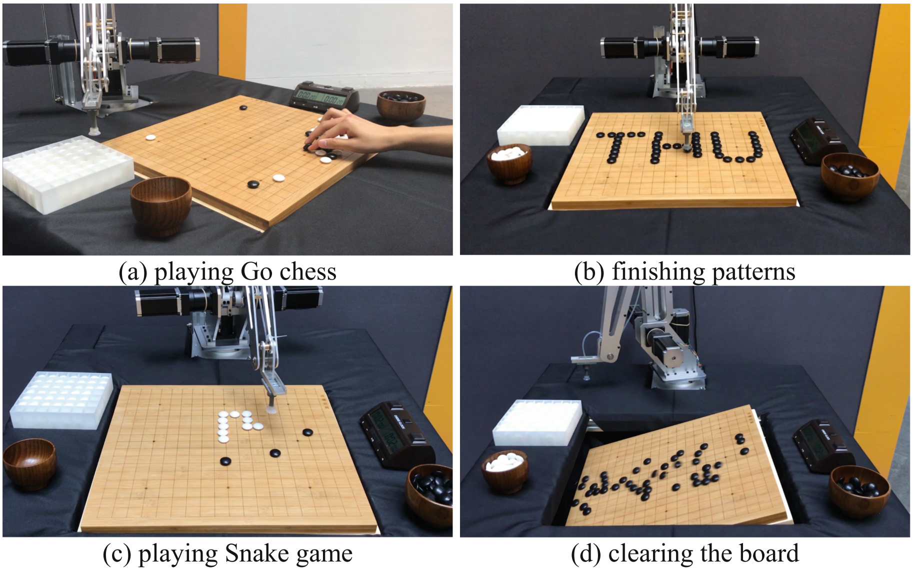
As is shown in Fig. 2, there are four pre-defined game modes: playing Go, finishing patterns, playing Snake game and clearing the board.

Different game modes differ in behavioral characteristics, which reflect the robot's different emotions. Playing Go is the *default mode* and reflects that the robot is taking the current match seriously. Finishing patterns and playing Snake game are two *teasing modes* which transform the chess board into a pixel game playground and reflect the robot's irony. Clearing the board is a *transient mode* and reflects that the robot is enraged by the human player.

Playing Go. During Go mode, both the human player and the robot can only place one stone per turn or remove stones with no liberties. Any other move is defined as invalid, which the robot will switch directly into a teasing mode. There is no noticeable hint of mode switching, which enhances the naughty personality of the robot.

Besides, if the player makes a series of N bad moves (which are low in winning chance), the robot will despise the human player by silently switching to a teasing mode.

Finishing Patterns. The go chess board can also be seen as a pixel game playground, which is natural for minigames such as finishing pixelated patterns.



(a) playing Go chess (b) finishing patterns

(c) playing Snake game (d) clearing the board

Fig. 2. Different interactions in four game modes

During finishing-pattern mode, the robot will guide the human players to finish a pre-defined pattern. All the patterns are designed with simple emotional meanings, which are easy to guess and understand for most players (Fig. 3).

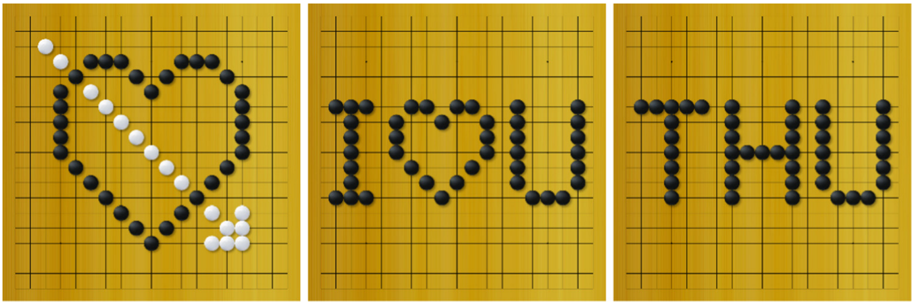


Fig. 3. Examples of pre-defined pixelated patterns

When entering finishing-pattern mode, the robot will first remove extra stones, and then finishing half of the pattern including stones in the key position to make it easy for human player to guess the entire pattern.

The initially proposed valid input in this mode is to place one or more stones belonging to current pattern, or to remove one or more extra stones. To allow for occasional errors in the design, human player's input is judged to be valid if the number of stones rightly placed or removed is larger than that of stones wrongly placed or removed.

Playing Snake Game. Snake game is a well-known video game, with its classic design dating back to 1976 in arcade game Blockade [12]. The player controls a snake to eat food and avoid hitting the surrounding border as the snake grows in length.

In sharp contrast to the game of Go, Snake game requires much less mental activity and has wider popularity. Therefore, it's integrated as a teasing game mode in "Naughty AlphaGo", which will appear when the human player is bad at Go (Fig. 4).

(a) classic Snake game [13] (b) Snake game on chess board

Fig. 4. Snake game on the platform of mobile phone and the chess board. (a) classic Snake game [13]. (b) Snake game on chess board

In Snake game mode, the robot controls the movement of the snake composed of white stones to eat food represented by black stones on the chess board. The human player's input is judged to be valid if the number of newly placed food (black stones) is larger than that of wrongly removed ones.

Besides, if the human player moves any one of white stones, the robot will feel offended and clear the board immediately to express its anger.

Clearing the Board. Clearing the board is a transient mode and reflects that the robot is enraged by the human player. After clearing the board, "Naughty AlphaGo" will switch to a random mode and start a new round of game (Table 1).

Table 1. Rules and valid user input for different game modes

Game modes	Basic rules	Valid user input (per turn)
Playing Go chess	Chinse rules of Go	Place one black stone
Finishing patterns	Finishing pre-defined patterns	Place stones in the pattern or remove the extra ones
Playing snake game	Robot controls snake while human player places food	Adding more black stones as food

3.4 Interaction Design

Interaction Flow. Different game modes are integrated into a complete interaction flow based on the personality settings of "Naughty AlphaGo". In brief, if the human player obeys the AI player's intention, the AI player will continue with current mode. Otherwise, the AI player will laugh at the human player or even get mad (Fig. 5).

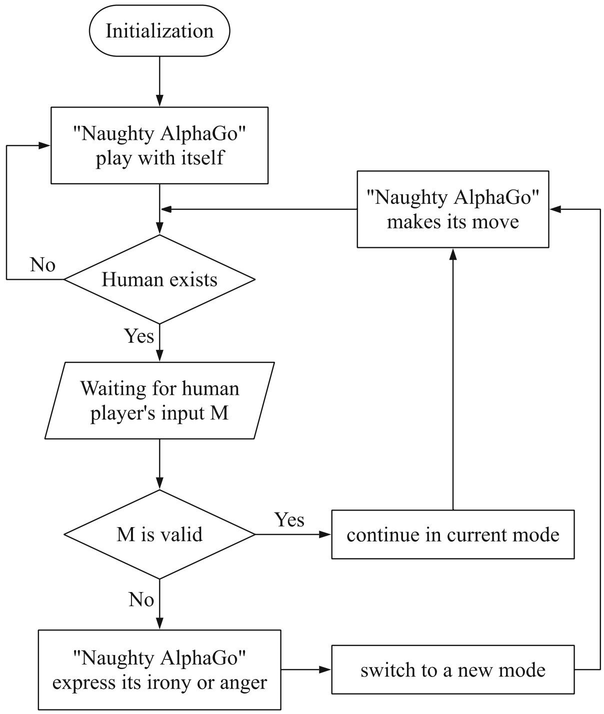


Fig. 5. Interaction flow of the mental model of "Naughty AlphaGo"

Dealing with Guidance. "Naughty AlphaGo" is specially designed to express its proud and naughty personality by capriciously switching from one game mode to another without any obvious hint. However, in order not to confuse human player, proper guidance is needed for user to understand different game modes through interaction.

When entering finishing-pattern mode, the robot will first remove extra stones, and then finish half of the pattern including stones in the key position to make it easy for human player to guess the entire pattern. Besides, the robot will also double tap on the chess board to give the user a hint of right position for black stones.

When entering Snake game mode, the robot will initialize the board with a snake at least 3-stone long and 3 pieces of food. Then it will eat all the food by itself to give user the intuition of Snake game.

Tangible User Interface. As shown in Fig. 7, the user interface is designed similar to standard Go match layout. The counting-down clock is a common device in standard Go match for both players to make move by turns. In this design, it can also help to detect when the human player has finished current turn by detecting the state of the player side button, which will be difficult otherwise with any possible input.

Besides, no clearing-board button is provided for the human player to draw a distinguished line between the AI identity and the human user. Only "Naughty AlphaGo" can clear the board on his own will, not as a servant for human player (Fig. 6).

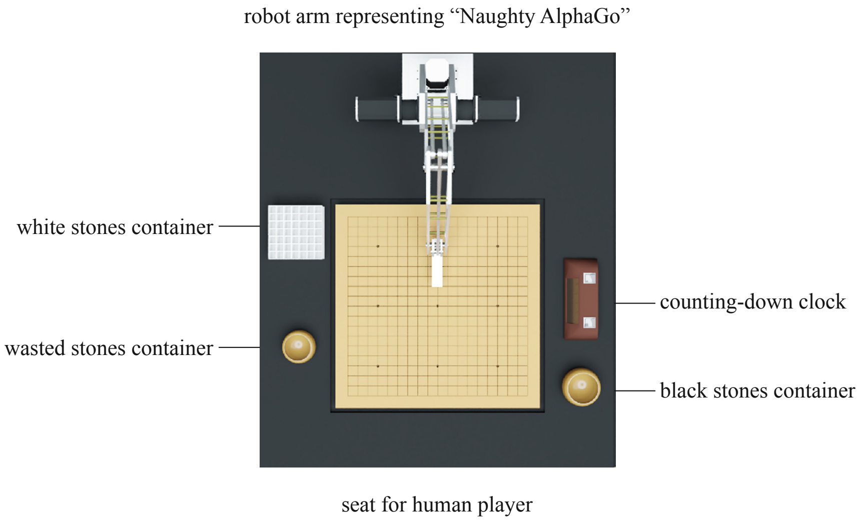


Fig. 6. User interface of the game playground

3.5 Kinematic Characteristic Design

Kinematic characteristic also plays an important role in reflecting the personality of robots. As is shown in Table 2, there are two main options for kinematic design. One is the humanoid way, which makes the robot imitate human as detailed as possible. Another is the mechanical way, which express its emotions by speed change and interactions.

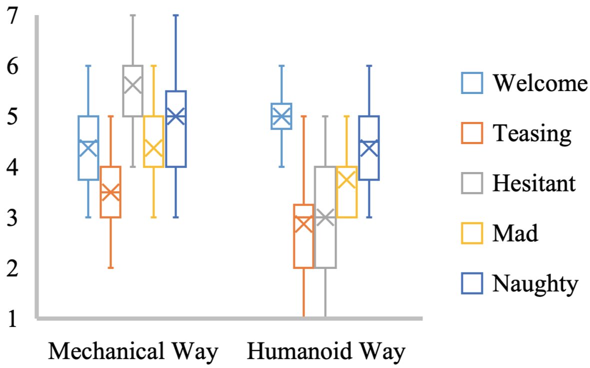
Table 2. Comparison between mechanical and humanoid way of kinematic characteristics

	Mechanical way	Humanoid way
Welcome	Speed up when moving	Wave the arm like nodding
Teasing	Double tap on the wrong position	Distract attention by move randomly
Hesitant	Change target points before placing	Tremble before placing
Mad	Pour out all the stones	Violently scratch the board

To compare the effectiveness of expressing emotions for both options, a user study was carried out based on Universal Robot 3 among 8 participants with no previous experience interacting with robot arms. The study adopts a within-subject design, which requires all participants to watch two series of recorded videos in Table 2 and evaluate the degree of emotion expression using 7-point Likert Scale. Different participants watch videos in different order for counterbalancing.

Figure 7(b) shows that mechanical way can better support users' understanding of its emotion and naughty personality. Therefore, the mechanical way of kinematic design is adopted in the final system.

(a) Universal Robot 3



(b) box plot analysis of emotion expression degrees

Fig. 7. User study for kinematic characteristic design

Overall, different game modes are combined with various kinematic characteristics and patterns on the chess board to let the robot express a wide range of emotions such as serious, capricious, arrogant or angry, which are expected to be perceived by human players through interaction.

4 Implementation

4.1 System Architecture

The whole system architecture is illustrated in Fig. 8. The system recognizes current board situation using an RGB camera and senses the existence of human player through a pressure transducer attached to the seat. The mental model processes the input based on AI algorithm and emotional state machine to decide the next output, which is shown in both behavior characteristic and robot arm movements.

The implementation of "Naughty AlphaGo" consists of three parts: (1) mechanical system to bring the AI player into 3D physical world and enable tangible interactions; (2) electronic and control system to control the logics of electronic installations; (3) algorithms to implement the emotional and intelligent mental model.

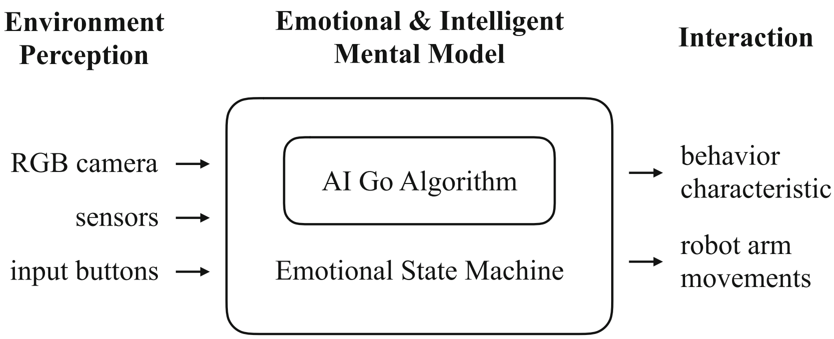


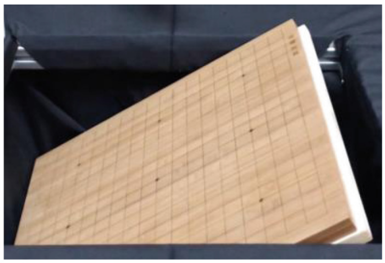
Fig. 8. System architecture of "Naughty AlphaGo"

4.2 Mechanical System

Robot Arm. Robot arm is a physical representation of AI player. Its mechanical performance not only affects the game play of Go, but also has a greatly impact on the human user's perception about AI player's identity. Therefore, the robot arm should have the mobility to reach the whole chess board and the precision to place stones on certain location. Besides, its movement should be smooth and flexible with adjustable speed.

A serial robotic arm with 3 degree of freedom (DOF) shown in Fig. 9(a) is selected instead of the parallel ones, since it's more similar to human's upper limb. Universal Robot 3 with 7 DOF shown in Fig. 7(a) was used in the early stage of research but not adopted in final design because it is unable to reach the full range of 19 $\times$ 19 chess board. Besides, too much DOF is unnecessary and does not resemble the structure of a real human's arm.

(a) Serial robotic arm



(b) Automatic clearance

(c) Stone picker with Air Pump

Fig. 9. Mechanical system design

Chess Table with Automatic Clearance. Clearing the chess board is an important behavior for the AI player to express its anger. To achieve automatic clearance, the chess table is specially designed using aluminum extrusions. The automatic clearance system is realized by tilting the chess board with a linear actuator, as shown in Fig. 9(b).

Stone Picker. Stone picker at the end of the robot arm is specially designed using air pump to pick up and place stones in a stable and robust way, as shown in Fig. 9(c). In the early stage the approach of electromagnets and iron stones is also experimented but not adopted because the stones need to be specially made and the electromagnet may pick up a bunch of stones since they are close on the chessboard and attract each other.

4.3 Electronic and Control System

The electronic and control system architecture of "Naughty AlphaGo" is shown in Fig. 10. Raspberry Pi 3B+ is used as main controller, which receives inputs from RGB camera, pressure transducer and chess clock. After making decisions using the mental model described in 5.4, the robot arm motors and air pump are controlled to perform interactions. A chess clock shown in Fig. 11 is modified to coordinate with the main controller.

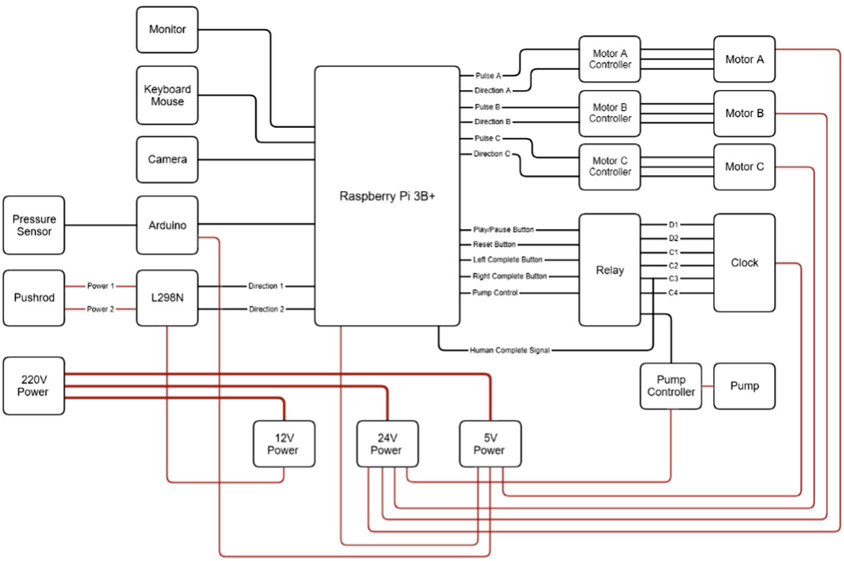


Fig. 10. Electronic and control system architecture

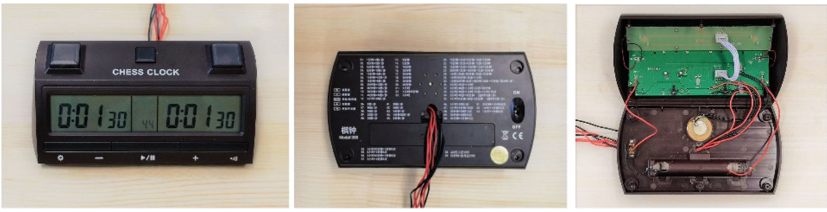


Fig. 11. Hacking into chess clock

4.4 Algorithms

Chess Board Recognition. The recognition of chess board situation is realized using a computer vison method. The Logitech Pro C920 camera first captures a photo of the chess board, then the intersections on chess board are recognized using linear interpolation and solving linear equation, as shown in Fig. 12. The average value of RGB channels within a rectangle at the center of each intersection is computed to identify stones on the chess board (Fig. 13).

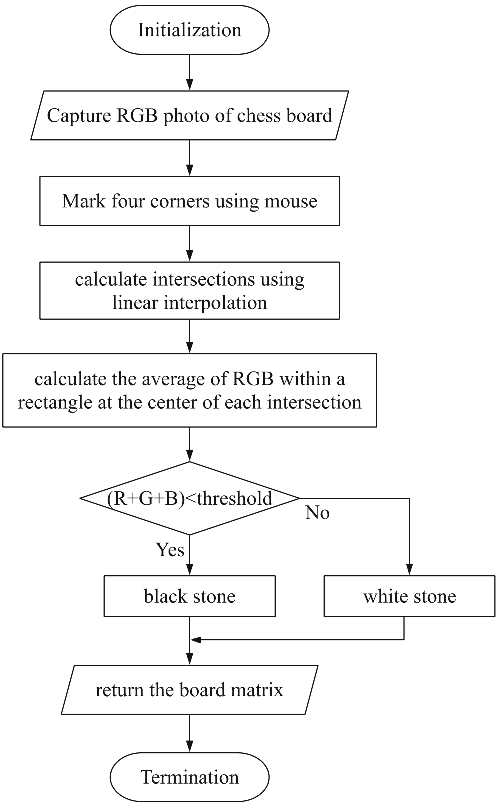
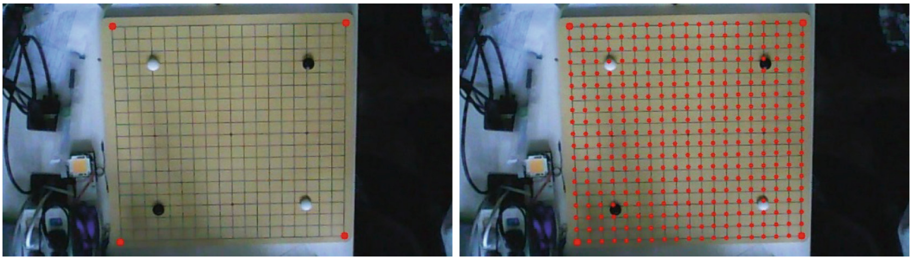


Fig. 12. Algorithm for chess board recognition



(a) Corner marker (b) Linear interpolation to get full grids

Fig. 13. Recognition of intersections on chess board

Emotional State Machine. The emotional design is implemented with an emotional state machine, which specifies the switching relationship between different game modes. The decision rules for mode switching in Go chess mode are shown in Fig. 14. For other modes, the switching relationship can be derived with the design in 3.3.

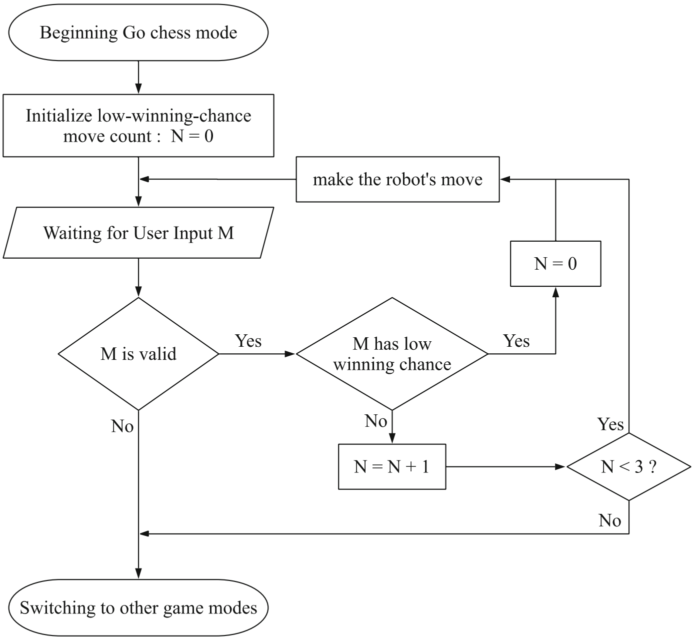


Fig. 14. Decision rules in Go chess mode

AI Go Algorithm. The AI Go algorithm in this research is similar to that used in AlphaGo [2], which combines deep neural networks with same structure and Monte Carlo tree search to take moves. This algorithm is validated in an official competition between Golaxy and Kejie on May 27, 2018.

5 Experimentation and Results

5.1 User Study

"Naughty AlphaGo" was on exhibition for 23 days during June and July 2018 in Tsinghua University. User study of the system was carried out during public exhibition to verify the effectiveness of its emotion expression ability and playfulness. Limited to the exhibition environment, an open-ended interview was conducted with 18 visitors during 2 continuous days, mainly inquiring about their experience and understanding of the AI Go player, their emotion perception during interaction and suggestions.

15 out of 18 participants interacted with "Naughty AlphaGo" for more than 10 min while the other 2 visitors only played for less than 5 min. 4 of 18 visitors have previous experience with the game of Go (Fig. 15).

(a) Whole view of the Art Installation (b) Visitors interacting with the Go robot

Fig. 15. Public exhibition of "Naughty AlphaGo"

5.2 Results and Analysis

The result of our user study shows that 11 out of 18 participants built a good understanding of its naughty personality through interaction. 3 participants built a basic understanding of its different game modes but didn't view it as naughty. 2 participants got confused and thought there might be some bug. Another 2 participants who played for less than 5 min just feel it unattractive and didn't experience with mode switching. Some of their comments are as follows:

- "I hardly know about Go but was attracted by the robot at first glance, so I gave it a try. Later I found out that it was playing the Snake game rather than Go. It's kind of like laughing at me." (P3, male, interacting duration >20 min)
- "I'm a teacher in primary school and the minute the robot cleared the board, I thought: 'Yeah, it's just like my student who sweeps away all his stationery on the desk when dissatisfied'." (P16, male, >20 min)
- "It's capricious like my three-year old cousin, who will get mad when I don't do things according to her will." (P9, male, >20 min)

- "I figured out it was finishing a pattern about heart, but I didn't know why it did this." (P1, female, 10–20 min)
- "It did something unexpected and I thought there must be some bug… I'm an engineer myself and I have got used to this." (P5, male, 10 $\sim$ 20 min)
- "I just walked in front of this art work and placed a stone on the board. But I'm not into chess game and left soon." (P12, female, <5 min)

It can be seen that previous experience has an important impact on human players' understanding of the personality of the robot through interaction. P9 and P16 both mentioned about their experience with naughty person, which helps their understanding of "Naughty AlphaGo". P5 and P16 both talked about their career, while P12 talked about her previous experience with chess game. This is reasonable because emotion perception through interaction relies a lot on previous experience.

Besides, longer interaction time is in positive correlation with better understanding of the personality of Go robot. This shows the importance of attractive display design and beginners' guide design.

Overall, 61% of the participants agree that this robot has naughty personality and emotions. 55% of the participants are willing to play for longer time if there's no limit to time and space. It can be concluded that "Naughty AlphaGo" can basically support human players' perception about an emotional AI player through interaction. But the playfulness of game design needs to be improved.

The limitations and suggestions from all participants include: "confused when switching game mode" (6 times), "adding more game modes" (mentioned 5 times), "speed up the robot arm" (5 times), "polishing appearance of the robot arm" (3 times), and "patterns are hard to guess" (twice).

6 Conclusion and Future Work

6.1 Conclusion

This study designed and implemented an emotional tangible intelligent Go robot "Naughty AlphaGo", which can support human players' perception about an emotional AI player through interaction.

Emotion expression mechanism based on behavioral and kinematic characteristics can support the perception of AI player's emotions. Behavioral characteristic is defined by how the robot behave towards certain input, which can be specified through interaction design. The mechanical way of kinematic characteristic design can better support users' understanding of the emotion and naughty personality in this research.

Longer interaction time is in positive correlation with better understanding of the personality of Go robot. Besides, previous experience of the human players has an important impact on understanding the personality of Go robot through. This shows the importance of attractive display design, beginners' guide design and the use of common experience to provide better emotional experience for users.

6.2 Future Work

To expand the variety of emotions "Naughty AlphaGo" can express, more game modes (such as the chess of *Gomoku*) can be designed and integrated into the emotional state machine.

The user guidance when switching among different modes needs to be polished to avoid confusing human users. Hints of current patterns can be shown on a LED display to reduce the difficulty of predicting the patterns.

Besides, the mechanical performance of robotic arm can be improved to shorten waiting time per turn. The appearance of the robotic arm should also be considered to enhance its naughty personality.

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Gaming Experience

Playful-Consumption Experience and Consumer Videogame Engagement in the Lens of S-R Model: An Empirical Study

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Abstract. This study aims to empirically investigate a conceptual model that is nested in a behaviorism paradigm. The model posits that consumer videogame engagement is triggered through the playful-consumption experience of a digital game. To validate the model, this study collected data from 460 teen videogame users which were subsequently analyzed on using 442 valid cases. WarpPLS 5.0 was used to analyze the PLS-SEM analysis. The results of measurement model for playful-consumption experience and consumer videogame engagement were sound and revealed a higher-order formative construct. Moreover, the findings of the structural model showed that playful-consumption experience has a significant positive influence on consumer videogame engagement. This study is unique in the field of digital games and consumer behavior studies because the study has empirically investigated the impact of playful-consumption experience on predicting consumer videogame engagement.

Keywords: Behaviorism paradigm (S-R model) · Playful-consumption experience · Consumer videogame engagement and PLS-SEM approach

1 Introduction

The digital videogame has turned into one of the world's leading cultural industries [1] that has combined total spending on gaming contents and its' related products to $23.5 billion in 2015 [2]. According to Borderie and Michinov [3], digital videogame playing is now considered the most common activity for many individuals in their everyday lives. The act of playing a digital game has gained gigantic popularity, which in turn

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has attracted academic research with sub topics of digital games [4]. Takatalo et al. [5] have emphasized that digital game playing has the ability to provoke rich and personally related experiences for videogame players.

The extant literature in the field of videogames indicate that numerous theoretical definitions have been employed to define and examine the concept of experience in digital game-playing. For example, scholars [6–9] have used the definition of immersion to examine player's experience in a digital game. Jennett et al. [8], have utilized three different concepts such as flow, presence and cognitive absorption to define the construct of immersion to understand gaming experience. While Takatalo, et al. [5] have developed a psychological framework known as PIFF *(presence-involvement-flowframework)* to investigate user experiences in digital game-playing. Other scholars [10, 11] have developed *GameFlow* and *EGameFlow* model on the basis of flow theory to assess the level of player's enjoyment in digital gameplay. Fang et al. [12], have also developed an instrument to measure player's enjoyment in terms of player's cognitive, affective, and behavioral reactions in computer game-playing. In another study, Fang et al. [4] have used the essentials of flow theory to measure the flow related elements in computer game-playing. Some other researchers [13, 14] have used the concept of fun to study fun related experiences in digital game-playing.

In videogame studies, various scholars [15–18] have argued that engagement is another concept that has been used by many studies [6, 19–21] to assess player's subjective experience, which is also termed as game-engagement in digital game-playing [22]. Several studies have described the notion of engagement in different forms, for instance, flow [20], immersion [6, 7] while other researchers [19, 21] have related the concept of game-engagement with other theories such as presence, flow, absorption, immersion, and involvement.

However, many studies [15–18] have raised the issue that scholars [6, 7, 19–21] have used different theories interchangeably such as immersion, flow, absorption, involvement, and presence to express the state of engagement in digital game-playing. We find that these studies [19, 21] have only used specific psychological dimensions and failed to include behavioral dimensions in measuring the player's level of engagement in digital game-playing [22, 23]. Many authors [16, 17, 22] have further corroborate that none of these theories have defined the engagement state as an active participation with a digital game. However, Brockmyer et al. [19] have used the theory of immersion to refer to a mental state of being involved in game playing and that a player has some kind of awareness of the environment. Other authors [9, 24] have used presence theory to investigate the player's devotion in the videogame-generated world. Brockmyer et al. [19] have applied the concept of absorption to assess how a player's feelings, thoughts, and emotions are suspended whilst ignored in game-playing. In another study, Klasen et al. [25] have used flow theory to express a player's involvement in digital game-playing and ignored other matters. Abbasi et al. [15] have further discussed that few studies [5–11, 26] have also chosen similar theories to evaluate the digital gaming experience, especially the mental-related experiences in game-playing. However, academics have failed to include other experiences such as sensory and emotional factors. Moreover, these studies [15, 18] have also highlighted that scholars [8, 19, 21] have used similar theories to define the construct of immersion and game-engagement to measure the level of subjective experience and a player's engagement in a digital game-playing. Hence, there is a dire need for a study in the field of digital game-playing that could explain the notion of engagement and experience utilizing separate yet relevant theoretical definitions in a more comprehensive manner.

This study first attempts to employ the definition of consumer videogame engagement accepted by [22, 23] to measure player's engagement with a digital game comprising both psychological and behavioral dimensions. Second, the study uses the definition of playful consumption experience given by [27] to measure player's experiences in terms of sensory, emotional, and imaginal experience in digital game-playing. Finally, research also intends this to propose and validate a conceptual model that predicts consumer videogame engagement through the level of playful-consumption experience of a digital game-playing.

The present study is the first in the field of digital game studies that applies the basic principles of the behaviorism paradigm to investigate the role of playful-consumption experience in predicting consumer videogame engagement.

2 Conceptual Model and Hypothesis Development

This study has applied the behaviorism approach to study the conceptual model. The behaviorism paradigm was originated by Watson [28] and established a stimulus-response model known as S-R [29]. The study by Bostan [30] also proposes that psychology should investigate a behavior that is observable and measurable. Garneli et al. [31] have illustrated that optimal learning occurs due to the degree of relevant stimuli and response. Heimlich and Ardoin [32] also argued about the behaviorism paradigm that individuals develop a behavior through their experiences relating to the association between the environmental stimuli and response. Therefore, we consider the S-R model of the behaviorism approach to be a suitable framework for the present study. In this paper, we conceptualize a digital game as an environmental stimulus (S) because a recent study defined a digital game as a computer-mediated environment that enables the individuals to gain the relevant experience of play [33]. Furthermore in this study, the experience of play is referred to the playful-consumption experience which is actually the part of the environmental stimulus means, a digital videogame playing. The playful-consumption experience of a digital videogame has a potential to create a response (R) for the videogame consumers as "consumer videogame engagement" [34].

The existing literature indicates that Abbasi and Abu Baker [34] have recently proposed a conceptual model to predict consumer videogame engagement through studying the impact of playful-consumption experience of a digital game-playing. In this research, the author's reviewed the following study [34] and found that their model lacks an empirical investigation of the proposed model.

However, the present study is different from the earlier study in two ways. First, it develops a conceptual model based on the behaviorism philosophy using the stimulus-response (S-R) model. S-R model provides a parsimonious description of environments and behaviors. Hence, this study also conceptualizes the S-R model as the parsimonious description of environment also known as stimulus (S) as *"the playful-consumption experience of a digital videogame"* and behavior also termed as response (R) as *"consumer videogame engagement"*. Due to having the parsimonious relationship between the playful-consumption experience and consumer videogame engagement, we aim to propose and empirically validate the conceptual model as a higher-order construct as illustrated in Fig. 1, which describes that the level of playful-consumption experience as stimulus (S) impacts the response (R) being consumer videogame engagement.

Fig. 1. Proposed S-R model

2.1 Playful-Consumption Experience

According to Abbasi et al. [27] the notion of playful-consumption experience has been defined as *"an intrinsically, motivating, active, and self-based videogame playing activity that is executed for a player's own sake and pleasure"*, which in turn involves a player to get playful hedonic experiences (imaginal, emotional, and sensory). The authors [15, 35] have explained that imaginal experience is used to refer to the mental state of visualizing things. The imaginal experience is measured through escapism, fantasy, and role-projection [27, 36–38]. The term role-projection refers to a mental state activity in which people visualize themselves into a particular character [36]. Few scholars [36, 38] have also considered the notion of escapism to discuss the mental task of individuals in which they escape from unpleasant real world happenings. The concept of fantasy also refers to a mental activity in which they construct the fictional world [38]. While the emotional experience explains the affective state which is measured through three dimensions such as emotional involvement, arousal, and enjoyment [37–39]. According to Holsapple and Wu [40], the term enjoyment refers to an emotional state in which individuals attain a sort of pleasure or happiness. Wu and Holsapple [38] have stated that the term arousal is used to refer to a situation in which people become attentive, excited and active. On the other hand, the emotional involvement describes an emotional state in which individuals feel that they are carried off by the action [41, 42]. Lastly, Hirschman and Holbrook [37] have defined the sensory experience as *"the receipt of experience in multiple sensory modalities comprising the sense of touch, sight, and sound."*

However, earlier marketing scholars [34, 43–45] have discussed that experience derives from the interaction between a consumer and a product and such an experience further creates a subsequent response. Several other studies [43, 44, 46] have also stated that experience also involves consumers to engaging physically, emotionally, and cognitively. More recently, in the field of digital game studies, authors have proposed that playful-consumption experience of a digital game is very interactive and as such a co-creative experience, which in turn influences players' overall consumer videogame engagement [34] and its second-order constructs as well in the digital game-playing comprising cognitive, affective, and behavioral engagement [15]. Hence, this study proposes the following hypothesis.

H: 1 Playful-consumption experience positively impacts on consumer videogame engagement.

2.2 Consumer Videogame Engagement

According to [22, 23], the notion of consumer videogame engagement is defined as *"a psychological state that triggers due to two-way interactions between the consumer (videogame user) and a digital videogame product, which generates different level of consumer engagement states such as cognitive, affective and behavioral."* [47, 48] have defined the cognitive state of engagement as *a "set of mental activities*, the affective engagement as *the summative and enduring level of emotions",* and the behavioral engagement as *"encompassing the behavioral manifestations"* that a consumer experiences and involves in the focal object. Few studies have reported that the cognitive state of engagement is measured through conscious attention [49] and absorption [50]. Conscious attention refers to the level of attention that an individual has in interacting with the object [49].

Whereas, the absorption refers to a pleasant state in which individuals are completely concentrated and occupied [51]. The affective engagement comprises the enthusiasm [47–49] and dedication [50, 52, 53]. According to [50, 53], the term dedication is used to express the sense of belonging to an object. Whereas, the idea of enthusiasm expresses the individuals' strong level of enthusiastic and excitement feelings with respect to their engagement in the object [49, 51]. Behavioral engagement is another state of engagement in the construct of consumer videogame engagement that further encompasses and fulfills social connection [49] and interaction [50, 51]. Social connection furthers the development of the relationship based on the inclusion of other individuals who have common and mutual actions among each other [49]. While the notion of interaction represents individuals' participation with the product and other individuals, such an interaction always supersedes the purchase transaction [51].

3 Methodology

This study involved teenagers students aged 16–19 years who study in Malaysian universities. We sampled teen students because they are considered as potential subjects for investigating digital game-playing behavior [54] and the fact that digital game-playing is a very popular activity among teenagers [55]. We have captured the participants' information in Table 1.

Table 1. Respondents characteristics

Respondents profile	%
Gender	
Male	59.5
Female	40.5
Age (Years)	
15–16	.9
17–18	18.8
19	80.3
Ethnicity	
Malay	55.7
Chinese	36.2
Indian	8.1
Education	
Secondary School Student	8.1
Diploma/Foundation Student	43.7
New Undergraduate Student	48.2
Frequency of Video-game play	
Everyday	35.7
Once a week	20.6
A few times a week	43.7
Average daily hours of Video-game play	
1–4 h/Daily	71.5
Above 4–8 h/Daily	24.7
Above 8–12 h/Daily	2.3
More than 12 h/Daily	1.6
Answers were recorded in multiple response setting (percent of cases means each percentage is out of 100)	
Most common game's genre played by users	
Action	64.7
Adventure	61.1
Arcade	33.0
Shooter	53.6
Role-Playing	43.0
Fighting	48.9
Strategy	57.7
Sports Game	38.5
Racing	49.8
Casual	21.9
Children' Entertainment	12.0
Family Entertainment	17.4
Flight	13.8
Other video games/Genre	6.6

(*continued*)

Table 1. (*continued*)

Respondents profile	%
Most common plat form used by videogame players	
Personal computer	79.0
Dedicated gaming console	29.9
Smartphone	68.6
Wireless device	21.3
Dedicated handheld device	8.8
Others	0.2
Location of game playing	
Home	96.8
Friend's place	17.4
Cyber cafe	17.0
Others	4.8

The study applied a quantitative research approach, using a questionnaire to empirically test the research model (Fig. 1). The study questionnaire was based on two main parts. Part one comprised of respondents' information and their digital gaming consumption details. Part two involved the two main constructs such as playful-consumption experience and consumer videogame engagement. The items measuring the consumer videogame engagement were adopted from [22, 23]. On the other hand, the items measuring the playful-consumption experience were adopted from another study [27]. The five-point Likert scale starting from 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree was utilized.

A multistage sampling technique was applied to collect the study data. According to Acharya et al. [56], a multistage sampling involves the repetition of two key steps such as listing and sampling. Following the multistage technique, the study managed to randomly select two states in Malaysia, Perak (one public university and one college) and Selangor (one private and two public universities). In each selected institution, we first applied for permission to collect the data. Once the permission was granted, systematic sampling was used in each of the institutions. The data were collected in the presence of the class-instructor. To filter the respondents, questions on "do you play a digital game" and "are you a user of a digital game-playing" were asked. In total 555 questionnaires were distributed and 460 were collected with response rate of 82.9% and 442 questionnaires were usable.

PLS-SEM is a comprehensive multivariate statistical analysis approach that facilitates the evaluation of the both the measurement model and the structural model, and it also assists in theory building [57]. This study used the PLS-SEM approach as the variables involved in the study have both the reflective and formative constructs [57, 58]. WarpPLS version 5.0 by Kock [59] was used to analyze the PLS-SEM analysis. In the next section we present the results.

4 Results

4.1 Step One: Measurement Model Assessment

The proposed study model (Fig. 1), comprised two main third-order or higher-order formative constructs representing playful-consumption experience and consumer videogame engagement. Figure 2 further shows that playful-consumption experience comprises three second-order constructs (two second-order formative constructs *imaginal and emotional experience* and one second-order reflective construct *sensory experience*). Imaginal experience included *fantasy, escapism, and role-projection* and emotional experience comprised of *emotional involvement, arousal, and enjoyment* as first-order reflective constructs. Whereas, consumer videogame engagement involved three second-order formative constructs being *affective, cognitive and behavioral engagement*. Cognitive-engagement entailed *conscious attention and absorption*,

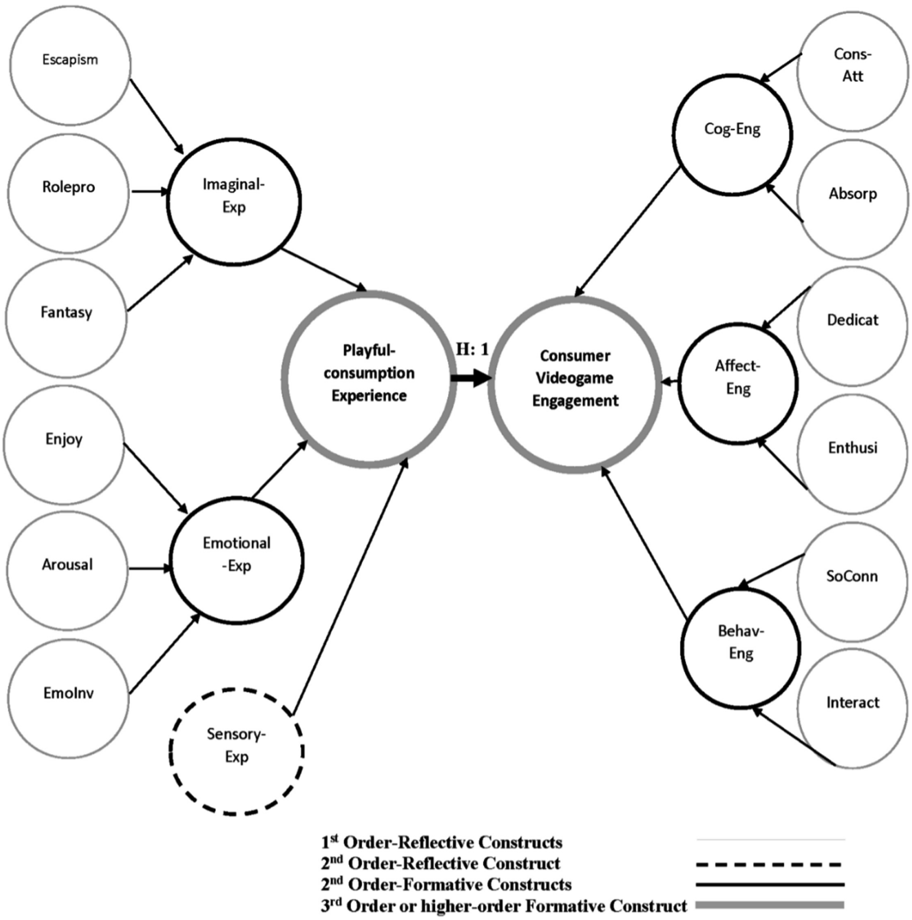

Fig. 2. A holistic view of the proposed model

affective-engagement comprised *dedication and enthusiasm*, while behavioral engagement consisted of *social connection and interaction*. To evaluate the reliability and validity of the measurement model, the study assessed first assessed all first-order and second-order reflective constructs separately, then we evaluated all second-order formative constructs and finally, we analyzed the main higher-order formative constructs.

4.2 Assessment of the Reflective Constructs

To evaluate the quality of the reflective constructs, Table 2 showed that all constructs met the suggested critical values [57, 58, 60]. Additionally, the full collinearity (FVIF) was also evaluated that refers to the vertical and lateral collinearity of one construct to other dimensions [61]. Tables 2, 4, and 5 reported that all constructs met the critical value (3.3) of FVIF [61].

Discriminant validity was also assessed for the reflective constructs. Table 3 revealed the results that the square root of the AVE (diagonal values) of each dimension is larger than its corresponding correlation coefficients. Hence it demonstrates that the constructs have achieved the adequate discriminant validity [62].

4.3 Assessment of Second-Order Formative Constructs

A two-stage technique recommended by Becker et al. [63] was used to create the second-order formative constructs, which is the default technique in WarpPLS. To assess the validity of formative constructs, the VIF should be assessed first, and it must be lower than (5) [57, 58] or (3.3) more restricted criteria by [61]. Next, these scholars [57, 58] also suggested to check the indicators' weights and their significance level to consider the validity and reliability of the formative constructs. Table 4 shows the result that the indicator weights of the second-order formative are statistically significant and VIF is also below the threshold value. Hence, the second-order formative constructs are valid.

4.4 Assessment of Third-Order/Higher-Order Formative Construct

The study again used the two-stage technique in WarpPLS 5.0 to create the higher-order formative construct. For evaluating higher-order formative construct of consumer videogame engagement and playful-consumption experience, we first assessed VIF that must be below (3.3) or (5) and second, we checked the significance of the indicator weights. Table 5 reported that the indicator weights of the formative constructs are statistically significant and their associated VIF is also less than the critical value. The results evidenced that both higher-order formative constructs are valid.

4.5 Step Two: Structural Model Assessment

To examine the structural model and hypothesis as in Fig. 2, the study used WarpPLS 5.0 to check two basic criteria such as the significance of path coefficient with effect size and T-value and the value of the R^2 coefficient for the endogenous construct.

Table 2. Measurement model: first-order constructs

Scale	Items	Loadings	Cronbach's alpha	CR	AVE	Full collinearity (FVIF)
Escapism	Playing a video-game gets me away from the reality	0.831	0.725	0.831	0.557	1.538
	Playing a video-game gets me away from the problems and pressures	0.798				
	Playing a video-game helps me escape from things that are unpleasant and worrying	0.540				
	Playing a video-game makes me feel like I am in a different world of reality	0.778				
Fantasy	Playing a video-game does not stimulate my imagination	0.703	0.713	0.841	0.640	1.445
	Playing a video-game helps me create daydreams	0.890				
	Playing a video-game helps me augment reality	0.796				
Role-projection	Playing a video-game enables me to project myself into a particular role	0.766	0.778	0.872	0.695	1.664
	Playing a video-game enables me to project myself into a particular task	0.905				
	Playing a video-game enables me to project myself into someone else	0.825				
Enjoyment	Playing a video-game is not really fun	0.722	0.862	0.907	0.711	1.466
	Playing a video-game provides me with a lot of enjoyment	0.878				
	Playing a video-game is enjoyable	0.874				
	I enjoy playing a video-game	0.889				

(*continued*)

Table 2. (*continued*)

Scale	Items	Loadings	Cronbach's alpha	CR	AVE	Full collinearity (FVIF)
Emotional involvement	When I am playing a video-game, I feel deeply about this video-game	0.843	0.723	0.845	0.645	1.666
	When I am playing a video-game, I get into this video-game	0.765				
	After I finish playing a video-game, I may carry the video-game playing experience with me for a while	0.799				
Arousal	Playing a video-game makes me inspired	0.829	0.776	0.870	0.691	1.888
	Playing a video-game makes me wide-awake	0.851				
	Playing a video-game makes me motivated	0.813				
Sensory experience	Playing a video-game influences my physical movement	0.675	0.839	0.882	0.555	1.789
	My body adapts sudden actions, as a reaction to certain situations in the video-game (e.g. tries to move my hand in the direction of gun I am pointing in the game etc.)	0.777				
	The peripheral video-gaming device (joy-stick, joy-pad, and other accessories) makes me actually feel the physical experience of the game	0.753				
	The video-game music stimulates my emotions to adapt and react accordingly (e.g. I play aggressively with aggressive music, I play calmly with soft music and react in fear to a horror music etc.)	0.743				
	The scenic beauty of the video-game is aesthetically appealing me	0.785				
	The visuals of the video-game fill my appetite for unique and different structure, shapes and design	0.734				

(*continued*)

Table 2. (*continued*)

Scale	Items	Loadings	Cronbach's alpha	CR	AVE	Full collinearity (FVIF)
Conscious Attention	I like to learn more about this video-game	0.745	0.869	0.902	0.607	2.449
	I notice information related to this video-game	0.801				
	I pay a lot of attention to anything about this video-game	0.856				
	I keep up with things related to this video-game	0.821				
	Anything related to this video-game grabs my attention	0.764				
	I concentrate on this video-game's story for a long time	0.673				
Absorption	When I am playing this video-game, I forget everything else around me	0.754	0.825	0.877	0.589	2.294
	Time flies when I am playing this video-game	0.710				
	When I am playing this video-game, I get carried away	0.809				
	When I am playing this video-game, I feel immersed	0.795				
	I feel happy, when I am playing this video-game intensely	0.767				
Dedication	This video-game inspires me	0.803	0.768	0.845	0.528	2.405
	I am enthusiastic about playing this video-game	0.492				
	I am proud of playing this video-game	0.748				
	I find this video-game full of meaning and purpose	0.787				
	I am excited when playing this video-game	0.757				
Enthusiasm	I spend a lot of my discretionary time playing this video-game	0.604	0.784	0.854	0.540	2.278
	I am heavily into playing this video-game	0.775				
	I am passionate about playing this video-game	0.793				
	I enjoy spending time playing this video-game	0.737				
	I try to fit playing this video-game into my schedule	0.751				

(*continued*)

Table 2. (*continued*)

Scale	Items	Loadings	Cronbach's alpha	CR	AVE	Full collinearity (FVIF)
Social connection	I love playing this video-game with my friends	0.833	0.804	0.885	0.719	1.538
	I enjoy playing this video-game more when I am with others	0.858				
	Playing this video-game is more fun when other people around me play it too	0.852				
Interaction	In general, I like to get involved in the discussions about this video-game playing	0.815	0.856	0.897	0.636	2.178
	I am someone who enjoys playing this video-game with others like-minded video-game players	0.711				
	I am someone who likes actively participating in the discussions about this video-game playing	0.854				
	In general, I thoroughly enjoy exchanging ideas on this video-game with other video-game players	0.818				
	I often participate in activities relating to this video-game	0.782				

Table 3. Correlation between discriminant validity and constructs and testing

Dimensions	Escape	Fantasy	Rolpro	Enjoy	EmoInv	Arous	SenExp	ConsAtt	Absorp	Dedicat	Enthusi	SocialC	Interac
Escape	0.746												
Fantasy	0.331	0.800											
Rolpro	0.437	0.376	0.834										
Enjoy	0.355	0.198	0.207	0.843									
EmoInv	0.365	0.476	0.314	0.318	0.803								
Arous	0.342	0.287	0.383	0.356	0.429	0.831							
SenExp	0.385	0.313	0.465	0.300	0.392	0.529	0.745						
ConsAtt	0.391	0.304	0.369	0.395	0.457	0.559	0.500	0.779					
Absorp	0.469	0.314	0.460	0.361	0.426	0.435	0.520	0.602	0.768				
Dedicat	0.378	0.261	0.325	0.459	0.447	0.578	0.429	0.668	0.550	0.727			
Enthusi	0.305	0.204	0.388	0.271	0.407	0.441	0.467	0.597	0.624	0.573	0.735		
SocialC	0.213	0.189	0.111	0.359	0.309	0.316	0.307	0.387	0.369	0.369	0.410	0.848	
Interac	0.267	0.286	0.389	0.225	0.395	0.435	0.423	0.566	0.548	0.534	0.617	0.495	0.797

The square roots of average variances extracted (AVEs) shown on diagonal with bold numbers.

Table 4. Evaluation of formative measurement model on the second-order constructs

Constructs	Items	Scale type	Weights	Significance	Full collinearity	VIF
Imaginal experience		Formative			1.7	
	Escapism		0.437	<0.001		1.287
	Fantasy		0.413	<0.001		1.214
	Role-projection		0.453	<0.001		1.336
Emotional experience		Formative			2.19	
	Enjoyment		0.413	<0.001		1.19
	Emotional Involvement		0.444	<0.001		1.275
	Arousal		0.457	<0.001		1.312
Cognitive engagement		Formative			3.148	
	Conscious Attention		0.559	<0.001		1.569
	Absorption		0.559	<0.001		1.569
Affective engagement		Formative			2.929	
	Dedication		0.564	<0.001		1.488
	Enthusiasm		0.564	<0.001		1.488
Behavioral engagement		Formative			1.794	
	Social Connection		0.578	<0.001		1.324
	Interaction		0.578	<0.001		1.324

Table 5. Evaluation of formative measurement model on the third-order/higher-order constructs

Constructs	Items	Scale type	Weights	Significance	Full collinearity	VIF
Playful-consumption experience		Formative			2.043	
	Imaginal experience		0.400	<0.001		1.594
	Emotional experience		0.408	<0.001		1.667
	Sensory experience		0.395	<0.001		1.546
Consumer videogame engagement		Formative			2.043	
	Cognitive engagement		0.385	<0.001		2.592
	Affective engagement		0.389	<0.001		2.727
	Behavioral engagement		0.358	<0.001		1.760

Indicator weights and the significance level of the second-order constructs on the associated third-order/higher-order construct

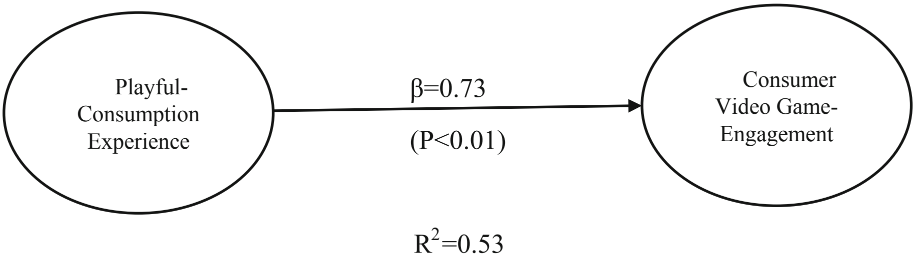

Fig. 3. Structural model results

Table 6. Structural model results

Hypothesis testing	Path coefficient	SE	f^2	T-value = Path coefficient/S.E	P-value
H1: Playful-consumption Experience → Consumer Videogame Engagement	0.727	0.043	0.528	16.90**	0.001

Table 6 revealed that the relationship between playful-consumption experience and consumer videogame engagement is significant with path-coefficient 0.727. WarpPLS 5.0 also calculated the effect size as shown in Table 6, to examine how much playful-consumption experience contributed to explain the consumer videogame engagement. The results indicated that the f^2 is 0.527 which is above the value 0.35 [64], representing the large effect of playful-consumption experience in predicting consumer videogame engagement. Whereas, the value of R^2 for consumer videogame engagement is 0.53 as shown in Fig. 3.

Additionally, warpPLS 5.0 calculated six-global fit indices for overall model [59, 65]. These six fit-indices represent an overall model-data fit that was more than acceptable: average path coefficient (APC) = 0.727, $P < 0.001$; average R-squared (ARS) = 0.528, $P < 0.001$; average adjusted R-squared (AARS) = 0.527, $P < 0.001$; Average block VIF (AVIF) not available; average full Collinearity VIF (AFVIF) = 2.043, acceptable if <= 5, ideally <= 3.3; and Tenenhaus GoF (GoF) = 0.623, small >= 0.1, medium >= 0.25, large >= 0.36.

5 Discussion and Conclusion

In this study, we aimed to empirically validate the conceptual model suggesting that playful consumption experience of a digital game has an impact on consumer videogame engagement. Our results showed that playful-consumption experience of a videogame positively influences on consumer videogame engagement. In this manner, the study contributes to the videogame and marketing literature in many ways. First, Abbasi and Abu Baker [34] have conceptually posited a model suggesting that playful-consumption experience of a digital game leads to increased consumer videogame engagement. However, the present study has extended their viewpoint and has empirically investigated the impact of playful-consumption experience on consumer videogame engagement. This study also contributes to the stimulus-response models of behaviorism theory by identifying and validating the stimulus as *"playful-consumption experience"* and response as *"consumer videogame engagement"* in the field of digital game-playing and consumer studies. Many marketing scholars [43–45] added that experience comes from the interaction between consumers and a product, which in turn creates and enhances engagement with the product. Our study applied this concept in the field of digital gaming and empirically investigated that playful-consumption experience emanates from the digital game-playing, which in turn impacts consumer videogame engagement. Furthermore, this study provides a new insight to the gaming industry to understand level of players' experiences and engagement. With this model, game developers can also evaluate multiple engagement states and experiences players have with the digital game.

The study initially discussed the literature that had investigated the notion of experience and engagement and highlighted the limitations of existing research. To address the limitations, we primarily attempted to define experience as playful-consumption experience that comprises imaginal, emotional, and sensory experience and also define engagement as consumer videogame engagement which includes affective, cognitive engagement and behavioral engagement. Next, the study examined the role of playful-consumption experience in predicting consumer videogame engagement. The empirical investigation was accomplished using PLS-SEM approach and the results of measurement model showed that the higher-order formative constructs had sound reliability and validity. The results of structural model indicated that playful-consumption experience had a positive significant influence on predicting consumer videogame engagement.

This study is limited in understanding the S-R model in a digital game context and we only selected individuals who are videogame users. Future studies can apply the same model to investigate the particular consumers of a particular genre of a digital game and future research can also extend the S-R model to include S-O-R Model. Methodologically, we could extend the analysis with Confirmatory Tetrad Analysis to further test path directionality in a more data drawn way.

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Affective Video Games: A Systematic Mapping Study

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Abstract. Human-Computer Interaction is expanding towards natural modalities of human expression. In this context, affective video games estimate the emotional state of the player to give a response according to some purpose, e.g., to adapt game difficulty. Advances in estimating emotional state and adapting game elements, allow us to have an idea of which are the best ways to develop adaptation in affective videogames and to explore the research gaps in the affective video games area. This paper presents a systematic mapping study of Affective Games. The Systematic Mapping is a simple five-step process followed to obtain an overview of the studies related to Affective Games, comprising many studies through the understanding of their summaries or, in some cases, their conclusions. Results show that the studies on the Affective Video Games area have increased during the last years. To construct the systematic map of the literature, we carried out a classification of the affective measures in five categories: direct physiological measures, indirect physiological measures, direct behavioral measures, indirect behavioral measures, and self-reported measures. The results show that 67.3% of the studies do not consider the adaptation of video games and 42.3% of the studies use direct physiological measures. Besides, there is a lack of research in the application of indirect physiological measures to estimate the affective state of the player and determine the video game adaptation elements.

Keywords: Affective video games · Affective measures · Emotional states · Systematic mapping study

1 Introduction

Human-Computer Interaction (HCI) is expanding towards natural modalities of human expression [1]. Within this context, affective and emotional approaches to HCI rise as new research methods [2]. Affective Games (AGs) are one of the emerging topics in the HCI field [3]. These games are mainly serious applications capable of determining the emotional state of the player and adapting some elements of the system according to his/her purpose. In this direction, one of the challenges in the AGs research area is to gather, in a non-invasive way, the affective state of the player to provide better adaptive mechanisms [4].

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Consequently, the state of art of the AGs was analyzed to learn from the evidence and get the design patterns and better practices to develop serious affective games with healthcare purposes. Along with it, the obtained information gave a general overview to identify gaps in the AGs area.

This paper aims to present the cover of the emerging field of AGs as a first step in the comprehension of this area. A Systematic Mapping Study of the literature was performed, applying a broadly used methodology in software engineering [5]. Each phase of the SMS provided information and details to build a map of the studies from the AGs area. Through the SMS methodology, information of interest was obtained to enrich the knowledge on the AGs area.

Section 2 introduces the systematic mapping methodology. Section 3 presents the systematic map of the literature in the Affective Video Games area, also proposing a classification schema of the affective measures. Finally, Sects. 4 and 5 present the discussion and conclusions of the study.

2 Methods

A Systematic Mapping Study (SMS) provides an information structure about a topic at hand. The SMS is a five-step process, starting with the definition of the research questions, followed by a search for primary studies. Next, the found papers are screened for including them in or excluding them out of the SMS. As a fourth step, key-wording of the abstracts is obtained to finally perform the data extraction and the mapping of the selected papers [5]. The methodology followed, and the results obtained in each phase are summarized in Fig. 1.

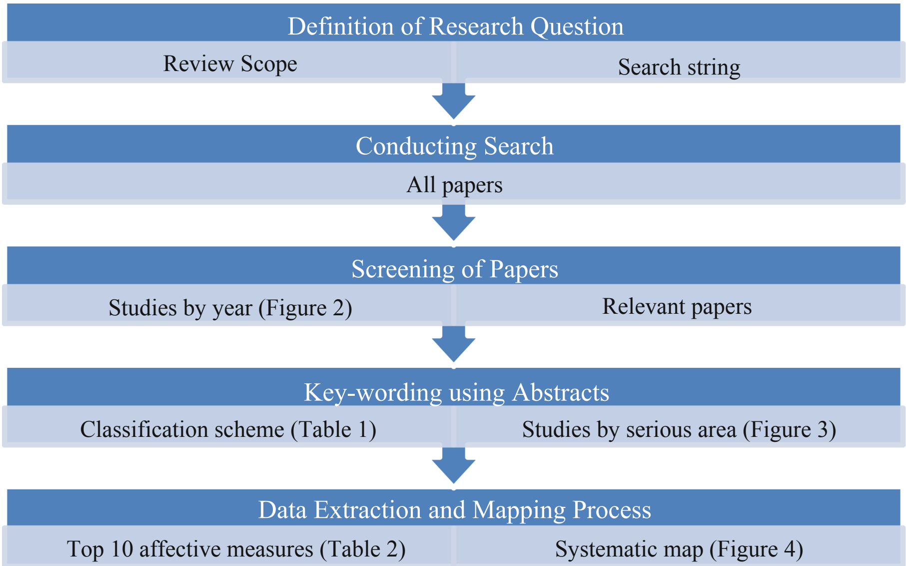

Fig. 1. The five phases of the Systematic Mapping

The specific research questions defined in the study are:

- Q1. Which application domains have been reported in the literature on AGs?
- Q2: What measures are used to determine emotional states of the players in existing AGs?
- Q3: Which adaptive elements have been reported in the analyzed literature?
- Q4: Which measures and adaptive elements have not been explored in AGs?

We used the following search string to obtain the documents for analysis from the Scopus, IEEE Xplore, ACM Digital Library, and Google Scholar databases:

"Affective games" OR "Affective gaming" OR ("Affective computing" AND videogames)

After performing the search, we obtained 187 papers. The screening of papers and application of the exclusion criteria resulted in the selection of 102 papers. Inclusion criteria included papers reporting some affective measure in the abstract or conclusions. Exclusion criteria included repeated papers, non-experimental studies, and non-affective video games.

3 Results

The data collected for responding to each one of the research questions are presented in this section.

– Q1. Which application domains have been reported in the literature on AGs?

From the 102 papers only 22 papers reported the application area in the abstract, within these we extract the application area registered and their percentage for the 22 articles (Fig. 2).

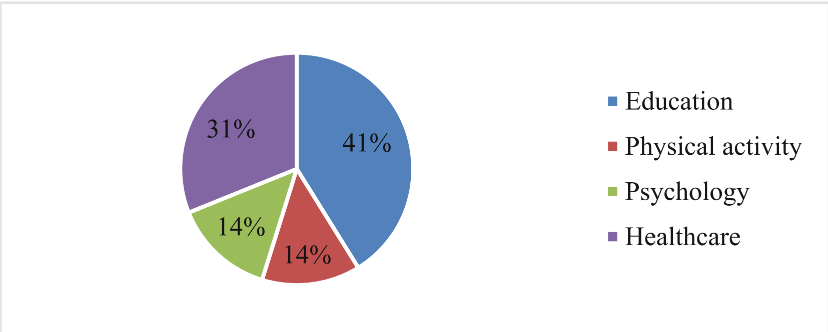

Fig. 2. Application areas of Affective Video Games reported in the literature

– Q2: What measures are used to determine emotional states of the players in existing AGs?

The most used measure is the Electrodermal Activity (EDA), also reported as Galvanic Skin Response (GSR), followed by Heart Rate and Heart Rate Variability, Face recognition, Electroencephalography (EEG), Temperature, respiration, Electromyography (EMG), Electrocardiography (ECG), Gamepad and user's questionnaires (Table 1).

Table 1. Top 10 affective measures during the last 10 years

Measure	Year										
	09	10	11	12	13	14	15	16	17	18	Total
EDA, GSR	–	4	1	–	3	–	3	2		5	18
HR, HRV		2	2	–	3	–	3	1	1	2	14
Face recognition	1	–	–	3	2	1	3	–	1	3	13
EEG	–	–	1	1	2	1	1	–	–	–	6
Temperature	–	1	–	–	1	–	1	1	–	2	6
Respiration	–	–	1	–	1	–	–	1	–	2	5
EMG	–	1	–	–	–	–	–	–	–	2	3
ECG	–	–	–	–	–	–	–	–	–	2	2
Gamepad	–	–	–	–	–	–	1	–	–	–	1
Questionnaire	–	1	–	–	–	–	–	–	–	–	1

Due to the diversity of measures to estimate emotional states, a classification scheme is proposed to organize the studies. Table 2 shows the proposed classification schema of the affective measures. The classification of the analyzed studies by category is presented in Fig. 3.

• Q3: Which adaptive elements have been reported in the analyzed literature?

The classification scheme in Table 3 presents the adaptation elements considered. Adaptation elements included: interface components, difficulty levels, non-player characters, and score flow. The classification of the studies according to the schema proposed for adaptation elements is presented in Fig. 3.

– Q4: Which measures and adaptive elements have not been explored in AGs?

Based on the two proposed classification schemes, the studies could be ordered and represented in a diagram that links the categories of affective video games and adaptation elements, with the number of studies. The graphical representation of these crossed categories is known as the systematic map (Fig. 3).

Information like the publication year was taken into account from a set of 102 papers. Figure 4 shows the statistics per year.

Table 2. Categories of affective measures

Classification	Description
Direct physiological measures	Are measures attaching a sensor to the body of the player, e.g., Heart Rate (HR), Galvanic Skin Response (GSR), or Electroencephalogram (EEG)
Indirect physiological measures	Measures of signals from the body that can be measured by pointing a camera to the player like Face Emotion Recognition or pupil size
Direct behavioral measures	This type of affective measure depends on what the player express explicitly, e.g., how the player presses the gamepad buttons, or how the player manipulates the touch screens
Indirect behavioral measures	Measures achieved in an implicit manner such as game screen recording or some visual artifact mechanism interpreting the visual language of the player
Self-reported measures	Are taken by the player's externalization of his/her feelings regarding their affective state; these measures can be taken using surveys, think-aloud methods, interviews, among others
Multiple measures	Multiple measures include more than one direct, indirect, physiological or behavioral measure

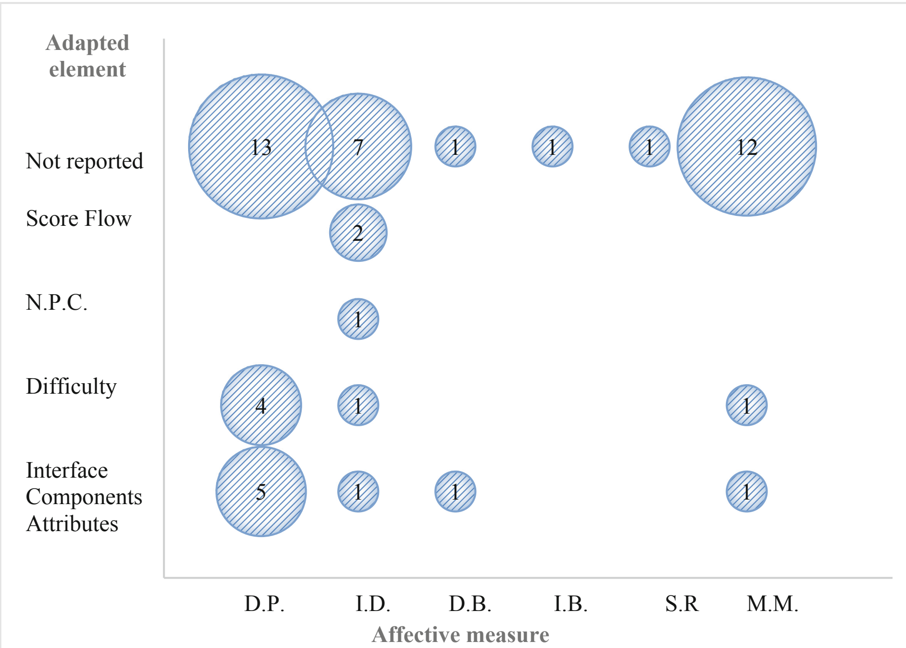

Fig. 3. Systematic map: In the affective measure dimension, Direct Physiological Measures (D.P.), Indirect Physiological Measures (P.I.), Direct Behavioral Measures (D.B.), Indirect Behavioral Measures (I.B.), Self-Reported Measures (S.F.), and Multiple Measures (M.M.)

Table 3. Categories of adapted elements

Adapted element	Description
Interface components attributes	It refers to all elements in a single game scene that change their visual features like size, color, and form according to the affective state of the player
Difficulty	It refers to the change in the dynamics of a game which implies greater skills on the part of the player. Some of these are more speed or more complexity in the challenges
Non-player characters	It is noteworthy that several games are focused on characters that interact with the player either as allies or, in serious games, as agents for a specific purpose in which they are required to react to the player's emotions to make the player have an enhanced experience
Score flow	When the score or awards of the game are not only limited to the performance and are influenced by the affective reaction; those studies were added to this group
Not registered	Many articles do not give details of elements adapted according to the affective state of the player. However, they did have affective measurements registered

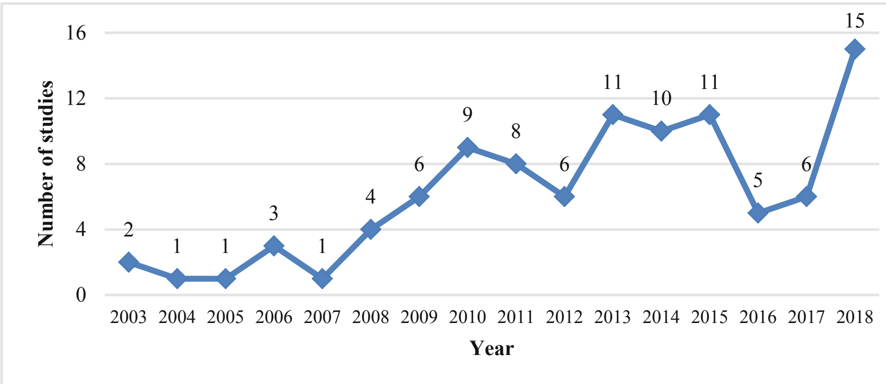

Fig. 4. Number of affective games studies per year

4 Discussion

The Systematic Mapping Study of the literature provided a map of the current studies in the AGs area, characterizing the measures used to determine emotional states of the players and the adaptation elements reported in some of the studies. With the obtained results, several points regarding the SMS research questions are discussed.

- Application domains reported in the literature on AGs

During the last two years, there was a growth in studies about the AGs area. Education is the area with more serious video games available, with 40% of the studies reported, followed by healthcare applications, and other health-related areas such as physical activity and physiology. Some of the papers not dealing with specific application domains included theoretical papers not referring to a product of presenting development or experimental results; instead, they reported the introduction of concepts or the description of best practices or design patterns from previous research works [6]. In addition to the theoretical studies, enhancing user experience was the purpose of other relevant papers; it was seen that uses of AGs characteristics in serious videogames improved their outcomes [7] and in the field of entertainment AGs provoked expected emotions in the players [8]. Measures used to determine emotional states of the players.

Some authors have suggested a classification of measures as direct and indirect [4], while others mention physiological and behavioral type measures [9]. In this study, these two classifications were considered within the affective measures found, and it was decided to combine them, e.g., a measurement such as the heart rate measured by a monitor was considered a direct measure because it is necessary to connect a device to the body and it is a physiological measure. With the combination of categories of direct-indirect and physiological-behavioral type, the measures that are not automatically taken but require the player to express them were also considered as a separate group. One of the interests in the exploration of these studies is to guarantee the measure of the affective state of the player most accurately and straightforwardly. Studies with multiple measures offer a higher precision; however, they are not easy to implement outside a laboratory setting. This type of studies was left in a separate group, focusing on studies with individual measures. The affective measures can also be classified by accuracy, complexity, objectivity, and intrusiveness. With these classification types, any practitioner could have better criteria to select affective measures by convenience or interest; there is much to improve in the proposed classification schema by keeping these considerations in mind.

After applying the classification schema, EDA was found the most used direct physiological measure (31.74%), and the facial recognition was the most used indirect physiological measure (88.23%). Similarly, the measure of behavior that was most used was the gamepad entry (33.33%), and the questionnaire was the most used tool as for how the player expresses his/her emotions (50%). The face emotion recognition can be categorized as a physiological measure and a behavioral one, depending on the control that a person has to express their emotions towards the game.

- Adaptation elements reported in the analyzed AG

From the few studies that report having adapted some game element, the interface components attributes are the most adapted element (15.38%), followed by difficulty (11.54%). From the adaptive elements, we expected to find and were not visible in the explored documents include the adaptation of content, such as scenarios, history, characters, educational content among others. Some studies that did not fit within the classification scheme included design patterns, best development practices, AGs engines, models of emotions and others.

- Map of measures and adaptive elements in AGs

From the systematic map, most studies have focused on determining the best way to identify the affective state of the player. There is a lack of research focusing on the adaptability of games, and 67.3% of the studies do not consider the adaptation of video games. So far, there has been a great interest in finding the best way to determine the emotional state of the player, so that practitioners adapt the elements of the game according to their purpose; 42.3% of the studies used measures of a direct physiological type. Many of the studies that performed physiological measures to determine the affective state of the player tested their results with the opinion of how the same players felt (ground truth), only one study took this measure as its gold standard.

5 Conclusion

This paper aims to present the cover of the emerging field of AGs as a first step in the comprehension of this area. The classification scheme together with the systematic map could help in finding gaps and suggesting ways to solve problems by analyzing relationships between affective measures and adapted elements within affective video games. Many studies use direct physiological measures as a more accurate way to determine the affective state of the player. With the increasing use of wearable devices, there is a smooth, non-intrusive, and more objective manner to determine the affective state of the player. The study does not pretend to be entirely conclusive; it allows to see ways to continue exploring in more specific areas (it could be with a more in-depth methodology like a systematic review) and to see advances and tendencies until the moment.

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Analysis of Motivation Model Using Real User Data from Social Games for Smartphones Extended to Social Factors Based on Maslow's Hierarchy of Needs

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Abstract. We constructed a motivation model that represents the motivations to continue playing social games using Maslow's hierarchy of needs and partially validated it using actual user data.

Keywords: Social game · Maslow's hierarchy of needs · Smartphones

1 Introduction

Many social games for smartphones have been developed. However, how to make the games enjoyable to users and have users want to play for a long time are significant issues to be addressed.

2 Related Research and Issues

Attempts have been made to clarify how to make games enjoyable to users and what elements of the game users enjoy.

Attention is on how to design better game content, i.e., User Interface/User Experience and task/goal design of game content [1], [2], specifically, on what content users are enjoying. To explain the skills and motivation of users playing non-network- and small-group battle-type games, motivation models are constructed using flow theory [3].

With the spread of and improvement in high-performance, network-type games enabling a large number of players to simultaneously play through a network have become popular, such as massively multiplayer online role-playing games (MMORPGs). Examples of game-content elements using such a network are relationships such as those formed in the real world, large number of users collaborating to reach a goal, and users competing with each other.

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User motivation derived from such social factors and not only from the difficulty level of the content/goals, which have been used in non-network- or small-group battle-type games, need to be investigated. To analyze motivation derived from these social factors, questionnaires have been provided to users of MMORPGs and factor analysis has been conducted. Studies have been conducted to clarify not only the sense of accomplishment but also the motivation and satisfaction derived from these social factors [4].

Due to the explosive spread of smartphones and the improvements in their performance, social games for smartphones have become popular. As a result, people who have never played conventional games have begun to play them on smartphones; thus, users have become more and more diversified. Focusing on the social factors of games as the motivation of users to continue playing such games is considered important. User behaviors, such as how he/she actually plays the game, how he/she communicates with others, and his/her actions in the game, are taken into account. However, there have not been many attempts to construct a general motivation model that takes into account these social factors in what motivates users to play a game by using actual user data.

3 Objectives

Our goal was to address the issues with developing and playing social games for smartphones, i.e., "how to make games enjoyable to users and have users want to play for a long time", using actual user data from "Kaburin" and "Puzzle Wonderland" (KLab Inc), we

1. constructed a general motivational model of user behavior in network-type games such as smartphone social games, and
2. partially verified the model using actual user data of two such games.

4 Analysis of General Motivation Models of Social Games for Smartphones

There are several reasons users would want to continue playing a game. One user may be satisfied with earning a high score, another may want to continue playing the game because he/she enjoys playing with others, and yet another may like the characters.

Therefore, we first considered what factors elements of social games for smartphones can satisfy users.

- Satisfaction with a character's appearance
- Satisfaction with a character's personality
- Satisfaction with background music in the game
- Satisfaction with story
- Satisfaction with genre
- Satisfaction with the game world
- Satisfaction of cooperating with others

- Satisfaction of competing against other users and winning
- Satisfaction of knowing how to play the game
- Satisfaction of continuing to play
- Satisfaction of advancing in the game
- Satisfaction with high score
- Satisfaction when clearing a level that could not be cleared before
- Satisfaction with the characters as they improve
- Satisfaction when improving game skills
- Satisfaction when playing high-quality games
- Satisfaction when obtaining items
- Satisfaction when a desirable item/character emerges from a loot box
- Satisfaction when obtaining a desirable item at an event
- Satisfaction when can boast about obtaining items and characters
- Satisfaction when earning high scores in a team battle
- Satisfaction when entering the top ranked group in an event
- Satisfaction with outstanding achievements at game competitions
- Satisfaction of appearing as a guest at an official event.

We discovered that these factors can be organized in chronological order after playing games such as proficiency in playing games, playing state of games, or improving characters in the game. When starting a game, the user judges from the character's appearance, music, game world, etc. whether the game meets his/her preferences. If it does, the user starts playing the game. Next, especially if the user is unfamiliar with the game, he/she would first want to become familiar with how to play the game and take part in tutorials and exercises. As the user becomes used to the game, i.e., his/her game skills improve or the game character becomes more powerful, he/she would want to continue playing. As the game becomes more interesting, the user will be able to proceed a simple stage earlier; thus, becoming more satisfied with a sense of accomplishment and progress. As the user becomes more accustomed to the game, he/she will be able to immerse him/herself deeper into the game world; thus, he/she will become more satisfied. It is possible for a user to become satisfied by gaining a new sense of accomplishment by targeting a high score, challenging him/herself by playing a more difficult stage, and achieving them. As a result of self-confidence in skills, the user will be satisfied by being told that they are 'amazing, strong, or good' when playing against or cooperating with others. If the user's proficiency in the game increases and his/her satisfaction increases, his/she will want to be in the top group at an event. Of course, depending on the user, it is not necessary for all these types of satisfaction to be met at the same time, e.g., "I am not good at playing games, but I am happy because I can play with my friends".

From this analysis, we found that users have new game needs depending on his/her understanding and proficiency of the game, the state of game play, or degree of character growth, so user will continue the game if these needs are met.

5 Correspondence Between Maslow's Hierarchy of Needs and Needs Within Social Games and Constructing Motivation Model for Social Games

Based on the analysis in the previous chapter, we constructed a general motivation model for smartphone social games based on meeting the needs of users in such games as described by Maslow's hierarchy of needs, which is a universal desire model for the real world, i.e., "physiological", "safety", "love", "esteem", and "self-actualization".

5.1 Needs and Motivation to Continue Playing Social Games

Before starting a game, a user is asked to confirm that the game's characters, music, game genre, and game world match his/her preferences. Only after these match will the user play the game. After starting the game, there are needs of getting used to the game, wishing to acquire knowledge of the game, and wanting to train the character, especially for game beginners. The user will proceed only after these needs are met. These needs can be grouped as the "user is will not enjoy game if this is not satisfied". A user who is not satisfied will quit the game thinking that it is too difficult to play. Next, the user will become more accustomed to the game and want to advance further, so the following needs arise, "I want to get better because I am still bad at it", "I want to make the character stronger because it is still weak", and "I want to acquire a good item from the loot box". According to these needs, the user practices more and trains his/her characters. At this time, the relationship among user skill, degree of game difficulty, and enthusiasm becomes clear, which is explained through flow theory. As a result, a user can advance further in the game by obtaining better items and earning higher scores; thus, becoming more satisfied. These needs can be grouped as the "need to be able to steadily advance in the game to gain satisfaction". Next some users cannot be satisfied by playing alone. Users will want to play and compete with each other, belong to a guild, or increase the number of friends. Of course, some users, especially those who are accustomed to social games, want increase the number of friends immediately after starting a game by trying to join guilds, compete in matches, or playing cooperatively. Other users try to play games regardless of other users. These needs can be grouped as the "need of playing with others". Thus, users who want to stand out or be praised among the group will emerge. To meet these needs, these users will try to be top ranked at an event, become stronger than others, obtain better items, and play a more of an active role in cooperative play. These needs can be grouped as the "need of being more prominent in the game and being praised". If all these needs are met, the user will aim for higher scores or try to become the top player. Such a need is the desire to meet the "need of attaining the highest state he/she can attain within the game" (see Fig. 1).

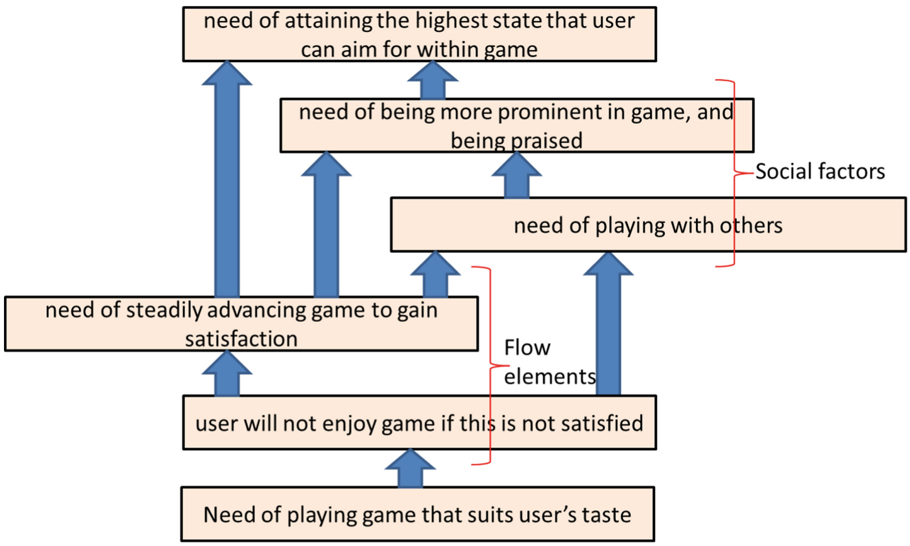

Fig. 1. Needs regarding smartphone social games

5.2 Needs Regarding Smartphone Social Games and Maslow's Hierarchy of Needs

From the previous section, we discussed the following needs: "need of playing a game that suits the user's taste", that "of user is will not enjoy game if this is not satisfied ", that "of steadily advancing in the game to gain satisfaction", that "of playing with others", that "of being more prominent in the game and being praised", and that "of attaining the highest state within the game".

Based on the analysis of these needs, we discovered that the motivation for a user to play a game can be partially explained using Maslow's hierarchy of needs. Therefore, we corresponded each element of Maslow's hierarchy with each need. The " user is will not enjoy game if this is not satisfied" corresponds to the "basic needs, e.g., food and sleep", i.e., Maslow's "physiological need". The "need of steadily advancing the game to gain satisfaction" corresponds to "the need of not feeling uneasy, being stable without disease or injury" in the real world, i.e., Maslow's "safety need". The "need of playing with others" corresponds to the "need of belonging to a group in society" in the real world, i.e., Maslow's "love need". The "need of being more prominent in the game and being praised" corresponds to the real-world "need of people wanting to be recognized", i.e., Maslow's "esteem need". The "need of attaining the highest state that a user can aim for within the game" corresponds Maslow's "need for self-actualization" in the real world. The "need of playing a game that suits the user's taste" does not correspond to any need in Maslow's hierarchy.

We constructed a motivation model for game users based on this correspondence (see Fig. 2).

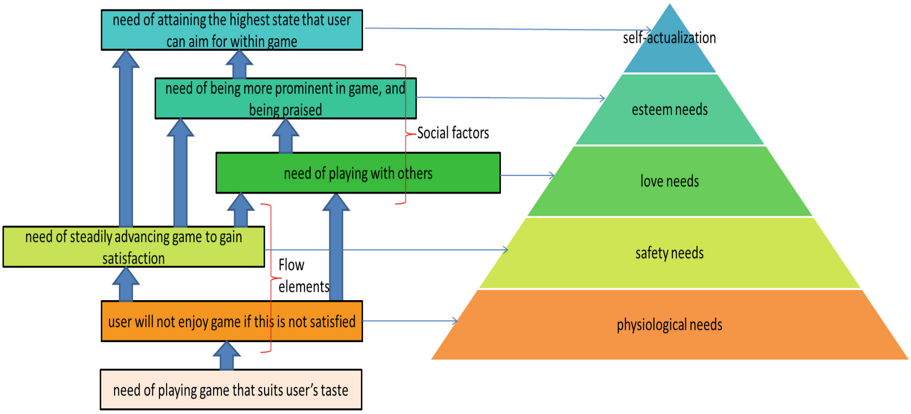

Fig. 2. Our motivation model for social games and Maslow's hierarchy of needs

6 Validation of Motivational Model Using Actual User Data

From the previous chapter, even in social games for smartphones, the user behavior corresponds Maslow's hierarchy of needs. If these needs are met in the game, the user is satisfied with the game and will continue to play for a long time. If he/she is not satisfied, he/she will quit the game.

In this chapter, we discuss the partial verification of our motivation model constructed using actual user data from two smartphone social games.

6.1 Model Validation for Predicting Continuation of Play

We first predicted the continuation of play by using actual user data from the game Kaburin then verified that our model could predict the motivation of user continuation.

"Physiological need: user will not enjoy game if this is not satisfied" and "safety need: need of steadily advancing in a game to gain satisfaction" for predicting continuation of play

Our model can accurately predict the motivation for a user to continue playing a game if these needs are met.

Therefore, we considered that continuation of play can be predicted from the play situation of the user based on the idea that the data representing the play status of each user' reflects whether the need was met. Therefore, we thought that "game progress speed", "total number of times played", "what stage is being played", "how far the game is progressing", and "play times/day" can predict continuation by machine learning.

The data of 1,000 users who continued playing Kaburin for 30 days or more existing at the 14th day after game start and 1,000 users who stopped playing in less than 30 days were prepared. After learning, we confirmed whether these features can be used for predicting continuous play 30 days after the start of a game (see Fig. 3).

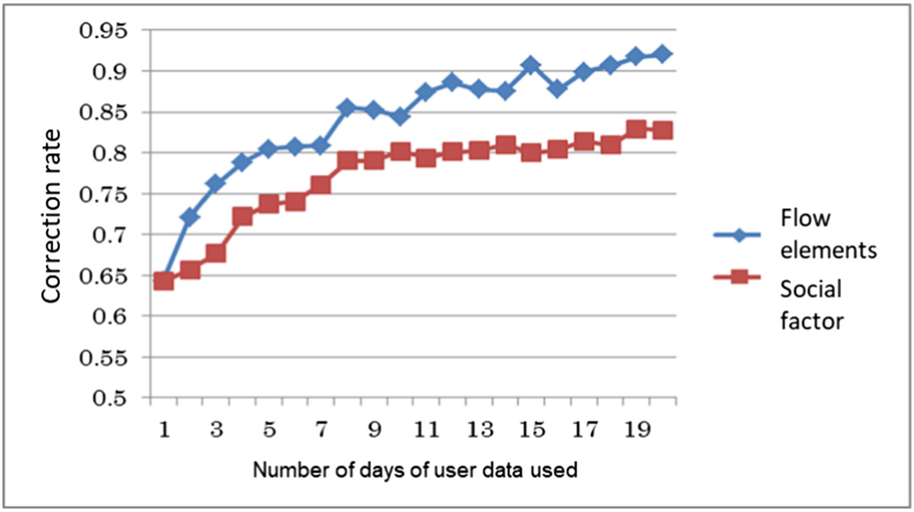

Fig. 3. Predicting continuation of playing Kaburin through machine learning

By using the learned machine and using the user data for 20 days from the start of the game, continuation of play could be predicted with an accuracy of 90%, confirming that "game progress speed", "total number of times played", "what stage is being playing", "how far the game is progressing", and "play times/day" are related to continuation of play.

We then investigated these results. For users whose physiological needs were not met, e.g., they did not play the game well because they do not know how to play, "total number of times played" and "play times/day" should decrease and "the progress speed of the game" should worsen. On the contrary, for users whose physiological needs were met, "the progress speed of the game" should better. We then investigated the "need of steadily advancing in the game to gain satisfaction". We may found users for which this need was not met, e.g., users who were frustrated by difficult content and could not proceed to the goal, by focusing on "what stage they were playing" and "how far they were progressing". Some of these users did not proceed and quit the game. As described above, the features used for analysis are "physiological need" and "safety need" and used to predict continuation of play. We verified that "physiological need" and "safety need" in our model are related to continuation of play.

Regarding "progress speed of game", user game skills and the degree of difficulty are reflected, and it can be said that it has flow elements. Based on flow theory, users feel satisfied if they are playing at an appropriate degree of difficulty and improve their game skills by trying more difficult content. However, we did not found it, This is for future work.

"Love need: need of playing with others" for predicting continuation of play

We next focused on "love need: need of playing with others". This is met if users are satisfied with the interactions and relationships with others in the game. "The number of times the communication function was used" and "the number of times the communication element was used by others" were used. Similarly to the previous section, we learned the features of 1,000 users who played Kaburin for 30 days or more existing at the 14th day after the game started and 1,000 users who stopped playing in less than 30 days through machine learning. Using the learned machine, we then confirmed whether these features can be used for predicting continuation of play 30 days after the start of the game (see Fig. 3).

From this result, it was shown that continuation of play can be predicted with 80% accuracy by using user data for 20 days from the start of the game. This confirms that "number of times of using the communication function" and "number of times the communication element was used by other users" in a game in which "love need" is reflected are related to the continuation of play.

Relevance of each need

We found that continuation of play and the characteristics of the actual data in which each need appeared are related and that continuation of play can be predicted. Some of the needs with our model could be confirmed with the actual user data.

Maslow stated that the importance of a need differs depending on the person. In fact, there are users who say, "I am not good at playing games, but I can continue playing games as I can play with my friends". Therefore, we further analyzed this prediction result and confirmed the relevance of each need.

For users who continued playing, we first confirmed the actual continuation of play and prediction results on the 30th day (see Table 1).

Table 1. Actual continuation of play and prediction results of each learned machine

Actual	Prediction by flow elements	Prediction by social factors	Number of users?
Did not continue	Did not continue	Did not continue	1234
Did not continue	Did not continue	Continued	70
Did not continue	Continued	Did not continue	65
Did not continue	Continued	Continued	46
Continued	Did not continue	Did not continue	39
Continued	Did not continue	Continued	26
Continued	Continued	Did not continue	225
Continued	Continued	Continued	503

The prediction results by learned machine differed. Let us focus on the pattern in which the prediction of one learned machine was correct. The number of users who have "Prediction by Flow Elements is 'Continued'" and "Prediction by Social Factors is 'Did not continue'" is as many as 225 people.

From these results, it seems that users seemed to emphasize "physiological need" and "safety need" to continuing playing Kaburin.

Therefore, continuation of play is predicted by each learned machine. If these prediction results are different,

– Prediction was done using flow elements using learned machine only from user data with different prediction results.
– Prediction was done using social factors using learned machine only from user data with different prediction results.

We then confirmed which prediction accuracy was higher (see Fig. 4).

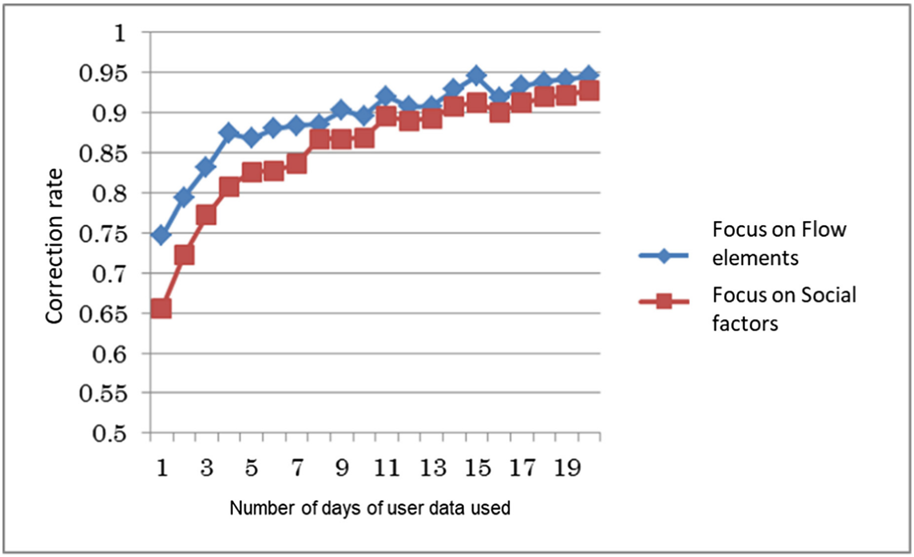

Fig. 4. Forecast results with emphasis on flow elements and social factors

We found that prediction accuracy improved up to 95 and 90% emphasizing flow elements and social factors, respectively. Prediction emphasizing flow elements improved prediction accuracy, so we confirmed that users of Kaburin place greater emphasis on flow elements. Therefore, it can be said that users of Kaburin emphasize "physiological need" and "safety need".

6.2 "Esteem Need: Wanting to Be More Prominent in Game and Being Praised"

"Esteem need" is met when a user is praised by others. Users who want to communicate with others want to have their "esteem needs" met. We analyzed the relationship between "number of other users a user spoke to", "number of other users who spoke to a user" and "the number of days of continuous play of Kaburin" (see Fig. 5) and those of Puzzle Wonderland" (see Fig. 6).

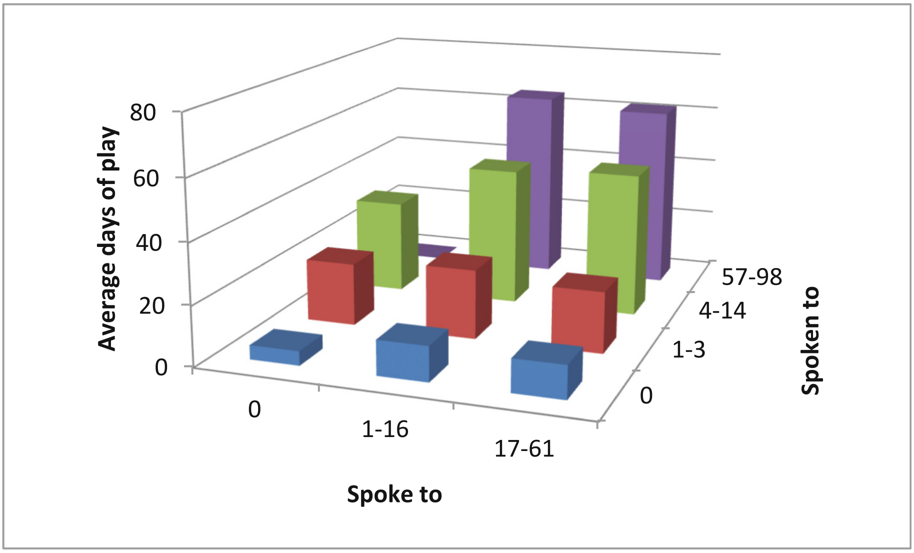

Fig. 5. Spoke/Spoken to and number of average days playing Kaburin

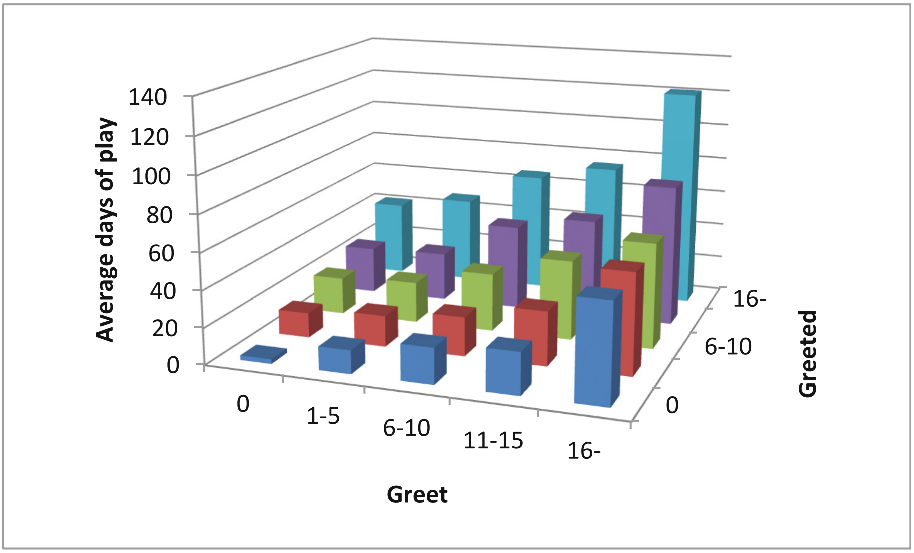

Fig. 6. Greet/Greeted and number of days playing Puzzle Wonderland

Users who were spoken to by others when playing Kaburin and Puzzle Wonderland had been playing the game for a long time, particularly, users who communicated more actively continued to play Puzzle Wonderland. Therefore, the “number of other users a user spoke to” and “number of other users who spoke to a user” in the actual user data are related to continuation of play with respect to “esteem need”.

7 Conclusion

We considered what factors elements of social games for smartphones can satisfy users. And we found that users have new game needs depending on his/her understanding and proficiency of the game. We defined these needs "need of playing game that suits user's taste", "user will not enjoy game if this is not satisfied", "need of steadily advancing game to gain satisfaction", "need of playing with others", "need of being more prominent in game, and being praised" and "need of attaining the highest state that user can aim for within game". Based on the analysis of these needs, we discovered that the motivation for a user to play a game can be partially explained using Maslow's hierarchy of needs. Therefore, we corresponded each element of Maslow's hierarchy with each need "physiological needs", "safety needs", "love needs", "esteem needs" and "self-actualization".

We developed a model using real user data from social games for smartphones extended to social factors based on Maslow's hierarchy of needs.

Finally we partially verified it by using actual user data from two such games. And we predicted the continuation of play by using actual user data from the game Kaburin then verified that our model could predict the motivation of user continuation. And we found users who were spoken to by others when playing Kaburin and Puzzle Wonderland had been playing the game for a long time, particularly, users who communicated more actively continued to play Puzzle Wonderland.

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Increasing Motivation for Playing Blockchain Games Using Proof-of-Achievement Algorithm

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Abstract. *Satoshi Nakamoto* introduced a peer-to-peer electronic payment system in the paper "Bitcoin: A Peer-to-Peer Electronic Cash System" [12] in 2009. The payment system introduced in this paper (now known as blockchain technology) had a big impact on digital data transfer in a point that using blockchain technology, digital data transfer can be done without having third parties to give trust to the transfer process. In this paper, we focus on one of the key components of the blockchain technology, "*consensus algorithm*". We propose a consensus algorithm "Proof-of-Achievement (PoA)" which is an algorithm optimized for blockchain games, focusing on the number of tasks achieved in the game. Using the PoA algorithm, we aim to increase the motivation for playing blockchain games. Through a user study, this paper discusses the effects of the PoA algorithm.

Keywords: Blockchain · Consensus algorithm · Gamification

1 Introduction

Blockchain Technology was introduced by Satoshi Nakamoto in the paper "Bitcoin: A Peer-to-Peer Electronic Cash System" [12] in 2009. Using the blockchain technology, peer-to-peer data transfers can be done without the trust of third parties.

Recently, many applications are being developed using the blockchain technology including "blockchain games", which are games which uses blockchain to "prove the provenance of specific virtual items" [3]. For example, Spells of Genesis [6] is a blockchain game which treats some of the cards used in the game as a token on blockchain, which makes the cards collectible and tradable outside the game, having the ownership of the card proved by blockchain.

In this paper, we focus on one of the key components of the blockchain technology, "consensus algorithm". Consensus algorithms are algorithms which determines who will generate the block and get the reward. Each blockchain uses a certain consensus algorithm. For example, Proof-of-Work (PoW) for Bitcoin and Ethereum, Proof-of-Importance (PoI) for NEM [9] and Delegated-Proof-of-Stake for Lisk. Based on the consensus algorithm, transactions on the blockchain are gathered and verified to form a "block". These blocks form a chain and since "To modify a past block, an attacker would have to redo the proof-of-work of the block and all blocks after it and then catch

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up with and surpass the work of the honest nodes" as explained in [12], the transactions will be non-reversible.

However, most of the blockchain games which rank high in trade volume [2] work on Ethereum blockchain which allows the blockchain game developers to easily deploy smart contracts, which are proved to be secure and non-reversible by the blockchain. However, Ethereum being a "decentralized platform that runs smart contracts" [5], it is not optimized for developing blockchain games. Therefore, we propose the Proof-of-Achievement algorithm, which is optimized for blockchain games which (A) Motivates the player to play the blockchain game by giving incentives from the blockchain. (B) Has a design based on gamification which motivates the user. (C) Realize high-speed transaction and high scalability.

In this study, we have conducted a user study to investigate the effects of the PoA algorithm. Through the results of the user study, we discuss if the PoA algorithm could increase the motivation for playing the blockchain game.

Our final goal is to develop a game platform based on the proposed blockchain system and be able to trade cards or game items from different games on the same blockchain.

This paper is structured as follows. In Sect. 2, we show some related works. This includes some examples of consensus algorithms that are related to this paper, an example of a blockchain game and the explanation of DApps. In Sect. 3, we will explain our approach. This includes how the Proof-of-Achievement (PoA) works and how PoA will motivate the blockchain users. Section 4 includes he explanation of our prototype system. We explain the how the prototype system is implemented and the what kind of game the participants will use. Section 5 includes the explanation of the user study and the results. Finally, in Sect. 6 we will conclude the study.

2 Related Work

2.1 Consensus Algorithm

Proof-of-Work

Bitcoin is the first and the most notable cryptocurrency. Cryptocurrency is a "*medium of exchange, created and stored electronically in the blockchain, using encryption techniques to control the creation of monetary units and to verify the transfer of funds*" [15].

The consensus algorithm used in Bitcoin is Proof-of-Work (PoW). Also, Ethereum blockchain, which has the third largest market cap in all the cryptocurrencies (as of January 16, 2019) [4] and many other blockchains such as Litecoin, Monero or Dash use PoW algorithm. PoW ensures the transactions to be non-reversible by expending CPU efforts. The blocks can only be redone by expending the same amount of machine power and generate blocks to catch up with and surpass the longest chain [12]. Therefore, as long as the attacker does not monopolize more than 51% of the total machine power, the blockchain cannot be attacked and the blocks and the transactions cannot be reversed.

However today, most of the miners (untrusted nodes that provides machine power to the blockchain), form "mining pools" which are *"large pools built out of independent entities that place their hashing power under the control of a pool manager that coordinates their efforts, collects rewards, and redistributes those rewards to the participants in proportion to their effort"* [7]. Because of this mining concentration problem, in 2014, GHash mining pool actually exceeded 51% of the total mining power. Also, on January 06, 2019, Ethereum classic was targeted by a 51% attack and some transactions were reversed [14].

This concentration problem is making the PoW blockchains "not non-reversible" and has become a serious problem.

Another problem is the concentration of wealth. Since PoW rewards more to the people who have more machine power, rich people with more machine power become richer and ends up in the concentration of wealth. In fact, the top 1% of the Bitcoin holders own 80% of all Bitcoins (starting from 2014) [16].

Proof-of-Importance

Proof-of-Importance (PoI) is a consensus algorithm used in NEM blockchain. This consensus algorithm is similar to Proof-of-Stake algorithm, which is a consensus algorithm where the determination of who adds the next block is weighted by how many tokens (called "stakes") you have [10]. In addition to the stakes, PoI is also weighted by the amount *"how much they transact to others and who they transact with"* [16]. From to these amounts, the score called the "Importance" is calculated, and higher your importance is, higher the chance of getting rewarded from the blockchain will be. Mining in PoI is called "Harvesting" and does not require a large amount of machine power. Therefore, the reward from the blockchain is distributed also to regular people who do not have expensive mining machines, which leads to even wealth distribution and solves the concentration of wealth which occurs with PoW blockchains.

Figure 1 explains how harvesting works. Instead of having every user generate the block, each user delegates harvesting to special nodes called Super Nodes (SN) with certain requirements [9]. Each SN generates blocks depending on the importance of the users who delegated their harvesting to the SN. Finally, the SN distributes the reward from the blockchain to the users depending on each user's importance.

2.2 Spell of Genesis

Spell of Genesis is *"the first blockchain-based mobile game ever made"* [6]. The game was first launched in 2017 as a combination of trading card game and point and shot arcade game. Some cards used in the game are treated as tokens on the blockchain and called the "blockchain cards". The screenshot of the game and the blockchain card is shown in Fig. 2.

Cryptocurrency called BitCrystal was also distributed through an ICO (Initial Coin Offering). Both the blockchain cards and the Bitcrystals are treated as tokens on a Bitcoin blockchain through Counterparty, a platform that provides the ability to create your own tokens on the Bitcoin blockchain.

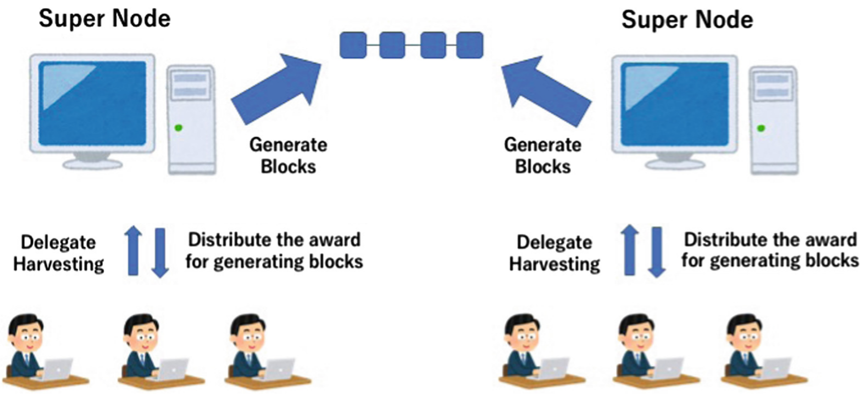

Fig. 1. Description of Proof-of-Importance (Illustrations used from [18])

Fig. 2. Screenshot of gameplay (Left) and the blockchain card (Right) [3]

2.3 DApps

DApps (Decentralized Applications) are applications that most or entire part are decentralized. The examples of possible aspects of an application that can be decentralized are backend software (application logic), frontend software, data storage, message communication and name resolutions [1]. Today, most of the blockchain games which rank high in trade volume [2] are DApps and work on Ethereum blockchain which allows the blockchain game developers to easily deploy smart contracts, which are proved to be secure and non-reversible by the blockchain.

In [1], the authors explain the advantages of being decentralized as follows.

1. Resiliency

When the application logic of the application is controlled by a smart contract, unlike applications that run on a centralized server, DApps will be available as long as the platform (the blockchain the application is running on) is running.

2. Transparency

The code of DApps is allowed to inspect by everyone so no unfair actions can be done by the game developers.

3. Censorship resistance

Since the smart contracts will be stored on the blockchain, no one, even the developers can change or undo the smart contracts.

However, as mentioned in the Introduction section, Ethereum blockchain currently uses PoW as consensus algorithm. Therefore, the final goal of this study is to develop a blockchain game platform, which works similar to Ethereum blockchain and uses consensus algorithm optimized for blockchain games.

3 Our Approach

3.1 An Overview of Our Approach

In this paper, we propose a new consensus algorithm optimized for blockchain games. The aim of the consensus algorithm is to realize a blockchain which avoids problems such as the concentration problems which can be seen in PoW and uses the reward from the blockchain to motivate the blockchain game players.

3.2 Proof-of-Achievement

We propose a consensus algorithm named Proof-of-Achievement (PoA). The basic concept of PoA is “The player who achieves more tasks in the game earns more reward”. Instead of using machine power as in PoW or PoS, PoA blockchains run by the achievements of the blockchain game users. The design of PoA gets the idea of PoI algorithm. However, while PoI determines the reward using “importance score”, PoA uses “achievement score” to determine the reward. As well as PoI, since PoA does not use machine power as in PoW, concentration problem can be avoided.

3.3 Monetary Incentive

In most of the blockchains, a reward is given to the nodes when a block is generated, as a monetary incentive to support the blockchain network [12]. As well as these blockchains, PoA blockchains will also give blockchain game players rewards when a block is generated calculated by the number of tasks done in the game, which will work as a monetary incentive.

Providing monetary incentive is one of the suggested methods to give extrinsic motivation to users. However, it is indicated that the effects of monetary incentives widely vary [11]. Therefore, we will evaluate the effects of our method through a user study.

3.4 Gamification

In [13], gamification is described as *"the use of video game elements in non-gaming system to improve user experience (UX) and user engagement"*. This approach is useful to give intrinsic motivation to users when it is used properly. The game elements used for gamification are often achievements (badges), levels, or leaderboards.

In our approach, we add a leaderboard to the mining process to increase the motivation of mining, which leads to an increase in the motivation of playing the game. The achievement score of each user will be shown on the leader board. This is possible because basically, all the data on the blockchain including achievement score is transparent and visible to everyone (except for some untraceable blockchains like Monero).

3.5 Tokens in PoA Blockchain

Achievement Tokens
Achievement tokens are used to calculate the achievement score of each node. The achievement score of a node will be the ratio of the number of node's achievement tokens to the total number of achievement tokens distributed. Achievement tokens will be distributed to the blockchain game players each time a task is achieved by the player. By handling the achievement tokens on the blockchain, transparency of the movements of achievement tokens will be provided by the blockchain. This will prevent unfair actions by certain games (e.g. giving a large amount of achievement tokens to a certain user to make him/her have partially high achievement score).

Currency Tokens
Currency tokens are cryptocurrency which will be traded on cryptocurrency markets. The tokens will have some benefits related to the game (e.g. get discount on game items when paid by the currency tokens) so that the tokens will be in demand and be at a certain price.

Game Tokens
Game tokens are tokens of game characters, items, or cards used in the game as explained in the Introduction section. As well as other tokens, game tokens can be sent and received outside the game.
Trades of game characters or game items can also be implemented on games that run by the server-client model. However, the trades will have to be done under a certain rule made by the developers of the game. For example, certain trade fee will be charged or trade between different games will be unavailable (or very limited). Having the game tokens on blockchain will provide the player's control of their trades.

3.6 The Network of the Blockchain with PoA

The network of the PoA blockchain basically functions the same way as the PoI blockchains as explained in Fig. 1. Each player in the network delegates the mining process to special nodes, and the special nodes generate the blocks. Finally, the special nodes distribute the rewards to each node depending on their achievement scores.

4 Prototype System

4.1 Implementation

The game for the experiment was implemented with Android Java and Ruby on Rails. To make the implementation simpler, our system is implemented using the server/client model instead of the actual blockchain system. However, there is no difference in UI. Therefore, using the server/client does not affect the evaluation result.

4.2 Basic System

The game for the experiment is a trading card game originally created for the experiment. To start a battle, the players select the opponent from the menu (Fig. 3). There are two types of battle, player battle and CPU battle. The difference between the two types is that for player battle, the player battles against the card deck other players have created. On the other hand, for CPU battle, the player battles against a deck the developer has created beforehand (5 different difficulties).

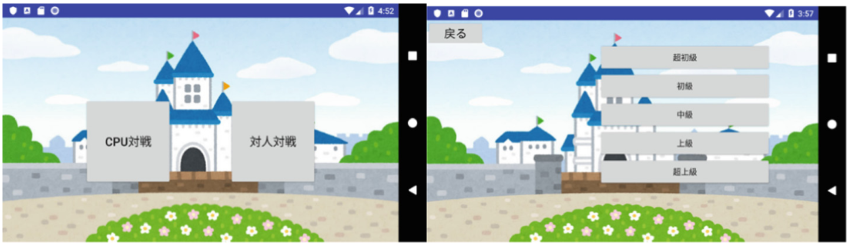

Fig. 3. Screenshot for choosing an opponent (Left: CPU or player, Right: difficulty)

However, every battle in the game is played against computer AI. The player and the opponent played cards in turn until the hit point of either of the player reaches 0. The screenshot is shown in Fig. 4.

4.3 Gacha System

Gacha is a well-used way of getting characters or cards in Japanese smartphone games. To get characters or cards from the gacha, players use in-game points. A Japanese smartphone game often have 2 types of gachas in the game. One type of gacha uses points you can get free in the game, and the other uses points you buy with actual money (or sometimes given free in the game).

In our system, two types of gachas are implemented as well as many of the Japanese smartphone games. One is “normal gacha”, a gacha you use points you can get free in the game (we called the points “gacha points”). The other is “rare gacha”, a gacha you use points you buy with actual money (and given in the game for doing difficult tasks. The points were called the “stones”). The cards that can be obtained

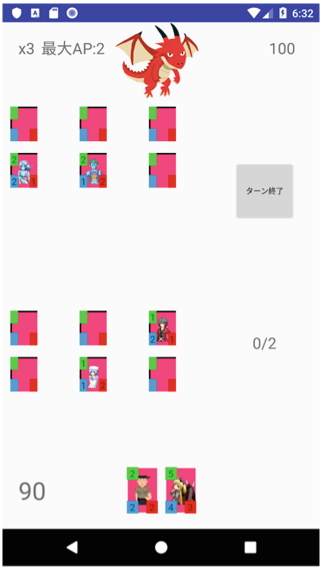

Fig. 4. Screenshot of battle

from the "rare gacha" is often more powerful than the cards that can be obtained from the "normal gacha". However, in the experiment, the participants could not actually buy stones. Instead, the rewards from the blockchain were automatically converted to stones and could be used as in-game currency. The actual gacha in the game is shown in Fig. 5. The amount of points or stones needed to get cards once (5 cards) was 100 points for normal gacha and 50 stones for rare gacha.

Fig. 5. Screenshot of "normal gacha"

4.4 Tasks

There are 2 types of tasks in the game. The tasks are as follows.

Daily tasks: Daily tasks are tasks that can be done each day. Once you do the task, you will not be able to do the same task again until next morning (5 a.m.).

The daily tasks are as follows,

1. Play player battle 3 times.
2. Play player battle 5 times.
3. Play player battle 7 times.
4. Play player battle 10 times.
5. Play CPU battle 3 times.
6. Play CPU battle 7 times.
7. Play CPU battle 10 times.

The reward for each task is 100 gacha points for task 1, 2, 3, 5, 6, 7 and 50 stones for task 4 and 8. In addition, for each task, the player gets 1 achievement point.

One-time Tasks: One-time tasks are tasks that can be done only once throughout the experiment. The one-time tasks are as follows.

1. Defeat CPU of difficulty "very easy"
2. Defeat CPU of difficulty "easy"
3. Defeat CPU of difficulty "medium"
4. Defeat CPU of difficulty "hard"
5. Defeat CPU of difficulty "very hard"

By completing each task, the player get 100 stones and 10 achievement points.

4.5 Amount of Reward Paid from the Blockchain

How much reward should be paid to the players in the experiment? This is very difficult to determine considering the following 2 points.

The price of the cryptocurrency: We need to first determine how much the blockchain will reward the players. However, because of the high volatility of cryptocurrencies today, it is very difficult to determine how much the price of the currency tokens should be. For example, the price of NEM was about 0.4 dollars on May 1, 2018, while the price was about 0.07 dollars on December 30, 2018 [4].

The number of players: The number of players must also be determined to determine how the reward from the blockchain should be distributed. 2 times more the players exist, half the reward for each player will be. However, it is very difficult to know how many players actually play the game (not the number of devices installed).

Considering these points, we decided to roughly estimate the amount of rewards and the number of active players. First, we decided to use the price of Lisk. This is because the consensus algorithm used in Lisk blockchain called DPoS is similar to PoI thus similar to PoA as well and has a fixed price of reward (4 Lisk for each block created). In addition, we supposed the number of players to be 1 million considering smartphone games in Japan with 5 top highest DAU (Daily Active User) reported by [8] (Fig. 6).

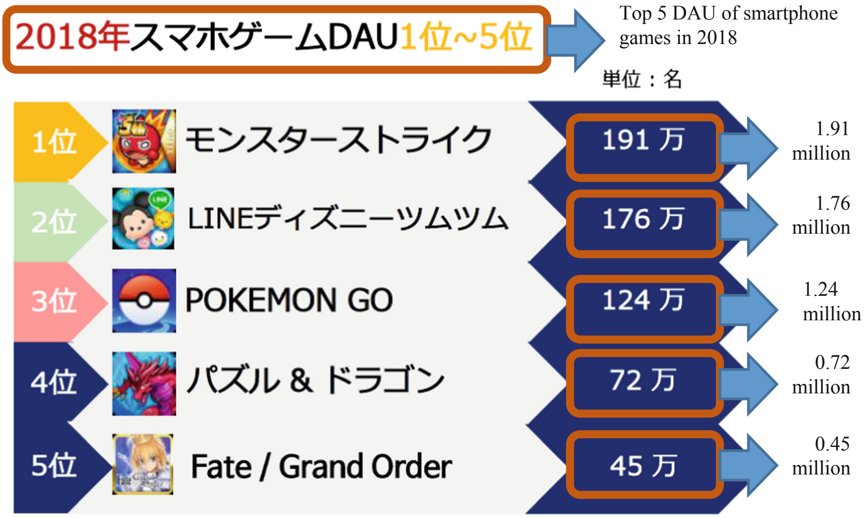

Fig. 6. Top 5 DAU of smartphone games in 2018 [17]

From these numbers, we calculated the amount of reward as below. (n:4 [Lisk/block], y: 300[yen/Lisk (Sep 2018)], b: 8640[blocks/day], P: 1,000,000[players], p: 8[number of participants])

$$n \times y \times b \div P \times p \approx 80[\text{yen}]$$

Therefore, 80 yen were distributed per day to the participants in Group A calculated by the achievement score of the user and automatically converted to gacha stones. The conversion between yen and stones was as below.

$$300 \text{ yen } \rightarrow 50 \text{ stones}$$

We did research on a few Japanese smartphone games and found out that the price of getting a character or cards once from a gacha, costs approximately 300 yen [18–20].

However, as we have mentioned before, we must note that the amount calculated above is a rough amount and can range very widely. Therefore, in a further study, we need to do experiments with other amounts of reward.

4.6 Blockchain Menu

Figure 7 shows the blockchain menu and the leaderboard which only the participants in Group A can see. In the blockchain menu, the participants can see the information of the recent 5 blocks (achievement score and the actual amount of gacha stones obtained). The blocks were generated every hour. The leader board shows the achievement score of the player and other players. The name of other players is not shown on the leaderboard. Instead, the identifier of the players is shown. This is

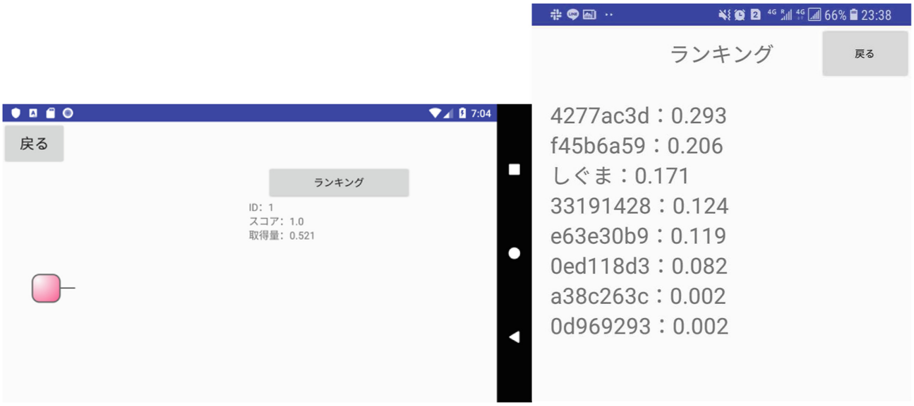

Fig. 7. Screenshot of the blockchain menu (Left) and the leaderboard (Right)

because, in actual blockchains, the data and the address is public to everyone, but the actual owner of the address cannot be known. From the leaderboard, the players can know how much achievement score other players have and the ranking.

4.7 Trade System

Trade system was implemented, and the players could buy and sell cards using stones. This system was aimed to increase the usage of stones. However, because of the low usability of the trade system, this system was never used throughout the experiment.

5 User Study

5.1 The Overview of the User Study

A user study was conducted using 8 participants (7 male and 1 female, average age: 22.5). The 8 participants were randomly split into 2 groups (Group A and Group B) with 4 participants each.

We developed a trading card game that can be played on Android smartphones, and had each participant play the game whenever they wanted to. The experiment was held for 15 days continuously. The groups differed in the following way,

Group A: The app included the system of PoA. The players earned rewards from the blockchain based on the PoA algorithm and could see the leaderboard.

Group B: The app did not include the system of PoA. The players earned no rewards from the blockchain and could not see the leaderboard.

The participants in both groups were not informed that two groups existed. Therefore, to make the participants in Group B appear on the leaderboards of the participants in Group A, achievement score for the participants in Group B were calculated in the same way (without the reward).

After the experiment, we did an interview to the participants in Group A and asked questions.

5.2 Results

The basic information of the participants

Table 1 shows the basic information of the participants. This includes the age and the average time of playing smartphone games per day. A1-4 are participants in group A and B1-4 are participants in group B.

Table 1. The basic information of the participants

	Age	Average time of playing games per day [hours]
A1	25	1
A2	23	3
A3	20	2
A4	21	0.17
B1	24	1-2
B2	23	0.1
B3	21	0.5
B4	23	2

However, 2 participants (A4 and B4) played the game only once throughout the experiment. Therefore, the 2 participants are excluded from the results.

Comparison between 2 groups

Figure 8 shows the comparison the of number of plays between group A and group B. However, the system did not count the number of plays which exceeded 10 times for each type of battle (player battle and CPU battle) because there are no tasks for playing more than 10 times. Therefore, the maximum number of plays per day per participant is 20 (10 for player battle and 10 for CPU battle). In addition, the dates are split into 5 sections, 3 days each (1/7-9, 1/10-12, 1/13-15, 1/16-18, 1/19-21). Throughout the study, the number of plays of group A exceeded group B.

Comparison between the top players from each group

Figure 9 shows the number of plays of the players which played the most in both groups (participant A3 and B3). From the graph, you can see that participant A3 kept motivated throughout the study while the motivation of participant B3 declined as the time passed. You can also see that the participant A3 was motivated by PoA from the interview which is explained in the later section.

Interview result

We asked th participants in group A the following questions.

1. What did you think about the amount of the reward from the blockchain?
2. Did the reward from the blockchain motivate you to play the game and why?

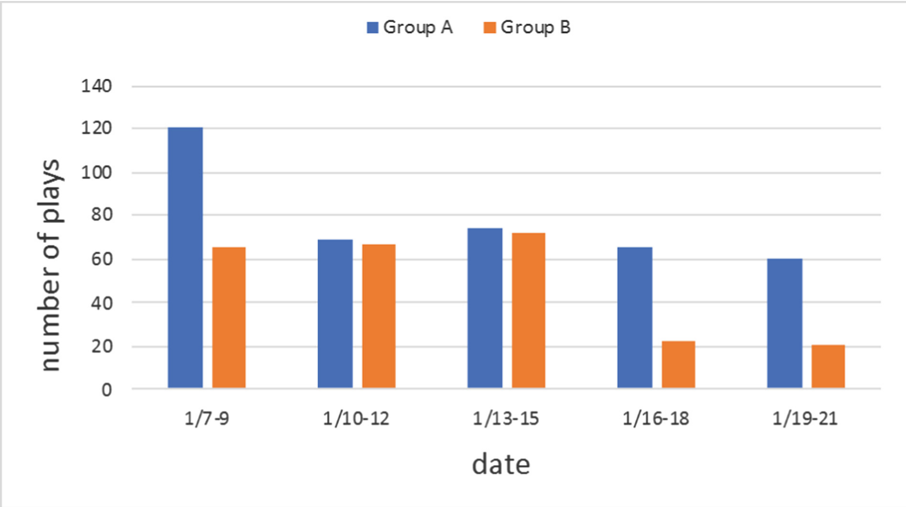

Fig. 8. Number of plays of each group

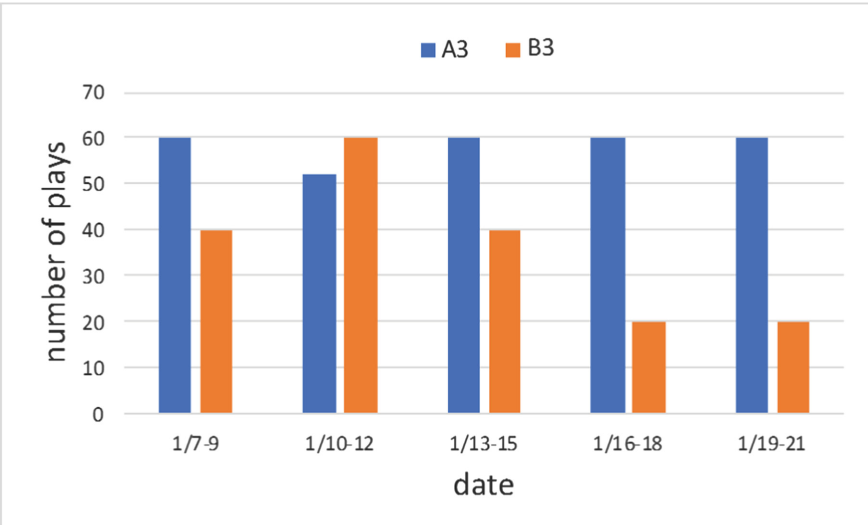

Fig. 9. Number of plays of A3 and B3

3. Did the leader board motivate you to play the game and why?
4. Do you have any comments about the experiment?

Table 2 shows the comments to the question, *“What did you think about the amount of the reward from the blockchain?”*.

Table 2. Comments to the question "*What did you think about the amount of the reward from the blockchain?*"

Participant	Amount
A1	The amount was small
A2	The amount was small
A3	The amount was small

Every participant answered that the amount of the reward from the blockchain was small. However, the total amount of stones the participants obtained from the blockchain is shown in Table 3. You can see that none of the participants reach the amount of stones required for 1 gacha (50 stones).

Table 3. Total amount of stones obtained from the blockchain

Participant	Amount
A1	35.937
A2	13.671
A3	49.016

Table 4 shows the comments to the question, "*Did the reward from the blockchain motivate you to play the game and why?*".

Table 4. Comments to the question "*Did the reward from the blockchain motivate you to play the game and why?*"

Participant	Comment
A1	No. Didn't feel the increase of stones because the amount was too small
A2	No. The amount was too small
A3	A little. Felt pleasure obtaining stones.

Only participant A3, who obtained the rewards the most, felt himself motivated by the blockchain. Other participants both mentioned that they were not motivated because the amount was too small.

Next, Table 5 shows the comments to the question, *"Did the leader board motivate you to play the game and why?"*

Participant A3 was motivated by the leaderboard as you can see from the comment above. However, participant A1 and A2 were not motivated by the leaderboard. They both mentioned that they could not understand the meaning of achievement score displayed on the leaderboard (The explanation was written in the manual). Participant A2 also mentioned that it would have been better if the actual name was displayed.

Table 5. Comments to the question, *"Did the leader board motivate you to play the game and why?"*

Participant	Comment
A1	No. Didn't feel anything. The score display was difficult to understand.
A2	No. The score display was difficult to understand. It was better if the actual name was displayed.
A3	Yes. The leaderboard motivated me to pass the other participants and keep myself in the 1st place.

Finally, Table 6 shows the comments to the question *"Do you have any comments about the experiment?"*

Table 6. Comments to the question *"Do you have any comments about the experiment?"*

Participant	Comment
A1	It was better if there were more trades
A2	It was better if there were more trades
A3	It was better if there were notifications that tells the amount of obtained stones
	It was better if there were more trades

Every participant answered that it would have been better if there were more trades. They also commented that the usage of the trading system was not very good. Since no trades were done by the participants, the usage of the stones was limited to getting cards from the gacha. Therefore, obtaining stones were less attractive to participants.

6 Conclusion and Future Work

6.1 Conclusion

From the user study, we can see that the PoA algorithm succeeded to motivate one participant while it failed to motivate 2 others. The reason the 2 participants were not motivated mainly comes from the amount of the rewards. In addition, the usages of the rewards of the blockchain was very limited. This made the rewards less attractive to the participants.

6.2 Future Work

The amount in the user study is roughly calculated as explained in Sect. 4.1, we need a further study with different amount of rewards. In addition, in the user study, the rewards from the blockchain were automatically converted to gacha stones. However, in our proposal, the rewards are meant to be cryptocurrency with many usages (e.g. exchanging with legal tender, used for trading game items, get special bonus in games). Therefore, further studies using a system with these functions implemented may have results.

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Video Game Playing Enhances Young Children's Inhibitory Control

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Abstract. Inhibitory control (IC), one of the main components of executive function, is a high-order cognitive process that enables individuals to suppress prepotent reactions and resist irrelevant interference. It develops rapidly in early childhood and provides a foundation for cognitive and psychosocial development in children. Although differing perspectives exist, there is some agreement that IC may be enhanced through video game practice and training, and that the level of cognitive engagement (CE) may affect the training outcomes. This study explored the effects of training video games on IC (measured by a Go/No-Go task) in 90 four- to six-year-old children. Participants were randomly assigned to one of three conditions: low CE (played *Whack-A-Mole*), high CE (played *Talking Tom Gold Run*), or a control group (received no training). Both training groups were asked to play the assigned video game for 5 min/day for 5 consecutive days. Results showed that the experienced gamers performed better at IC than did non-gamers. Video game training triggered significant improvements (preschoolers responded more accurately and quickly in the Go/No-Go task after a total of 25 min of training). Reaction times were negatively correlated with accuracy, i.e., children who responded faster also made fewer mistakes. However, the level of CE in video games had no differential impact on IC in the present group of young children. These results highlight the potential beneficial effects of video games on IC in preschoolers, and indicate that video game training may serve as a promising alternative to conventional IC interventions.

Keywords: Video games · Young children · Inhibitory control · Executive function · Go/No-Go task

1 Introduction

In this era of information and technology, video games have become almost ubiquitous in children's lives. A considerable literature has grown up on the potential effects of video games on cognitive ability [1, 2]. Recent evidence has suggested that video gaming might lead to enhanced *inhibitory control* (IC) [3, 4]. However, some other studies have found that IC is negatively affected by video game experience [5, 6]. In considering here whether playing video games improves IC, we begin by explaining the meaning of the term IC.

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1.1 Executive Function and Inhibitory Control

IC is a central component of *executive function* (EF). According to Najdowski et al., EF can be regarded as the chief executive officer of one's brain [7]. Although an established concept in psychology, EF is difficult to precisely define and there remain different beliefs about the structure of EF. Some researchers have conceptualized EF as a unitary system [8, 9] whereas others have considered EF to be a multidimensional construct [10]. To date, most researchers have reached the agreement that EF consists of three separable but interrelated higher-order cognitive processes (IC, cognitive flexibility, and working memory), which regulates goal-directed action and adaptive responses to the changing environment [11].

As a core function of EF, IC involves the ability to resist automatic but task-irrelevant responses. Classic examples of IC in early childhood include suppressing the impulse to eat a forbidden cake or to avoid touching an appealing but banned toy. Children who score highly on measures of IC are able to behave themselves in such situations, while those with lower scores seem to be more reckless. IC plays a crucial role in one's physical, cognitive, and psychosocial development [12]. It is a reliable predictor of young children's school readiness as well as achievement in mathematics and reading [13, 14]. Deficient IC has been detected in individuals with attention deficit hyperactivity disorder [15] and autism spectrum disorder [16].

The *Go/No-Go task* is the most important measure used in assessing IC [3]. This paradigm is an Information and Communication Technologies based task, aiming to evaluate a participant's capacity to inhibit inappropriate responses [17]. A Go/No-Go task requires the participants to perform an action (e.g., press a button) as quickly as possible when they see certain stimuli (i.e., Go trials), but withhold their responses when other stimuli are present (i.e., No-Go trials). IC is indexed by response accuracy and reaction times (RTs), with higher accuracy and shorter RTs indicating higher efficiency in IC [18, 19].

1.2 Inhibitory Control in Young Children

The rudiment of IC in young children is the effortful control of one's primitive reflexes and other pre-dominant behaviors, such as reaching an attractive toy [20]. The ability to refrain from a prepotent response begins to emerge in infancy, likely in the first year of life [21], and develops most rapidly in the preschool period [22]. The growth in IC during the early years can be explained in part by the maturation of attention and integration of different EF skills [23]. Another possible explanation is that functional changes in the prefrontal cortex during this period also contribute to the development of IC [24, 25].

To date, evidence for whether IC can be improved by training has been mixed. Some studies have failed to show any beneficial effect or transfer of IC training to other tasks [26, 27]. In contrast, other cognitive intervention studies have demonstrated that IC, just like other EF components, may improve with training [28, 29]. A number of researchers have identified that consistent exercise through cognitive stimulation or aerobic activities is able to strengthen brain connections and enhance IC [29, 30]. Furthermore, IC training yields stronger effects for young children than for adults [31].

1.3 Video Game Training

Studies on the benefits of gaming have documented that video game experiences may have the potential to facilitate IC in children [3, 4]. Certain types of video game, especially those requiring a high level of *cognitive engagement* (CE), have been found to be capable of enhancing EF [32]. CE refers to a mental state in which people devote their cognitive energies and allocate their attentional resources to master acquisition of challenging knowledge and skills. Complexity, novelty, and diversity have been identified as the key factors of highly cognitive engaging training programs [33].

Computerized cognitive training may take 2 to 14 weeks to benefit EF, and a longer training duration has been found to produce better EF outcomes [29]. However, recent evidence suggests that young children's behavior may be easily affected by even brief exposure to video games, due to the vital function of play during early childhood [36]. Further studies regarding whether IC can be stimulated by video game training over a short period of time would be worthwhile.

1.4 The Present Study

Although the effects of IC training remain controversial, given the brain plasticity of young children and the importance of IC [35], future research is needed to better understand the impacts of video game training in this context. Considering that the level of CE and the length of intervention time may influence the outcomes of IC training, this study aimed to elucidate whether a short duration (25 min in total) of low or high CE video game training could improve the IC of young children IC as measured by a Go/No-Go task.

Based on previous findings, we hypothesized that (1) experienced video gamers would outperform non-gamers in IC at pre-test; (2) video game training would promote young children's IC in less than 2 weeks; and (3) high CE video game training would produce greater improvements than low CE video game training at post-test.

2 Method

2.1 Participants

Ninety children (47 boys and 43 girls) aged 4.46 to 6.03 ($M_{\text{age}} = 5.04$, $SD_{\text{age}} = 0.31$) participated in this study. They were recruited from a kindergarten in China, and written informed consent was obtained all parents/guardians for children to participate. Prior to commencing the intervention, parents reported their child's gender, date of birth, and previous video game experience, including (1) whether their child had played video games before, (2) how many times their child played video games on a weekly basis (in general), and (3) how many minutes their child spent gaming per week on average.

2.2 Procedure

Figure 1 illustrates the structure of the study. The pre-test assessment took place two days before the start of the training, and the post-test took place two days after the end of the training. In the training session, participants were randomly assigned to one of three groups. One group played a low CE video game (*Whack-A-Mole*), another group played a high CE video game (*Talking Tom Gold Run*), and the third group which served as a control group continued with their routine activities. Training was completed for 5 consecutive days (5 min per day). Children completed all the tasks and training sessions individually in a quiet and familiar room inside their kindergarten.

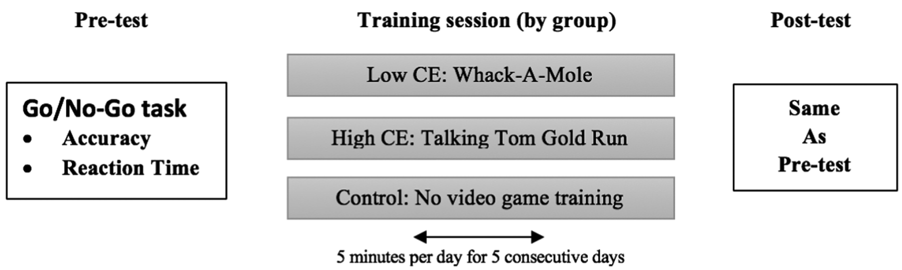

Fig. 1. Procedure across groups (n = 30 for each group).

2.3 Assessment (Go/No-Go Task)

The IC task was a Go/No-Go task for children. It was created and implemented using E-Prime™ software (Psychology Software Tools, Inc). The Go/No-Go task contained two types of trials: Go trials and No-Go trials. Participants were instructed to press the space bar when they saw a "Go" stimulus (an animal other than crocodile) and refrain from responding when a "No-Go" stimulus (a crocodile) appeared. The practice session composed of 16 trials including 4 No-Go trials, and the test session comprised 40 trials of which 25% were No-Go trials. Figure 2 shows the sequence of events during each trial. First, a fixation point was presented in the center of the screen for 500 ms. It was followed by a randomized distributed Go or No-Go stimulus, which appeared and remained on the screen until the participant made a response, for a maximum of 800 ms. Feedback was given during the practice trials but omitted during the testing trials. The number of correct responses and RTs were recorded. Higher accuracy scores and shorter RTs reflected higher levels of IC.

2.4 Video Game Training

The training device was an iPad (Apple Inc.). Both training games were free commercial games that could be downloaded via the iTunes App store (Fig. 3). Both games required the ability to inhibit prepotent responses to environmental stimuli. In the training groups, each child was instructed to play the assigned game for 5 min per day for 5 consecutive days (total training = 25 min).

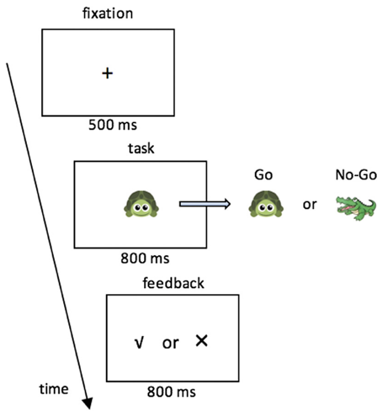

Fig. 2. Illustration of the sequence of events on a trial. Feedback was only provided in the practice trials.

Fig. 3. Screenshots of the two video games: Whack-A-Mole (*left*), and Talking Tom Gold Run (*right*).

Low CE video game. Whack-A-Mole (CLCM Inc). The goal of the game is to force the popped-up moles back into the holes by whacking them with a mallet, and to avoid hitting other objects, such as bombs. The moles and other objects were presented randomly. Children were instructed to respond as quickly and accurately as possible.

High CE video game. Talking Tom Gold Run (Outfit7 Limited). This is a runner game in which players are enabled to run indefinitely. During the running sequence, children were required to move their characters (such as Talking Tom) to avoid obstacles and collect items (e.g., gold bars). The game became more difficult as the child proceeded and children were asked to run as far as they could.

In order to examine the degree of CE, children were asked to evaluate the complexity, novelty, and diversity of the video games on a 5-point Likert scale after their first exposure to the games. The 5-point scale was illustrated using five circles of different sizes, with the smallest circle representing the least degree and the largest circle representing the highest degree. Higher mean scores on this scale indicated that the video game involved more CE.

3 Results

3.1 Manipulation Checks

The high CE video game was scored more highly by participants for complexity, novelty, and diversity than the low CE video game (see Table 1 for details). These results indicated that CE between the two games was successfully manipulated.

Table 1. Manipulation check, demographic, and video game experience variables by group

	Low CE (n = 30)		High CE (n = 30)		Control (n = 30)		Statistic	Effect Size
Variable	M/n	SD/%	M/n	SD/%	M/n	SD/%	t/F/χ^2	d/η^2/Φ
Manipulation Check:								
Complexity	3.50	1.17	4.03	1.00			$-1.90^{\dagger}$	0.49
Novelty	3.37	1.13	3.93	1.26			$-1.84^{\dagger}$	0.47
Diversity	3.37	1.30	4.00	1.08			-2.05^{*}	0.53
Demographic:								
Age	5.07	0.30	5.07	0.31	4.99	0.31	0.62	0.01
Gender	14 F	46% F	11 F	37% F	18 F	60% F	3.30	0.11
Game Experience:								
Frequency	2.67	1.95	2.27	1.67	1.77	1.76	1.90	0.04
Time	19.83	10.04	19.67	8.50	15.33	11.67	1.90	0.04

* $p < 0.05$, † $p < 0.10$.

3.2 Demographic and Video Game Experience

After random assignment, no gender or age differences were found among the experimental groups (Table 1). The groups did not differ in previous gaming frequency or time spent per week on gaming.

Preliminary analyses revealed that the experienced gamers performed better at pre-test than non-gamers. Compared to those who had never played video games (M = 33.07, SD = 3.71, n = 15), gamers (M = 36.23, SD = 3.02, n = 75) responded with greater accuracy on the Go/No-Go task, $t(89) = -3.56$, $p < 0.001$, d = 1.01. The RTs of gamers (M = 594.55, SD = 52.80) were faster than those of non-gamers (M = 631.77, SD = 58.21), $t(89) = -2.45$, $p < 0.05$, d = 0.65. The more time spent video gaming each week, the more accurate (r = 0.35, $p < 0.001$) and faster ($r = -0.27$, $p < 0.01$) gamers responded at pre-test (Fig. 4). In addition, as gaming frequency increased, gamers' IC pre-test accuracy increased (r = 0.33, $p < 0.01$) and RTs reduced ($r = -0.282$, $p < 0.01$). Additionally, gaming time was positively correlated with gaming frequency, r = 0.58, $p < 0.001$.

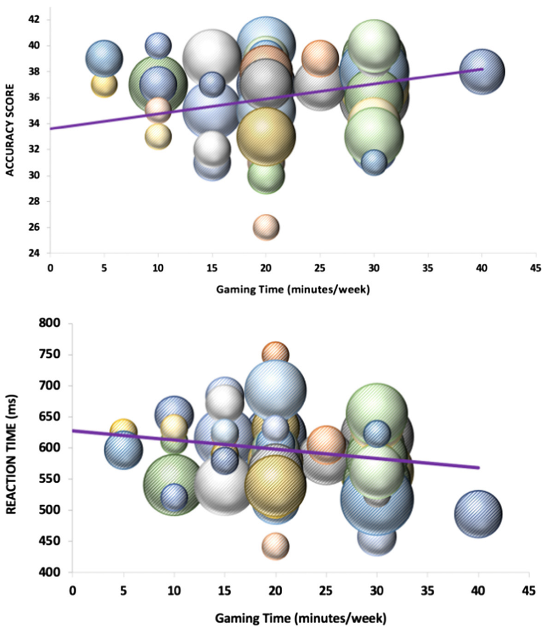

Fig. 4. Correlations among gaming time, frequency, and accuracy (*top*)/ reaction times (*down*). Gaming frequency is represented through the size of the bubbles.

3.3 Training-Induced Inhibition Changes

Accuracy. To determine the influence of training on IC accuracy, a repeated measures analysis of variance (ANOVA) was performed, with Time (pre-test, post-test) as the within subject factor and Group (low CE, high CE, control) as the between subject factor. Descriptive statistics for the pre- and post-test scores are shown in Table 2. Analysis revealed a significant effect of Time [$F(1,87) = 5.36$, $p = 0.023$, $\eta^2 = 0.06$], as well as main effect of Group [$F(2,87) = 5.62$, $p = 0.005$, $\eta^2 = 0.11$]. At post-test, participants showed improved accuracy (pre-test: $M = 35.81$, $SD = 3.32$; post-test: $M = 36.56$, $SD = 2.69$). Children in the low and high CE groups were more accurate

Table 2. Means and standard deviations for accuracy and reaction time scores, *t* test statistics, *p* values and effect sizes (*d*) for comparisons conducted between pre-test and post-test

		Pre-test		Post-test			
Measure	Group	M	SD	M	SD	t	d
Accuracy	Low CE	35.77	3.07	37.07	2.69	-2.43^{*}	0.45
	High CE	36.23	3.36	37.97	1.77	-3.30^{**}	0.65
	Control	35.43	3.56	34.63	2.39	1.32	0.26
Reaction Time	Low CE	607.23	54.54	582.75	61.52	$1.88^{\dagger}$	0.42
	High CE	596.03	57.66	583.75	45.79	$2.00^{\dagger}$	0.24
	Control	599.00	54.57	598.38	49.23	0.07	0.01

* $p < 0.05$, ** $p < 0.01$, † $p < 0.10$.

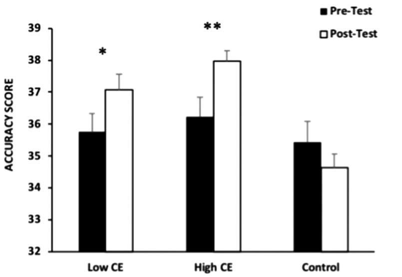

Fig. 5. Pre-test and post-test accuracy across groups. Error bars represent standard errors. * $p < 0.05$; ** $p < 0.01$.

than control group children (low CE: $M = 36.42$, $SD = 2.49$; high CE: $M = 37.10$, $SD = 2.27$; control: $M = 35.03$, $SD = 2.53$). Importantly, there was a significant Time $\times$ Group interaction, $F(2,87) = 5.92$, $p = 0.004$, $\eta^2 = 0.12$. Post-hoc analyses showed significant improvements at post-test in both the low and high CE conditions with medium effect sizes, but no improvement was found in the control group (see Table 2 and Fig. 5 for details).

Reaction Times. A 2 (Time: pre-test, post-test) $\times$ 3 (Group: low CE, high CE, control) repeated measures ANOVA on RTs was carried out, and revealed a significant effect of Time, $F(1,87) = 4.75$, $p = 0.032$, $\eta^2 = 0.05$. Participants reacted more quickly at post-test than at pre-test (pre-test: $M = 600.75$, $SD = 55.19$; post-test: $M = 588.29$, $SD = 52.51$). No significant Group effect [$F(2,87) = 0.27$, $p = 0.77$, $\eta^2 = 0.006$] was observed. Time did not significantly interact with Group [$F(2, 87) = 1.45$, $p = 0.24$, $\eta^2 = 0.03$], although a downward trend was found in the low and high CE conditions, with small effect sizes (see Table 2 and Fig. 6 for details).

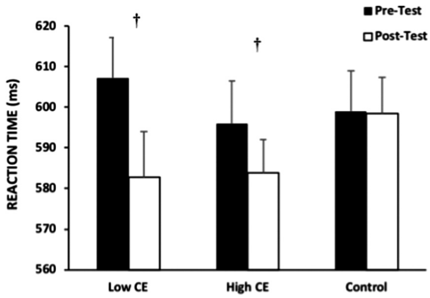

Fig. 6. Pre-test and post-test reaction times across groups. Error bars represent standard errors. † $p < 0.10$.

Correlations Between Accuracy and Reaction Times. As shown in Table 3, RTs were negatively correlated with accuracy scores, indicating that participants with shorter RTs also tended to be more accurate. Meanwhile, positive correlations were found between pre- and post-test accuracy, and between pre- and post-test RTs.

Table 3. Correlations between accuracy and reaction times (RTs)

	Pre-test accuracy	Pre-test RTs	Post-test accuracy
Pre-test RTs	-0.34^{***}		
Post-test accuracy	0.44^{***}	-0.29^{**}	
Post-test RTs	-0.36^{***}	0.49^{**}	-0.46^{***}

* $p < 0.05$, ** $p < 0.01$, † $p < 0.10$.

4 Discussion

In this study, we found that brief exposure to video games requiring the ability to inhibit prepotent responses to environmental stimuli was beneficial in improving IC in children. The improvements in accuracy were larger than for RTs. Furthermore, previous video game experience was linked to higher IC performance at pre-test. These results, which are consistent with previous findings, support the prediction that video game playing can enhance IC in young children.

There are several possible explanations for the video game training-induced improvements in the IC of young children observed here. One possible explanation may relate to neuroplasticity in early childhood. More specifically, frequent video game exercise may help consolidate brain connections and brain structures, which in turn help enhance IC. Some neuroimaging studies have shown that video game interventions are able to cause increases in the frontal lobe gray matter (associated with EF) of non-gamers [36, 37]. Another possible explanation may be related to the training-related enhancement of attentional capacity. For instance, a recent study conducted by Qiu et al. [38] demonstrated that just 1 h of video game play was capable of improving the ability of participants to focus on relevant information while disregarding distractions, namely, visual selective attention. Such capacity is thought to be a fundamental resource underlying IC [23].

Another compelling finding of this study is that young children showed improved IC after only a short period of intervention, i.e., 25 min in total. This is a new finding in the literature. Existing evidence has consistently documented that IC training typically takes more than 2 weeks to take effect in older participants. This discrepancy may be due to the power of play during early childhood. Just as the old saying goes "play is a child's work", a considerable amount of research has confirmed that play is the most valuable way in which a child learns [39]. No other activity could supersede play as the most effective learning approach for preschoolers. The reasons why previous IC training studies have failed to elicit changes in a shorter time may be related to the sample used (e.g., older participants) or utilized less interesting intervention methods (e.g., a modified Stop Signal Test or aerobic exercises) [26, 40, 41].

The results of this study indicate that appropriate video games may serve as potential training tools to promote the development of IC in young children. Dale and Green [42] describe three unique properties of video games that make video game training an alternative and effective intervention. First, video games are more interesting, engaging, and rewarding than other training programs. Activities with these features are often associated with better learning. Second, dynamic game difficulty leads video game play to become a distributed practice (that is, practice that can be divided into many short study sessions over a long time), which is beneficial to individuals' learning. Third, gaming may prompt people to engage in a "learning to learn" mode, which means that video game training could help learners develop a cluster of abilities which assist their future learning.

Contrary to expectations, the levels of CE did not show any significant impact on children's IC performance. A possible explanation might be that both training games shared a common cognitive mechanism and activated similar brain networks [43]. This may be one of the reasons why some researchers have chosen to use a sedentary activity (such as watching a video) as a low CE manipulation [44]. Therefore, further research is needed to determine the effectiveness of cognitive engaging/disengaging IC training programs. In addition, this unexpected result may be explained by the fact that high CE programs are successful in promoting working memory [38] but it remains unknown whether they also function in the same way for IC.

This study is subject to a number of potential weaknesses. First, the findings that IC accuracy and speed are correlated with previous video game time and frequency should be interpreted with caution, because it is possible that these results have been confounded by computer experience. That is, people who play computer games may simply be learning to interact with the computer – regardless of the specific task. Second, gaming time and frequency as measured here were only a rough estimate provided by parents, so the validity of the correlations between video game experience and IC might be impaired. Third, this study only explored the immediate outcomes of video game training. Due to the fact that training benefits may diminish after practice ends, it is worth investigating the longer-term training effect in future studies.

5 Conclusion

Overall, this study strengthens the evidence that video game playing has the potential to improve IC in young children. The following findings are notable: (1) The experienced gamers were better in IC at pre-test than non-gamers. (2) Compared to the control group, children who received a short period of low/high CE video game training (5 min/day for 5 days) performed more efficiently in IC at post-test – more specifically, they responded more quickly and accurately in the Go/No-Go task. These findings contribute to a better understanding of the positive impact of video games on young children's development. In conclusion, this study suggests that video game training may serve as an alternative educational intervention for facilitating the development of IC in young children.

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Yuri Game: Romance and Characterization in Gameplay

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Abstract. Yuri games are generally considered as a category of games that the theme of them focus on yuri relationship and stories between characters rather than gameplay. The concept of yuri originates from Japan and refers to the intense emotional connection in female/female relationship regardless of the sexual orientation of participants. This research explores the method of gameplay in yuri games and the way gameplay can influence the characterization of game heroines, thus have an impact on the story-telling of the whole romance as well as the player experience. The analysis focuses on several typical cases of yuri games.

Keywords: Yuri game · Gameplay · Romantic relationship · Visual novel · Interactive movie · Characterization

1 Introduction

Yuri games are generally considered as a category of games that the theme of them focus on yuri relationship between women, regardless of their game genre, though a considerable of yuri games are interactive novels or visual novels (*Flowers -Le volume sur printemps-*), which are substantially the same genre, and interactive movie games (*Life is Strange series*), while some yuri games are Japanese role-play games (*Night of Azure series*).

The term Yuri is a Japanese word which means lily flower, first used in Japanese manga to describe romantic or sexual relationships between girls or women, and nowadays it is commonly used in a variety of fields including anime, manga series, movies, fan fictions, and also games. It can be used to refer to female/female relationship in which every one of the participants can be both lesbian or not. The women in yuri relationships might be lovers, friends, family members, teammates or even enemies. This term concentrates on the intensity of emotional connection built by the participants, and the romance they might experience together, as well as the physical reaction, during the process of all the phase of the relationship: its formation, maintenance, evolution, even destruction, more than the sexual orientation of women involved. Meanwhile, the gender or age of creators who build up the yuri connection of characters does not matter, and so does the audience who can enjoy yuri relationship in all kinds of creative works, the only important thing is their perception towards the charters and their interactions.

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As for games, it is widely accepted that both yuri games and games with yuri elements exist. Yuri elements in games regularly refer to a wide range of game contents, including intimate friendship between heroines or supporting roles; players can choose their own gender and getting along well with other female roles; same-sex marriage or family allowed in game; one or more of the supporting characters are lesbian or bisexual; all characters in game are female, etc.

Comparing to absolute yuri games, games with yuri elements are more diverse in game genre. It is much easier to find yuri elements in popular genre like simulation game (*Stardew Valley*), role-play game (*Mass Effect* series), roguelike game (*Undertale*), fighting game (*Skullgirls*), first-person shooter game (*Overwatch*), etc. Most of the games with yuri elements do not focus on romance or interaction of characters, instead, these games concentrate more on gameplay and world view even without any romance between roles.

On the contrary, the most important part of yuri games is the romantic relationship (can be called *ship* or *CP* in short) between heroines, and in order to build up the relationship steadily, every part of game should make sense to the characterization: not only the lines spoken by roles and the appearance created by artists but also what players can do in the gameplay is to serve the story telling as well as authenticity of characters. Thus, it is obvious that the amount of yuri games is far less than that of games with yuri elements, which can be part of the reason for the narrow range of game genre that yuri games have chosen.

Although the concept of yuri comes from Japanese, there are different themes of yuri games completed in America, Europe and China. Nevertheless, there is a typical theme of yuri story which is frequently chosen by Japanese yuri game but rarely by games from other countries. It is always a story happens in an imaginary westernized Christian girl school and about schoolgirls who pair with girls from elder school grades (the president of student union and her assistants could always be important supporting roles) each other for instruction and will never leave the school environment during the story. It is a classic story type originated from Japanese yuri novel and has been recomposed in diverse media including manga, anime and game. Two of the most famous series with the girl's school theme is the *A Kiss for the Petals* series and the *Flowers* series. The former one is completely a visual novel without any gameplay while the latter one constructs an innovative form of showing how much other characters like the heroine if players make different choices based on visual novel.

Another recommended yuri game, *VA-11 Hall-A: Cyberpunk Bartender Action*, also based on visual novel system, is about the daily life of a girl bartender in a cyberpunk world however. The gameplay is well designed to display what a bartender can do in a society of advanced technology and a state of war, while the emotion connection of heroine with both customers and boss of the bar can be influenced by every step player have made.

In spite of visual novel, interactive movie shows more potential in simulating immersive atmosphere, of which *Life is Strange* series is an amazing example. Though there is obvious weakness in the ending chapter, its prequel *Life is Strange: Before the Storm* makes up for it in some circumstances. More analysis of gameplay in yuri game cases will show in other parts of the article.

2 Yuri Games and Games with Yuri Elements

2.1 The Origin of Yuri

The word *Yuri* is the romanization of Japanese word ゆりor ユリ, which means lily flower and is frequently used as names of girls in Japan. In 1970s, as the concept of *Bara*, the romanization of Japanese word rose flower, refers love and relationship between men, yuri was first mentioned to describe imitate female/female relationship in Japanese magazines. However, the culture of ambiguous or explicit intimacy between girls in Japan can be traced back to the beginning of 20th century when *Girl's Novels* were popular in school girls. At that time, students would like to pair with elder ones to establish an imitate relationship called *Sis* or *Sister* in girls' school. These couples of girl might act just like lesbian lovers or real sisters with consanguinity, and were both the loyal readers and the source of inspiration of *Girl's Novels.* One of most famous *Girl's Novels* writers was Kawabata Yasunari, whose novel *Otome no Minato* had won considerable popularity among teenage girls when published. Therefore, romance happening between girls couple in girls' school has become a classical theme in Japanese novel, manga and anime till today.

With the development of history and popular culture, works featuring romance between women have expanded all kinds of topics and backgrounds from school life to career life or magical fantasy. But when it comes to other countries beyond Japan, fans of these works have different opinions on the definition of the theme. The term yuri was used to infer porn works in Japan decades ago, while *shoujoai*, means *Girls' Love*, was used in the same way in western countries. What's more, GL, short for *Girls' Love*, refers to lesbian porn novels and manga on Chinese internet, while *Les*, short for lesbian, is used in the same way in Japan. It is a complete chaos and supporters of each term quarrel about the definition and the usage of these terms everywhere.

Fortunately, the jargon yuri has been widely accept to describe love and other imitate relationship (like loyal friendship) between women in fictional works nowadays. Whether the protagonists are lesbian or not, their intimacy and experience together is the real one, which is what really matters to this research.

2.2 Yuri Games

As the name suggests, yuri games focus on the romantic relationship of characters, and the romance itself is the only important thing the game wants to impress players. Just like other genre of fictional works, impressive ship (short for romantic relationship) based on attractive characters, meanwhile an unforgettable romance can contribute to the characterization of heroines a lot. Compared with novels or movies, games have more agency for players and more methods for developers to build the backgrounds and personalities. However, it brings more challenges to tell a story or create authentic characters at the same time. One of the writer of *Life is Strange: Before the Storm*, Zak Garriss, mentioned in an interview about the challenges when writing interactive narrative:

"The more agency we give you, the harder it is to create cinematic peaks" [3].

It can explain part of the reason why most of well-known yuri games are visual novels and interactive movies (the following Table 1 lists Top 10 English Yuri Games selected by a game website in 2016, all of the listed ones are visual novel), which are both narrative-focused genre of games. Another possible explanation can be the convenience of making visual novels with game engines free for commercial use like *KiriKiri* or *Ren'Py*, as well as the limited cost comparing with other game genre: only story scripts and 2D graphics can satisfy the minimum needs of a visual novel game. Therefore, it is welcomed by indie developers, especially those whose interests are not so common.

Table 1. Top 10 english yuri games selected by a game website in 2016 [14].

Rank	Title	Development company	Game genre
10	Sugar's Delight	Neko☆Soft	Visual Novel
9	A Kiss for the Petals – Remembering How We Met	Fuguriya	Visual Novel
8	Dahlia	Cosmillica	Visual Novel
7	Lonely Yuri	Yoru no Hitsuji	Visual Novel
6	Highway Blossoms	Alienworks	Visual Novel
5	Sacrament of the Zodiac: The Confused Sheep and the Tamed Wolf	Kuro Irodoru Yomiji	Visual Novel
4	Flowers – Le volume sur printemps –	Innocent Grey	Visual Novel
3	A Little Lily Princess	Hanabira	Visual Novel
2	Nurse Love Addiction	Kogado Studio	Visual Novel
1	Kindred Spirits on the Roof	Liar-soft	Visual Novel

(Though the ranking of yuri games above may not authoritative enough, it can also show the great percentage of visual game among yuri games.)

2.3 Games with Yuri Elements

Due to the reasons either mentioned above or not, both the amount and the genre of yuri games are not satisfying for yuri fans. In order to enjoy yuri in more kinds of games, fans begin to search yuri elements in games in which romantic relationship between women is not the theme. In some circumstances these games have been called yuri games, either, while comparing with games themed yuri, the definition of yuri games has been extended as generalized yuri games. Take *Overwatch* for example. Several lesbian and gay characters in *Overwatch* cannot change the fact that it is a multiplayer first-person shooter game in which background stories and imitate relationship of characters' matter not as much as the intensity of their battle skills, though their existence might be attractive towards LGBT players and yuri fans. To avoid confusion, these type of games will be defined as games with yuri games.

The range of yuri elements can be extremely extensive, including almost every part of game that can remind players of yuri and offer a reasonable background for yuri stories. Female protagonist games with female supporting roles who get along well with the protagonist are welcomed yuri elements, as well as at least one of the female characters is lesbian or bisexual and it has been confirmed in game explicitly (better with a past yuri romance whether the past yuri partner shows up in the game or not). When it comes to a yuri element judgment with less strictness, customized gender characters with female supporting roles in game is another choice.

In fact, not all the yuri fans are also visual novel/interactive movie fans, and it is a dilemma to choose games with great yuri romance and games with diverse gameplay at the same time. It is the reason why yuri fans will keep searching for yuri elements in games that are not themed yuri relationship until there are as many games of genre beyond visual novels/interactive movie themed yuri as visual novels.

3 Case Study: Exemplars of Yuri Games

This part contains spoilers for all the listed games.

3.1 Flowers -Le Volume Sur Printemps-

Flowers – Le volume sur printemps – (*Flowers* chapter of spring in short) is the first chapter of the *Flowers* series, which contains four chapters of stories about different yuri couples happened in four seasons at a private girls' school of *Saint Angraecum Academy.* It is a typical visual novel series with choice-driven narrative and part of the dating stimulator system, in which the choices players have taken for the protagonist will influence how main characters feel about the protagonist, and how the story moves on. When playing games, players can only read the story lines, appreciate the graphics and music, sometimes make choices according to the context, then there is nothing more players can paly with. On the other side, the low agency of player enables writers to take better control of story and characterization.

Flowers – Le volume sur printemps – is a story of Suoh Shirahane (the name means white feather and deep red color with darkness in Japanese), a teenage girl, who has a habit of reading all kinds of book and a shy personality as well as excellent appearance. Suoh started her first year in high school, where students are supposed to pairs with each other as *Amitié* and roommate at the same time under the construction of teachers based on a survey filled when the admission to school. As she is the chosen one and the protagonist, Suoh has two *Amitié* while a group of *Amitié* contains two students in normal. Obviously, it is a love triangle story between Suoh and her *Amitié,* Rikka

Hanabishi and Mayuri Kohsaka. It is absolutely a classic topic through the history of yuri.

As a visual novel, most of the romance story as well as characterization is accomplished by lines and branching narrative because of the limited gameplay space, however, the *Flowers* series have come up with a great idea to express the inner world of protagonist Suoh on the game interface (see Fig. 1.).

Fig. 1. The yuri icon on the dialog box, showing the status of relationship with both Mayuri and Rikka: more blossom the yuri plant have got, Suoh gets along better with Mayuri; on the contrary, when the yuri plant develop into seedling, Suoh can have romance with Rikka.

A splendid metaphor of yuri heroine's love heart in a yuri game is a dynamic yuri (lily) flower effected by her love choice. If the choice is to the interest of Mayuri, the yuri flower will tend to blossom, and if the choice can please Rikka, the yuri flower will tend to close and degenerate to a yuri seedling. It can also be the contrast of different attitude towards sexual orientation of two *Amitié.* Mayuri was always afraid of coming out in *Flowers – Le volume sur printemps –*, while Rikka is straightforward – she will never hesitate to confess her love for people she loves.

3.2 VA-11 Hall-a: Cyberpunk Bartender ActionFi

It is about daily life of a female bartender, Jill, working at the bar called *VA-11 Hall-A* in Glitch City, with a background of cyberpunk near future. Though there are biochemical androids, mechanically reinforced human as well as virtual idol in a completely post-dystopia life, people (androids) still need drinks after a long day work. Jill works with her collage Gillian, a hidden assassin but everyone in the bar pretend they don't know this, and Dana, boss of the bar with really hidden mysteries. The work of Jill is bartending drinks as customers' order, but when they think they are familiar with Jill enough, some of the customers begin to order unclearly, expecting Jill can get what they really want.

As for the yuri part, the main storyline of Jill's life was her past ex-girlfriend. Jill got the job of bartender to run away from the breakup, but failed to run away with her broken heart until one day when she finally understood the breakup with help of Dana and ex-girlfriend's younger sister, with the friendship of other customers.

VA-11 Hall-A can be a bartender life simulator more than just a visual novel. The bartending system has taken place of text choices, stimulating story branches depending on result of bartending (see Fig. 2.). Different customers prefer diverse tastes and volume of drinks, and the same customer could react differently with the same drinks at the different period of story. It is realistic just like what people usually do in reality, though in *VA-11 Hall-A*, there is neither real alcohol nor beer but variety of imitation for flavors of different wines. In spite of everyone knowing that there is no alcohol in drinks, drinks can always bring trust between customers and three staff of the bar. Characterization of customers is built in these drinks.

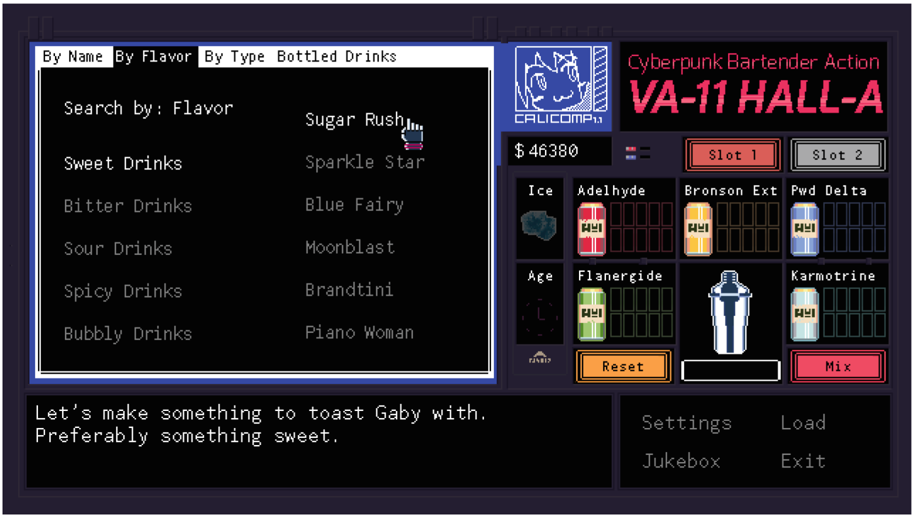

Fig. 2. The bartending system in *VA-11 Hall-A*. Players can experience work of bartender in this system: left part of interface is the filter of drinks recipes by categories; when player is sure about the name of drinks ordered, according to the recipes one can easily bartend target drinks with different volume of different ingredients listed in the right part of the interface.

When Jill finishes her work and back home, the smartphone interface as well as the scene of her apartment shows her private life at home (see Fig. 3).

In this part, another facet of Jill appears in front of players. Jill likes antique decorations and games in her room, as well as a photograph with ex-girlfriend though she refuses to admit. Jill needs money to pay monthly bills of room and electricity, also needs money for decorations to release pressure. If there is not enough money for bills, Jill will live nowhere; if do not buy decorations, Jill will concentrate on it instead of work the other day, finally result in mistakes and downgrade of income. But however Jill has performed in work, Dana will never forget to leave an additional tip for her with sweet words on the daily income sheet. It is not an easy life even in cyberpunk world, but in this way players can really have an immersive experience in Jill and the *VA-11 Hall-A* bar.

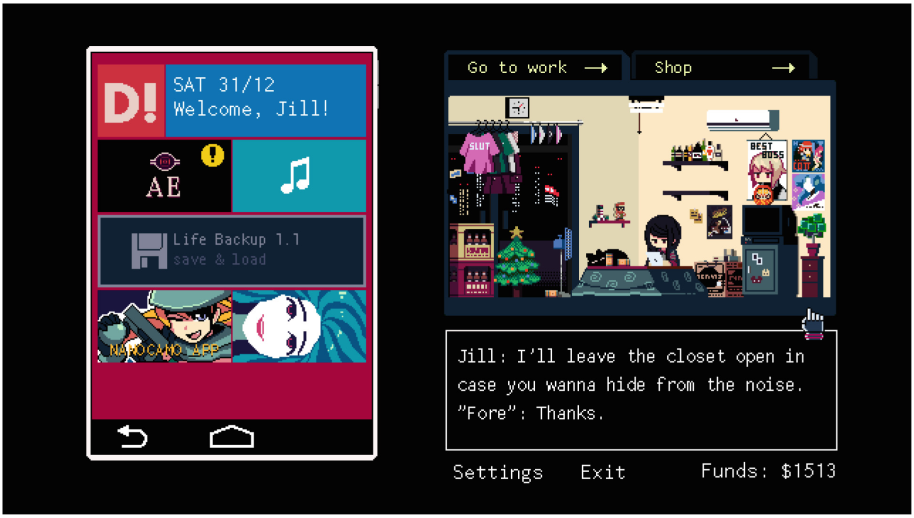

Fig. 3. Jill's home and a talking cat (right), her smartphone (left). On the smartphone, players can help Jill change the background music, decorate the room and read news or BBS, while Jill will have comments on massages on phone. What Jill says will show on the bottom box on the right interface. When at home, players can choose whether go to shop or go to work.

3.3 Life Is Strange and Life Is Strange: Before the Storm

Life is Strange series may be the one of the most famous interactive movie games and is absolutely more well-known than two yuri games mentioned above. It is a tragedy involving a seaside town and three innocent girls – Max, Chloe and Rachel and not all of them can survive at the end of story.

The heroine of *Life is Strange*, Max, went back to the town and found herself with the superpower of rewinding time at the moment of her childhood best friend Chloe, who haven't seen her for a longtime since she moved away from the town at middle school, was shoot accidentally in the washing room. The whole story of *Life is Strange* revolves around Max's superpower and its consequence, which also the main gameplay method through the storyline. Rewinding time makes it possible for nerdy Max to be popular by *predicting* what people would say and save Chloe again and again.

One of the most amazing part of design is in chapter 5, in which Max traveled through collapsed nightmare scenes that she has rewinded in these days to find a way out in order to catch the real murderer and save the town. Players have experienced the rewinding time together with Max, and have been the only ones who can understand Max after so many failed attempts (see Fig. 4.). Even though Max still insist on help Chloe out. The more difficulties Max has faced, the more impressive love for Chloe can be highlighted.

In the prequel *Life is Strange: Before the Storm,* without superpower of Max, who has moved away from town and never contacted Chloe on her own, Chloe was extremely upset because of losing her dad and new boyfriend of her mom's. The gameplay of rewinding time cannot be applied in *Before the Storm*, instead, a new

Fig. 4. One of the nightmare scenes Max has experienced through the way to the correct time. Walking along this nightmare road, Max and player reviewed the moments shared with Chloe in the few days after Max has brought her back from the bullet using time rewind, finally causing a series of catastrophes that will destroy the whole town.

system of quarrel as power of Chloe has been installed. Though the quarrel system contributes to the building up of romance with Rachel, it is not as impressing as rewinding system. Some part of the script of quarrel system is not convincing enough, especially when you try to frighten a door-guarding bruiser as a teenage girl (Chloe) with only words to get in a midnight live show and finally success.

One the country, the traditional gameplay way of walking-simulator and searching for target object inherit from *Life is Strange* performs well in *Before the Storm* in the case of helping Chloe repair the abandoned car at the garbage yard, because Chloe have learned mechanical maintenance from her beloved died dad William and is proud of her mechanical techniques when cheering up Rachel (see Fig. 5). It is a great combination of gameplay and characterization. All the stories of *Life is Strange* and *Before the Storm* began at that day when Chloe lost her dad and Max moved away. With the absence of Max, Rachel became part of her school life. Since there was no other dad in the reality, Chloe was still filled with sadness and thought of him frequently, so choosing the toolbox once belonged to William and repairing car was her own way of remembering her dad. Moreover, all this effort Chloe has made on the car was for the escaping plan with Rachel to their dream land Chicago. During the car plot, players can easily feel that Chloe was in high spirits imaging leaving the small town and start a new life with Rachel, seems that Chloe can finally emerge from the sorrow brought by dad and Max.

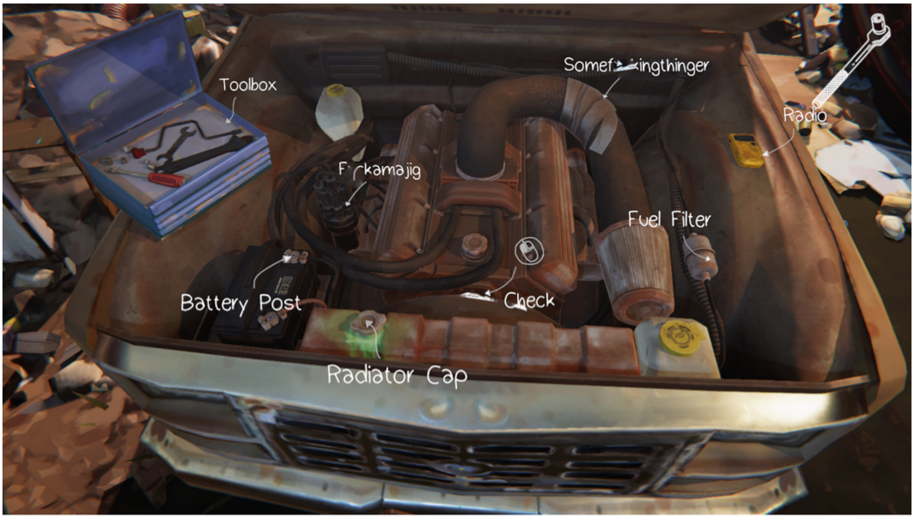

Fig. 5. A shot of broken car Chloe is working on. Players need to help Chloe chose the right tools and find some suitable mechanical parts for broken ones to revive the car in order to run away to Chicago with Rachel. (Some potentially offending language has been blurred.)

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Conceptualizing Fidelity for HCI in Applied Gaming

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Abstract. Fidelity of games as a concept describes the level of representation of, or accordance with reality. The level of fidelity has influence on the interaction between player and game. Our study discusses the outcomes of a literature study and three cases with the goal to propose a comprehensive framework of game fidelity. This framework could help game designers and researchers to adopt the 'right' or sufficient level of fidelity to achieve the intended objectives related to applied games. Our results show that functional and psychological fidelity have a higher impact on the experience and effects of applied games than their physical fidelity. Social and ethical fidelity are proposed as new dimensions of game fidelity that still have to be explored. In literature, both low and high levels of fidelity are described as effective in applied games, while a medium level seems not to be beneficial for the player.

Keywords: Applied games · Fidelity · Human computer interaction

1 Introduction

In this paper, we discuss necessary factors leading to the development of a new conceptual framework of game fidelity for digital, applied games. One of the vital theoretical issues in applied games research is the question about how to make connections between the game world and the 'real world'. This connection is bidirectional: from the game to the real world in the form of affective action, and from the real world to the game in the form of realistic representation (Galloway 2004). Failure to achieve the 'right' level of realism in a training environment such as an applied game, might result in false learning when applied to reality (Chalmers et al. 2009).

In comparison to images, where the question related to the representation of reality addresses notions of mimetic mirroring of reality, games additionally inherit the concept of action (Galloway 2004). As games require constant input from the player, a

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realistic game must be realistic in doing, in action (Aarseth 1997), and not only in its physical representation of the reality. Our proposed concept of *game fidelity* follows the paradigm in HCI that focuses on the quality of interaction, and the nature of meaning and meaning creation (Harrison et al. 2007) in the interaction between player and game. As such, game fidelity contributes to the engagement of a player with a game whereas engagement can be seen as desire and willingness to stick to a game for longer, and represents the lowest-level of involvement with a game towards immersion (Kayali et al. 2018; Brown and Cairns 2004). The feeling of being in places in games is furthermore related to the concept of presence, which can be subdivided into experiences of psychological immersion (or psychological fidelity), perceived naturalness (or physical fidelity), and spatial awareness, or engagement (Lombard and Ditton 1997).

Based on related research, we propose to approach the action-related representation of reality in digital, applied games along the following four dimensions:

1. **Physical fidelity** is the dimension that is most widely described in research so far (Harteveld 2011), the most notable example being visual fidelity. It is defined as the degree to which the virtual simulation emulates the physical properties of the target environment (Alexander et al. 2005).
2. **Functional fidelity** or action-related representation of reality, describes the need for realistic actions and functions that the game allows. It is the extent to which the virtual tools and devices react as the real tools to the tasks carried out by the users in the simulation (Alexander et al. 2005).
3. **Psychological fidelity** relates to activity, but not so much the physical activity as the cognitive and psychological dimensions of it, such as realistic levels of emotions, engagement, and stress. It is the level at which the virtual simulation is able to elicit affective states similar to real world experiences (Alexander et al. 2005).
4. **Social fidelity** in an age of MOO (RP) games points out that the realistic representation of social interaction and connection in games is still an underrepresented topic in games research. As games are an active medium, they require the social reality of the player and the social reality of the game (Galloway 2004). It describes how well the simulation is able to mimic real world social interactions.

We conceptualize the forms of realistic representation, or game fidelity with regard to designing games that foster human computer interaction and their contribution to creating meaning of and engagement with applied games. In this sense, we define game fidelity as a continuum, ranging from low levels of fidelity to high levels of fidelity. Our research approach is twofold. First, we report on the outcomes of a literature study to discuss existing approaches towards game fidelity and related concepts such as engagement, immersion, and presence. Secondly, we discuss various possibilities that can influence the fidelity of applied games and their effect on presence and target outcomes. With a cross-case analysis based on some of our recent results, we explore how to balance the four aspects of fidelity in applied games to produce effective outcomes in terms of presence and engagement in applied games. We conclude with a first step towards a comprehensive model of game fidelity.

2 Fidelity in Applied Games: Current Research and Gaps

In high fidelity design for both entertainment and applied games, technologies such as augmented reality (AR) can address all human senses, i.e., sight, sound, smell, taste and touch. Users can become aware of each other's activities by using AR environments for spatial remote collaboration (Lukosch et al. 2015). Yet, one challenge seems to be to create a realistic interaction between real objects and virtual objects (Schraffenberger and Van der Heide 2013). Another important challenge lies in the right balance between fidelity, design effort, and expected outcome of an applied game. To evaluate the right balance, we are working towards a better understanding of the aspects of game fidelity, and propose a framework of these elements that altogether creates the fidelity, or realism in applied games.

With the advance of AR and VR technologies, the possibilities to improve the realism in applied games has increased. The type of relationship between reality and games we are referring to in our work is called *interaction fidelity*. Interaction fidelity refers to the degree of exactness with which real-world interactions are reproduced in the game (McMahan 2011). Virtual training, one of the purposes of applied gaming, is seen as most effective when interactions show a high level of fidelity (Waller et al. 1998). For presence, engagement, and usability, a study found that both display and interaction fidelity had significant positive effects (McMahan et al. 2012). Further studies show that transfer from what has been learned within a simulation or game to the real world is one of the main reasons to use high fidelity (VR) environments (Chalmers et al. 2009; Bhargava et al. 2018).

In a study carried out by Bhargava et al. (2018), based on various tests, the authors show that high and low fidelity interactions can lead to better results of task performance, compared to mid-level fidelity. Yet, the different levels of fidelity had no significant impact on the learning outcomes. The tests included in their study were mainly focused on task and visual fidelity, which we would call physical and functional fidelity. Social and psychological fidelity has not been addressed in this work. Other research has shown that failure to achieve the 'right' level of realism holds the risk that the player adopts a 'wrong' or different strategy than needed in real life (Chalmers and Debattista 2009).

A multi-level study carried out by Chalmers and Debattista (2009), discuss the importance of multi-sensory stimuli in virtual environments when used for training purposes. One important finding they report on is that the more familiar an environment is to the player, the less he or she is paying attention. In addition, it is noted that there might be multiple interrelations between the senses addressed by any virtual environment. Recommendations from this study include that in designing a high-fidelity virtual environment, the parts of the environment that are vital for the experience should show a high level of fidelity, while others might show lower levels of fidelity without significant impact on the effectiveness of the virtual environment. Yet, their findings again mainly address the *functional* and *physical fidelity*, but do not include considerations with respect to *psychological* or *social fidelity*.

Cornacchione (2012) discusses the relationship between fidelity and training outcomes across different media and time. The results of his study with different levels of fidelity in a simulation environment used for learning imply that students tend to welcome learning strategies that show a higher level of functional and physical fidelity. Such higher levels of fidelity were also related to better training transfer from simulation to reality. Contrary to these results, Feinstein and Cannon (2002) show that many studies exploring the relationship between fidelity and learning found that lower fidelity actually can assist in acquiring the details of training and education (Alessi 1988; Dwyer 1974; Gagne 1954; Miller 1974). Hays and Singer (1989) state that it might be effective to move *away* from reality in order to increase learning effects.

On a more conceptual level, Harteveld (2011) defines three criteria for realism in game play: validity, flexibility and fidelity. In terms of validity, which he defines as the visual resemblance between reality and virtual worlds for training, much progress has been made in the past decades. With the increasing possibilities of high-speed graphical visualization, applied games have become more and more realistic. Applied games with adequate levels of detail for buildings and objects are readily available. Flexibility can be guaranteed by modular design of the games, the use of scenario editors, and by teacher-led games. Through applied games, different virtual scenarios can be designed and played.

An overview of literature on the relationships between fidelity and effect of virtual, game-based learning environments shows that results are often contradictory. These differences in findings can partly be explained by the distinctive understanding of the concept of fidelity the authors apply. This is the main reason why we propose a *multi-layered concept of fidelity* for applied gaming. Below, we first discuss findings from our own work, then propose a framework of applied game fidelity based on both our literature review and case study results.

3 Cross-Case Analysis: Applications in Safety, Security and Health

In this section, we illustrate the design process and effects of applied games through three different cases. The first case relates to a study in the safety and security domain using a game in a VR environment with the goal of training team situation awareness and communication. The second case reports on experiences with an AR game enforcing information asymmetry in the security domain to study collaboration and communication behavior of geographically distributed team members.

3.1 CharliePapa: VR Game for Police Training

In this case study, a high-fidelity virtual reality (VR) environment was developed and tested for its usefulness in police team training. Expected outcomes of this training are defined as improved situation awareness and communication skills in reconnaissance teams. For this study, three different aspects of fidelity were identified. First, the applied game represents *assignments*, which are described in terms of functional fidelity. Functional fidelity refers to the degree in which the roles, processes and tasks of the agents and the players match with roles, processes and tasks of the reference system of the game, mostly the “reality”. In the VR simulation game, a police officer from the

Netherlands is able to take over the role of a police officer of any rank the Dutch police offer and fit it to the tasks assigned in the game. The player is able to move around, represented by a virtual avatar in the game world, and is able to look, hear, communicate, and take appropriate action. The task in the game is based on a task description by a Dutch police officer of the rank and function that is represented in the game, for example the daily route of a surveillance team. This refers to the notion of functional fidelity.

Secondly, the surrounding in which the game takes place, its objects and avatars, are related to physical fidelity. This level of fidelity refers to the degree in which the environment of the game, the objects within the game world including their textures, color and movements, the agents in the game and their behaviors, and the sound match with the reference system of the game, mostly the "reality". For example, the computer-aided representation of a tree in this VR game has a high degree of audio-visual fidelity as its texture including shadow and light have a very natural look, corresponds properly with its environment regarding color and size, and its blossoms move with the circulation of the air.

Thirdly, emotions, such as stress, joy, anger, or doubt, that a player feels by accomplishing his or her tasks are termed psychological fidelity. Psychological fidelity refers to the degree in which the emotional and cognitive reactions of the player match with those in reality. It includes the perception of the game play process, the feeling of flow and experience of immersion within the game. For example, police officers experience stress when they face a dangerous situation, where important decisions have to be taken within seconds. The VR game includes high psychological fidelity as players have reported that they experience "realistic" stress and time pressure while carrying out their assignments in the game.

Following the three aspects of fidelity focused on in this study, we addressed them throughout the design process of the VR game. First, a participatory design model was adopted to ensure the validity of the simulation game scenarios by experts from the field and to enhance acceptance for the tool itself. In iterations, the scenarios were tested with an expert group, and the results were fed back into the design of the next scenario. The test sessions included a pre-test-questionnaire (summarizing input-variables), a briefing by the experts of the situation within the simulation game, video-based observations of the test sessions (the process), a post-test questionnaire, and a de-briefing phase focusing on both the play experience and the learning outcomes. The test sessions took place in experimental settings at a university, because the technological equipment was not sufficient at the workplace of the experts. The test groups were recruited from the experts available at the moment of the test, which was due to the flexible work schema of the experts. A minimum of two researchers were present as objective observers, without intervening in the game play process itself. Because of the limited number of experts in the field, the number of test persons available was also limited, which lead to a qualitative analysis of the data gathered from the tests.

Using questionnaires, the players were asked about positive and negative aspects of the game, regarding realism of the scenario, feelings of preparedness for future assignments, cooperation with team colleagues, and ability of recognizing deviant objects and behavior. In summary[1], the players mentioned that interaction with other team colleagues, which was supported with the set-up, was one of the most important elements of the game that provided realistic feeling. On the other hand, the visuals of the environment, especially the limited animations and variations of the avatars, did not foster realism for the game, as reported by the players. Communication was mentioned as the most important feature of the game that supported the objective of the preparation of the player for future assignments. The limited number of triggers and details of the scenario did not support this goal in the experience of the players. For the cooperation with other colleagues, the communication possibilities of the game were positively noted. On the other hand, the players stated that they tended to be very much focused on the game play, which interfered with communication with other players. For the task of recognizing deviant objects and behaviors, players reported that the options of the game to hide objects, to show relationships between objects, and to drop objects in very unusual places was seen as an advantage for the simulation game. Disadvantages were seen in the limited sounds within the virtual environment and the limited animations of the avatars. Thus, functional fidelity was high and appreciated by the players, but physical fidelity was too low to enhance the experience of the players. Psychological fidelity, referred to as being focused on the assignment in the game, was also high, but interfered with the communication aspects of the game. The outcomes of the first test lead us to develop of a second game scenario, aimed at a self-directed training activity without interaction with a trainer during game play.

In this case, functional fidelity was represented through the interaction and communication possibilities of the game scenarios and the role the trainer played and/or his absence from the game. Physical fidelity was represented by a detailed VR game environment. Psychological fidelity was represented by time pressure and communication, and the location of the players. It showed that the communication aspect had the highest impact on the acquisition of situational awareness within the teams. The training with the realistic game scenario that was based on an existing location was appreciated, especially for the training of novel team members, but did not include enough details to provide a realistic training situation. It seems that when an existing location is used as a reference for the simulation game environment, then every single detail has to show high physical fidelity. In summary, the qualitative evaluation showed that psychological and functional fidelity was more important for a positive player experience than physical fidelity, yet a lack of physical fidelity limited the experience of the players in the VR environment. As players mentioned that communication and exchange with other players was important for the learning experience, we conclude that in this case, a notion such as social fidelity plays an important role as well.

3.2 AR Box Game: Forensic Teamwork

In a project with the Dutch Police, we investigated how AR affects communication, information sharing, and situational awareness of geographically distributed teams in the safety and security domain (Lukosch et al. 2015). AR was used to remotely support

[1] For a more detailed design and analysis, see: Lukosch et al. 2012a, 2012b; Lukosch et al. 2014.

local professionals at a crime scene by connecting them via AR with remote experts. AR allowed remote experts to see the crime scene and jointly annotate it with local professionals. We conducted a series of experiments using realistic scenarios at staged crime scenes with professionals from the safety and security domain to study the effect of AR. All experiment setups were of high fidelity. The physical fidelity was supported by the staged crime scene. The functional fidelity was high, as apart from the AR technology, only real equipment was used. High psychological and social fidelity was achieved by conducting the experiments with professionals only.

Such a high-fidelity setup is difficult to achieve with regard to staging the crime scene and involving professionals. Also, from earlier experiments at a realistic training site, we learned that a realistic situation is sometimes too complex to study technologies in rigorous ways (see for more details see e.g., Datcu et al. (2014, 2015)). To study the effect of remote support via AR on coordination and communication of distributed teams in a more rigorous way, we thus designed the "AR Box game" to simplify the setup and complexity.

The "AR Box Game" is collaborative and mimics characteristics from a complex real scenario, but can also be played by non-professionals. For the game, we chose a scenario related to crime scene investigation. The game needs to be played by three players, one in the role of a remote police agent, and two as police agents investigating the crime scene.

At the crime scene, there are several boxes which can contain pieces of evidence (cf. Fig. 1, left). During the game, these pieces of evidence resemble blue, red, green, yellow and white Lego blocks. One of the local players has the skill to collect the evidence in the form of blue and red Lego blocks. The other local player can collect green and yellow Lego blocks. None of the players can collect a white Lego block; they are considered dangerous and possibly explosive.

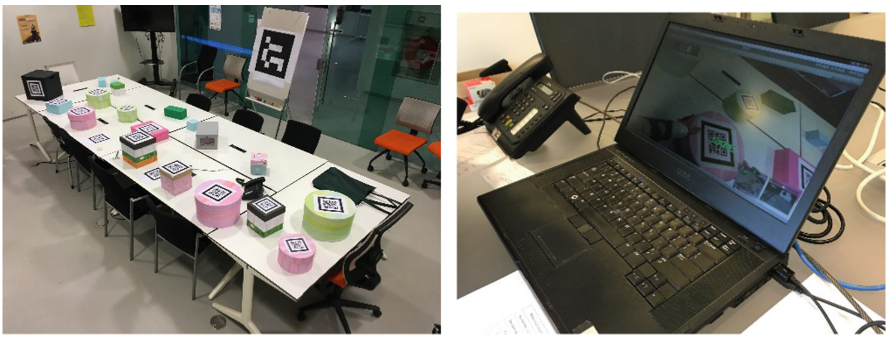

Fig. 1. The game setup for the local players (left) and the remote player (right)

The players either arrive at the crime scene at the same time and jointly investigate the crime scene, or they can do so sequentially. At the crime scene, it is their task to collect all non-dangerous pieces of evidence from the boxes. The local players are supported by a remote player who knows which boxes contain dangerous material and which do not. For this purpose, the local players share their view with remote player (cf. Fig. 1 right).

The goal of the game is to collect all evidence without opening one box containing a dangerous piece of evidence. Once all pieces of evidence are collected, the local players receive instructions from the remote player on how to combine the individual pieces of evidence, i.e., how to build a tower of Lego blocks showing a specific color pattern. If, during game play, a box containing a dangerous piece of evidence is opened, the game immediately ends and the players have not accomplished their task.

While playing, the players can exchange information in AR (for a detailed description of the underlying technology, refer to Datcu et al. (2016)). Only the remote player can see whether a box is dangerous or safe (cf. Fig. 2, left). Local and remote players can annotate boxes in AR e.g., to indicate the color of the block in the box or mark which boxes have already been emptied. The information the players leave behind on the boxes allows them to share information and coordinate their work (cf. Fig. 2, right). Local player(s) and the remote player can furthermore talk to each other during the whole game play using a continuously open audio channel.

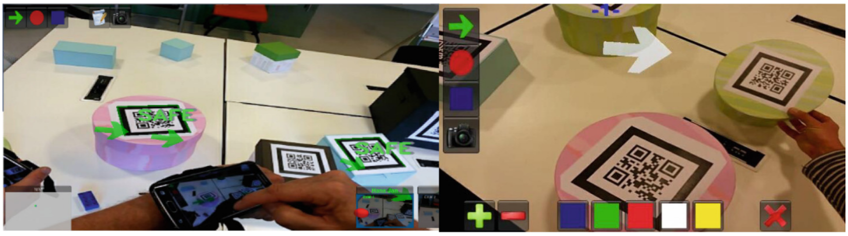

Fig. 2. View of the remote (left) and local player (right) showing information in AR

Compared to earlier high-fidelity experiments, the “AR box game” is of lower fidelity. The physical fidelity only mimics a crime scene. The functional fidelity is also lower, as the necessary actions are also only mimicking the ones from a staged crime scene. The story of the game is also of lower psychological and social fidelity, as the game story is only linked to a crime scene and the lower physical fidelity of the crime scene has an impact on the psychological and social fidelity.

The game was tested with four professionals from the field to evaluate the realism and fidelity of the game. All professionals had participated in at least one of the high fidelity experiments above. The game was played several times, during which the professionals took on the different roles of local player or remote player. Also, rounds of synchronous investigation with two players at the same time at the local site as well as asynchronous investigation were played. The observation and debriefing showed that the game was able to mimic the situation of distributed work and remote support as in the high-fidelity experiments. The story explosives being hidden in some of the boxes was strong enough to make the players feel as if they were in a real, serious situation. One participant remarked after they failed one round and opened the wrong box that he was shocked as if, in reality, his colleague would have been injured based on his wrong information. This also shows that games combining the digital and physical world have the potential to provoke strong, compelling experiences. In summary, this shows that lower fidelity, here specifically physical and functional fidelity, can result in similar experiences as high-fidelity setups. Surprisingly, the simple story of dangerous content in one box resulted in a high psychological fidelity for one participant. Here, future research needs to investigate whether this is also true for non-professional players that might feel less responsible for local-player actions.

3.3 Applied Games for Healthcare

It is becoming increasingly commonplace to use games which utilize virtual reality technology for health-related topics. A common application of games in health care is to train health professionals. For example the game *Night Shift*, developed by Jesse Schell's team, was used to train physicians' decision making skills in emergency departments (Mohan et al. 2017). Healthcare training applications can be classified under the general umbrella of training applications and hence follow a similar development process as other applied games for the training of professionals, as described in the previous examples given above. In this section, we focus on the application of applied games for rehabilitation and therapeutic purposes.

Mirror therapy is an example where physical, functional and psychological fidelities interplay. Mirror therapy is used to help patients with phantom pain manage their symptoms, as well as to help patients with motor impairments after a stroke (Regenbrecht et al. 2012; Thieme et al. 2018). In its most basic form, mirror therapy uses an optical mirror to show one side of the patient as if it is the other side. The aim is to mirror the unimpaired side so that it creates the visual illusion that the missing or impaired side is fully functional again.

Using an optical mirror to display a real hand of the patient can be considered the highest level of physical visual fidelity. However, when considering psychological fidelity, which also includes the experience of ownership of the virtual or mirrored limb, virtual reality technology might be able to elicit a stronger response (Hoermann et al. 2012; Regenbrecht et al. 2014).

Applied games which mimic some form of mirror therapy have been studied for their impact on motor rehabilitation (Laver et al. 2015). Regenbrecht et al. created Augmented Reflection Technology (ART), which was used for clinical and non-clinical studies (Hoermann et al. 2017; Regenbrecht et al. 2011; Regenbrecht, McGregor, et al. 2011). An augmented reality memory game, *TheraMem*, played by amplifying the movement of the impaired hand was used with patients in their chronic phase after stroke (Hoermann et al. 2014). *TheraMem*'s physical fidelity of the virtual components can be described as low, with most of the virtual objects having only vague resemblance to real world objects. However, the psychological fidelity related to the feeling of being in control of their augmented real hands could be, based on the reports of many users, described as high.

The use of game technology for phantom pain management has also been studied (Rothgangel and Bekrater-Bodmann 2019). In their review paper, Rothgangel and Bekrater-Bodmann pointed out that a number of studies have successfully created virtual and augmented reality applications. In particular, they pointed out that AR/VR technology can create virtual therapeutic environments beyond physical reality. For example for patients who have lost both their limbs, the representation of entirely virtual limbs without any real world counterpart is a necessity. Yet, even these virtual representations with an arguably low physical fidelity, aim to maximize the psychological fidelity i.e., the feeling of ownership and agency for the displayed limb.

Several aspects that link virtual components of rehabilitation applications with the experience of presence were discussed by Schüler et al. (Schüler et al. 2015; Schüler et al. 2014). In particular, they linked movement visualization, performance feedback and context information with presence dimensions. Movement visualization is linked to the way users are represented in virtual and augmented environments. The level of physical fidelity can, however, vary from fictive and abstract to anthropomorphic avatar representation, in either the first or the third-person perspective (Schüler et al. 2014).

Nevertheless, and necessary for all systems, is the need to provide feedback to patients about their performance and the results of their actions. In motor rehabilitation applications, patients need to be informed about the movements of their actual limbs as well as the results of these movements in the virtual environment e.g., did they grab the virtual diamond or catch the virtual butterfly (Jordan and King 2011; Lange et al. 2011). In augmented reality rehabilitation systems, this could be as simple as providing a video overlay of the actual hand over the virtual content and providing feedback about how well the hand posture matches the target posture (Pinches and Hoermann 2016). Feedback for patients on their movement performance and hence high functional fidelity of movement representation is essential for motor rehabilitation applications.

The third element, context information, is linked to realness perception and therefore, physical fidelity. This could be a very detailed virtual environment in which the patient performs therapeutic exercises, but can also be reduced to a minimum. In rehabilitation systems, this information can be used as a motivational aspect, but might not necessarily have a direct therapeutic impact. Hence, it is not just the physical fidelity of the context information which may be important, but how well this information matches the requirement of the task or exercise that the patient performs.

4 Towards a Framework of Applied Game Fidelity

In this section we summarize the results from the literature review, as well as our observations from the three cases illustrated above. As shown, the degree of realism of an applied game can be described in terms of a game's fidelity (Alexander et al. 2005; Salas et al. 2005; Harteveld 2011), and as such has impact on the processes within, and the outcomes of, a game. The (shared) experience of playing an applied game enables actors to perceive and comprehend a problem or system of which they are a part, such as a police agent or forensic researcher's work environment, or a patient within a rehabilitation process. Applied games represent media that enable a new, or at least different, view of familiar situations. Individuals are often deeply embedded in a situation in which they are not able to take on the role of a critical, so called first order, observer; they develop a blind spot for the situation and environment in which they participate. Applied games represent media in the sense that they act as second-order observers (as they mediate what we observe) and help in overcoming the blind spot of first-order observers of the system and the individuals themselves (Luhmann 1996). As such, applied games should be designed with the 'right' or at least a sufficient level of fidelity to serve as interactive second-order observer.

Related research shows that a higher level of fidelity does not necessarily lead to improved effects of an applied game. Yet, it seems to be hard to define the 'right' or at least sufficient level of fidelity for the design of applied games with a certain effect in mind. To help designers to better understand and assess the elements that constitute game fidelity, and that influence the game experience, we propose a framework of applied game fidelity that will have to be validated by case studies in the future. Table 1 summarizes the findings from literature and our cases so far.

Table 1. Proposed framework of interaction fidelity for applied games

Low → High	*Game Characteristic*	*Affected Concepts*	*Game Experience*
Psychological Fidelity	High accordance with reality	Emotion, Experience	Ownership, Agency
Functional Fidelity	High accordance with reality	Tasks, Procedures	Feedback
Physical Fidelity	Lower accordance with reality	Emulation, Audio-visual design	Recognition
Social Fidelity	To be studied	Interaction with other players and non-player characters	Collaboration

Table 1 shows the four dimensions of fidelity. Each dimension can be defined on a continuum from low to high fidelity. The table illustrates that psychological fidelity is directly linked to high accordance with reality, is triggering emotions and experiences, leading to experienced ownership and agency. Functional fidelity also affects the outcomes of a game when high accordance with reality is reached. It is related to the representation of tasks and procedures in a game, leading to effective feedback. Contrary to often seen research hypotheses, physical fidelity can be expressed on a lower level of resemblance with reality. It represents an audio-visual emulation of the reference system, and is related to recognition of the physical game space. Social fidelity has still to be studied, and relates to the interaction with other players and non-playable characters. It can lead to experienced collaboration. Further research will focus on the validation of the framework.

5 Discussion and Conclusion

As Bhargava et al. 2018 show, fidelity of a virtual environment did not have a significant impact on learning outcomes. The results show, contrary to common belief, that there is no linear relationship between level of realism and effectiveness of training. Abstraction and simplification can lead to excellent training outcomes (Toups et al. 2011).

Our own studies show that applied games that are designed to address the communication and interaction between team members contribute to the developmental process of situation awareness and communication. Thus, they are able to act as a second-order observer of systems and problems. A realistic VR of an applied game provides a shared experience to the players, and supports the perception of a situation. The environment plus information of other players enhances the individual comprehension of a situation. This study showed that communication and interaction of the players were two of the most important aspects, which we refer to as social fidelity. This fourth aspect, which has not yet been defined as such, will enrich the design of applied games with crucial social competencies individuals – as team members or not – nowadays need to actively participate in the systems of our networked society.

In summary, applied games require a high level of functional and psychological fidelity to be effective. While the appropriate and accurate provision of feedback to actions in the virtual environment (functional fidelity) is paramount, physical fidelity of the environment is less important. It can be speculated that a reduction of the physical fidelity of the environment to the bare minimum might help players focus on key aspects of the interventions, which in motor-rehabilitation games is to keep their attention on the observation or execution of movements, and in professional games to carry out realistic tasks, based on procedures of the reference system.

From our results, we can conclude that when learning is the goal of an applied game, physical fidelity does not have to be high in order to develop an effective tool. High fidelity games are usually costlier and more time consuming, which makes it a challenge to balance how much realism is needed in order to reach the intended effect. The target group and purpose of the game should carefully be evaluated against the cost of high fidelity, in order to design an effective game with a sufficient level of fidelity.

Further research should explore whether *ethical* or *value fidelity* could also be added to the framework, before the framework itself can be validated. When designing applied games, a game designer is influenced by his/her cultural background, experiences, and the expected outcomes of the game. Related values of the designer influence the design and application of a game, and the evaluation of its outcomes. Game designers should thus be aware of this influence, open to diversity and differing values of game players, and reflect on them. A diverse design team might limit the bias in this respect. An important aspect related to ethical fidelity is the responsibility of the game designer of an applied immersive game. In training games with sensitive content, or with vulnerable people as the target group, such as young, ill or elderly people, possible effects of the game should be considered in all stages of the design process. In an example of a game for humanitarian aid workers that was part of one of our research projects, some participants were affected by the high level of realism of the processes and reminded of impactful situations of field work. The game facilitators could not address this issue as they were not prepared for such reactions to the game. One approach to be explored in future research might be the notion of "value sensitive design" (van de Poel 2013), where such possible effects and risks are evaluated during the whole process of designing an artifact, such as an applied immersive game.

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The Strategic Use of Smartphone Features to Create a Gaming Experience of Mystery: The Mind Alone Case

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Abstract. In the present work, we discuss the creative process behind the Brazilian mobile game Mind Alone (Sioux Games, 2018). We start our discussion with a brief overview of mobile media and the Brazilian gaming market, in order to clarify why mobile games are a rich field to explore in this country, and to assess some aspects of the Brazilian gamer audience. After this introduction, we proceed to expound the main features of the game Mind Alone, aiming to finally put forward some ideas about strategic thinking in game design, game writing, and puzzle design, emphasizing the need of multidisciplinary thinking. This article recounts the whole creative process behind Mind Alone, highlighting some main phases: (1) brainstorming, including interviews with the production team at the Sioux company; (2) documentation, analyzing the "high concept template"; (3) production, elucidating the interface between art and coding (and how to merge smartphone features to create the game experience); and (4) beta-testing, comprising guidelines for a qualitative session. With this work, we intend to depict the full development of a mobile game, from brainstorming to publishing and documentation. It is important to highlight, in this context, that the author of this article was the game designer responsible for Mind Alone's mechanics and narrative.

Keywords: Game design · Mobile game · Puzzle design · Mind Alone · Brazil

1 Introduction

Mobile media and entertainment can be regarded as leading and intertwining milestones in the contemporary culture. In the light of this fact, we discuss herein a relevant issue concerning the processes of game design and puzzle creation. The lines between near and far, public and private, work and leisure, online and offline are becoming increasingly blurred by the disseminated use of countless mobile gadgets with wireless and fast-track connection to the internet, and also by the use of more traditional modes of access. The impressive rates of social appropriation of communication and information technologies entail changes in the way we live, get together, do business, and, of course, have fun—which happens in different kinds of "playgrounds" that we come across in our daily lives, according to Bogost [1].

While acknowledging the prominence of these "playgrounds"—in which the idea of "mass self-communication", as proposed by Castells [2], poses new challenges to the

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comprehension of current modes of sociability, entertainment and consumption—, we are going to focus our attention on the mobile game Mind Alone (2018), developed by a Brazilian studio named Sioux.

However, before opening the main discussion, focusing on the game design and the production of this title, it is important to contextualize the gaming market scenario in Brazil. A key aspect that must be understood is why mobile games may work as a strategic entry point for Brazilian companies to get into the global gaming market.

2 A Word About the Brazilian Gaming Market

The Brazilian gaming market is full of opportunities and peculiarities. The country is well-known abroad for being an emergent field where new game ideas can be explored, and also for its high levels of piracy, unfortunately. In a certain way, the country is a unique "ecosystem" where different business models and creative processes can be explored, given the size and the diversity of its population, of almost 220 million people.

The gaming industry in Brazil is not consolidated though, and under many aspects it is still in an initial stage. As a first step into our discussion, we can highlight some attributes of the Brazilian gaming market, using as reference the data collected in an important survey named Game Brazil Research 2018 [3] (*Pesquisa Game Brasil 2018*, in Portuguese), conducted by the company Sioux Games, which has published the game Mind Alone, our object of study in this essay.

In its fifth edition, the research comprised interviews with 2853 people, in an attempt to investigate some demographic, consumption and behavioral aspects of the Brazilian gaming field. The first information we need to highlight is the fact that 75.5% of the Brazilian population plays games in a wide range of platforms, like smartphones, tablets, computers, consoles, portable consoles, etc.

According to this research, the gamer audience in Brazil is mainly cross-platform, with 74% of players experiencing games on more than one device. Smartphones lead the numbers as the most popular gaming platforms in Brazil (37.6%), while consoles occupy the second place (28.8%), followed by computers, in third place (26.4%).

Another interesting piece of information from Game Brazil Research 2018 concerns the self-image of the Brazilian gamer audience: only 6.1% of the respondents considered themselves to be "hardcore" gamers. Most of the interviewed people identified themselves as casual gamers.

It was also remarkable, in the research about mobile games, that 60.7% of respondents said they played while in transit (bus, subway or car).

Finally, it is noteworthy that 53.6% of Brazilian gamers are women, and among the female audience the favorite platform is mobile (59%), in which they spend an average of one to three hours a week playing games.

From these preliminary data, it is possible to understand that Brazil is a fertile ground for mobile games and a place with high potential for new gaming business in this field. To reinforce how relevant the mobile platform is for games in Brazil, we can bring to our discussion the game entitled Horizon Chase (Aquiris, 2018). This game was the first Brazilian game launched for Playstation 4, in Blu-ray disc format. However, it had been previously launched for smartphones and tablets.

There are no massive game publishers in Brazil yet, and mobile platforms like App Store (Apple) and Play Store (Google) constitute interesting opportunities for game designers, indie studios and small gaming companies to showcase their work, in Brazil and abroad.

Based on this initial information, we will discuss, in the next topic, this article's object of study: the mobile game Mind Alone.

3 Mind Alone: A Mysterious Narrative for Mobile Devices

As we have already said, Mind Alone is an indie mobile game created and published by the Brazilian company Sioux [4]. It is a non-competitive single-player game. The player embodies the role of a character trapped inside his own mind. It is impossible to say whether they are dreaming, lying in a coma or dead. To find the answer for this mystery, the player must solve a series of puzzles, each portraying a memory that offers a hint of what happened. The memories start back in the character's childhood and advance until the present day. The player must solve all the puzzles to reach the threshold of the character's consciousness. In order to unriddle these enigmas, it is necessary to use most of the smartphone's features (gyroscope, internet connection, multi-touch screen, voice recognition, vibration) [5].

Gaming mechanics are essentially puzzle-based, following some methodologies proposed by Adams [6], about how to create effective enigmas. One special feature of the game is the interface, which was built using mainly alphabetical characters. In Mind Alone, the narrative and mechanics walk side by side to create the ambience of mystery and terror. In this game, according to Ince's thoughts [7], "story, dialogue, character profiles, etc. should all be created in a way that adds to the design of the gameplay".

Another aspect to be highlighted in Mind Alone's experience is that the game uses smartphone and tablet features to give life to the gameplay, as we discussed in the beginning of this topic. Some puzzles are solved using multi-touch on the screen, others lead the players to put the device upside down, or shake it, causing elements to move in the interface; in another case, the player must use their voice to activate a command, and there is even a transmedia puzzle that requires players to access a blog [8] in an internet browser, in search for an answer left by the game character.

Below, we display some print screens of Mind Alone's interface. As seen in Fig. 1, Mind Alone uses minimal elements to create its gameplay. The starting screen is one of the few parts of the game that use an image of a skull x-ray. All the other screens use only alphabetical characters. In the second print screen, there is a puzzle where we can read: "There was a big box full of toys on top of the shelf in my room. I loved to scatter the toys across the floor." The solution for this puzzle consists in tilting the smartphone or tablet 90º to move the BOX element toward the FLOOR element. In the third print screen, we can see another puzzle that says: "Our house was far away from the city and I liked to watch the stars in the sky. I pointed my finger to the distant small dots to create bigger stars." The solution is to touch the screen in the right sequence to

Fig. 1. The left image shows Mind Alone's opening screen. The center and right images show two examples of puzzles created with alphabetical characters.

transform the small dots into a big star. This is the core dynamics of Mind Alone: fixed screens with an enigma that, when solved, creates a button to the next.

Based on this overview of Mind Alone, we will discuss, in the next topic, the main subject of this article: the complete game design process, emphasizing documentation, beta-test qualitative interviews, some ideas about puzzle design, and how narrative must hybridize with gameplay in this scenario.

4 From Brainstorming to the Published Product: A Practical Approach for Mobile Game Designing

4.1 Game Design Process

In this topic, we emphasize the most relevant parts of Mind Alone's game design project. It is essential to follow logical steps, even in a simple puzzle mobile game, in order to establish a coherent integration among the different professionals working in the project (game designer, artist, programmer, and project manager).

Following the thoughts of Fullerton et al. [9], Mind Alone used a very synthetic game design process based on stages. The **first step** is the conceptual stage, when the narrative and the core gameplay are defined, based on intense research to check other similar games already published. The **second step** proposed by Fullerton is the brainstorming stage, in which people involved in the project start the first essays about how the narrative will materialize on the gaming interface. When these ideas are established, there comes a fundamental **third step**: the making of a prototype (or pre-prototype) of the game. In this phase, it is very important to save time by creating a fast pre-visualization of the game using paper, pen and other analog components, or assembling a digital prototype for a fast beta-test play, as we can see in Fig. 2.

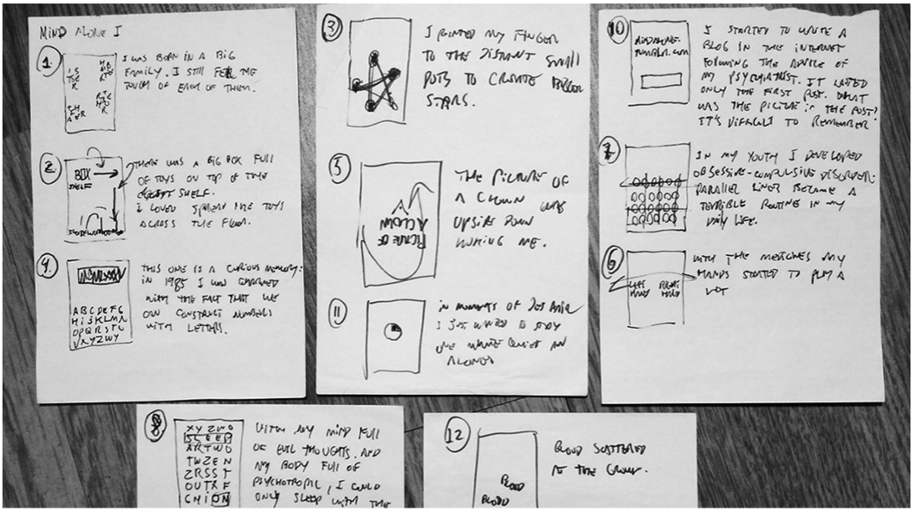

Fig. 2. Mind Alone's puzzle studies and analog pre-prototypes.

In the **fourth stage,** there is the challenge to establish the initial concepts of the interface. As we already discussed and saw in Fig. 1, the gaming interface was created using only alphabetical characters. In this case, most puzzle solutions come from the user's interaction with the text characters, so this is a part of game design that is central to the connection between gameplay and what the player is watching on the screen. For Mind Alone, Photoshop was an excellent tool to create interface studies that were used in the first prototypes.

The **fifth phase** is digital prototype and its test stage: with the mechanics and first layouts previously defined, it is possible to develop a simple version to be played on browsers or smartphones. The example below (Fig. 3) provides a better understanding of the relationship between gameplay and interface: there is a puzzle that starts with the text, "With my mind full of evil thoughts and my body full of psychotropic pills, I could only sleep with the lights ON. Fear and anxiety were my companions at that time." The player can see mixed characters on the screen. The word "ON", capitalized in the text, is a hint, and if the player touches the interface near the word "ON", in the mixed grid of characters, there is a subtle trembling to indicate a solution is near. If the player touches the word "ON", the interface will simulate lights on, by becoming white. An arrow will appear on the central superior part of the screen, indicating that the puzzle is finished, and the player can advance to the next one.

In this fifth stage, it is possible to start the beta-testing sessions with different kinds of players. For Mind Alone, the team at Sioux used a fast qualitative research approach after play tests. The research followed some ideas proposed by Cote and Raz [10], which consist in: (1) creating an introductory script to open the interview and recalling the study goals; (2) using warm-up questions to put the participant at ease and build rapport (e.g. "For how long have you been playing videogames? What is one of your favorite gaming memories?"); (3) using substantive questions to collect deeper data that

Fig. 3. Mind Alone's puzzle example in the final interface.

validate the research hypothesis (this part is crucial to the interview, because it is when players will give feedback about gaming interface, mechanics and other aspects); and (4) using demographic questions to gather data needed to describe participants in the final research report.

The **sixth phase** is the production stage, in which feedback provided by beta-testing sessions of the digital prototype is used as the main information source to orient the production of the final version of the game.

The **seventh phase** is the evaluation stage, carrying out final tests to assure the game is error-free.

Finally, there is the **eighth phase**, which consists in the launching stage, the moment that the publisher, Sioux, made the game available for download in mobile platforms (Android and iOS).

It is important to highlight that, during this whole process, the game was documented using specific files. In case of huge "triple A" games, it is possible to find a game design document with hundreds of pages. In Mind Alone's case, the team decided to register the gaming process in a high concept document that we are going to discuss ahead, in the next topic.

4.2 Documentation Using a High Concept Document

An essential part of any game design project is to register the main ideas and features of the game. For Mind Alone, Sioux Games used, with slight modifications, the "High Concept Document" model proposed by Adams and Rollings [11]. This document has already been shared with the Brazilian game designing audience [12], in another context. Still, it is important to include this content here, in order to highlight the relevance of documentation in the game designing process.

To register a gaming project is to create a guide and a reference for future games. These could be excellent tools to present the game for investors or to explain central ideas in a contest or gaming award. Another excellent use for this document is to have it as study material in game design classes. Below, we present the high concept document elaborated during the game design process.

- **Title of the game:** Mind Alone
- **Team:** Vicente Martin Mastrocola (game design, sound design, information architecture); Gabriel Romano (user experience, Unity programming); Guilherme Camargo (business model; planning strategy).
- **Publisher:** Sioux
- **Country and year:** Brazil (São Paulo), 2018
- **Game summary:** Mind Alone is a non-competitive single-player game based on plot, or story-related. The player embodies a character trapped in his own mind. It is impossible to say if they are dreaming, lying in a coma or dead. To reach the answer for this mystery, the player must solve a series of puzzles; each puzzle is a memory that offers hints on what happened. The memories start in the character's childhood and advance until the present days. The player must solve all the puzzles to reach the surface of the conscience. Mind Alone is an authorial game and does not demand special licenses.
- **Gaming references:** The Witness (Thekla Inc., 2016); Dark Room (Doublespeak Games, 2013); Lifeline (Three Minute Games, 2016); games focused on narrative features, with a clear invitation for players to become "co-creators" of the plot.
- **Player's motivation:** the character needs help to wake up from the prison of their own mind, in which they are confined, within an infinite loop of disconnected memories. Players must solve the puzzles, which have different difficulty levels, in order to reach the surface of conscience.
- **Keywords:** puzzle game; mystery; terror; enigma; mobile, transmedia; immersive; narrative
- **Target audience:** 16 + year-old players, fans of puzzle/enigmas, escape the room games, and horror/terror literature.
- **Highlights:** 95% of the game was created using only alphabetical characters combined with interesting artistic interfaces. Freeware. Some puzzles offer transmedia features, inviting players to explore blogs and sites. Fast.
- **Platform:** mobile game developed for the iOS and Android systems (created with Unity programming).
- **Game design goals:** the dark/mysterious narrative and the puzzle-based gameplay offer the players an experience of immersion, fear and tension. Thought-provoking puzzles are generated using simple interfaces.
- **Music and sound design:** dark ambient soundtrack with incidental sounds (doors opening, moans, screams, piano notes, etc.) Some sounding references come from artists like Richard Rich and Lustmord.
- **Business model:** freeware. The purpose of the game is to represent the Sioux studio in game design contests, festivals and gaming fairs. As a freeware game, another purpose of Mind Alone is to be studied in game design classes.

- **Mechanics examples:** Mind Alone uses various smartphone features to build its gameplay. There are puzzles that use touch screen, assembly of elements, movement of the device (detected by accelerometer and gyroscope), and puzzles with textual responses.

In the next topic, we highlight a most important part of the game design process of a game like Mind Alone: puzzle creation.

4.3 Puzzle Design

Ernest Adams, in his book *Fundamentals of Puzzle and Casual Game Design* [6], teaches some methodologies to create immersive and intelligent enigmas for games of different natures. In his text, Adams references the work of Scott Kim, a puzzle designer who formulated the idea of "eight steps to create a good puzzle". These eight steps were a central inspiration for the Mind Alone project and deserve to be shared in this article.

The first step proposed in this model is to find inspiration. It sounds obvious, but it is an essential part of the process. Solving lots of puzzles could be a great source of inspiration, but to search for ideas in other fields is also an interesting way of creating enigmas. Literature, movies, comics, toys and TV series are some examples of where to find inspiration.

The second step is considered to be a mantra in game design: "keep it simple". After creating the main idea of a puzzle, it is important to remove any excess. Exploring the features of the platform (console, board game, mobile media, etc.) can give you creative solutions for puzzle design. In Mind Alone's case, the team studied many possibilities of using different smartphone/tablet features to create a puzzle-based gameplay.

Prototype and fail fast constitute the third step. Once we have a promising idea on our minds, we need to construct models (analogical or digital) and test this initial version. Here, it is important to test the prototype with the project's team, but it is also crucial to test it with the very first beta-testers.

The fourth step consists in defining the rules. Adams [13] says that rules are "the key part of puzzle design" and reinforces that most puzzles are defined in terms of four elements: the board (or the space where the action occurs), the pieces (gears, gems, stones, levers, screens—the elements with which the player will interact); the moves (sequences of movements, simultaneous moves—what is allowed and what is not and what the side effects there are); and the victory condition (how players win the challenge).

Building the puzzles is the fifth step. When the mechanics is ready and functional, it's time to create the final version of the puzzle (analogical or digital). Here, we need to pay attention to the first aesthetical details, to information architecture and to providing clear instructions for the player.

The sixth step is to test the final version in order to achieve the desired outcome. Call new beta-testers and also use the first ones.

The seventh step is about devising a sequence: in a game with many puzzles—or many levels with puzzles—it is advisable to create a logical order for them. Increasing difficulty with some hints between the challenges is an interesting way to keep the player engaged in the gaming experience. As Koster [14] reminds us, the most immersive puzzles "are the ones that force the most self-experimentation. They are the ones that challenge us most deeply on many levels: mental stamina, mental agility, creativity and perseverance."

The final and eighth step is: pay attention to presentation. Sounds, graphics and other details will make the difference in the puzzle experience. A good puzzle enclosed in a poor layout could be terrible for the players. In Mind Alone, all the puzzles were created using textual characters and it forces a player's mind to imagine the situations behind the mystery. This is a relevant aesthetical component for this game and it invites the players to use their creativity to get a more immersive experience.

In the next topic, we will discuss briefly other details about the project Mind Alone, presenting some opinions from the team at Sioux Games. We intend to bring to this article some ideas about business model and the interface between gameplay and coding.

4.4 Some Words from the Team at Sioux

In this topic, we bring some thoughts and comments from the crew at Sioux, regarding the game Mind Alone. Fundamentally, we share some in-house information to serve as inspiration for anyone who would like to develop independent mobile games.

As it was said in the abstract, the author of this article is the professional responsible for information architecture, game design and narrative in Mind Alone. These aspects were previously discussed in this section. However, there are two important opinions yet to be mentioned here, regarding business model and code programming.

Guilherme Camargo, CEO at Sioux Games, says that even a freeware game like Mind Alone could be profitable in many ways. For Camargo, games like this allow the studio to explore new mechanics and reach new audiences. Sioux works mainly with gamification and advergames projects, and an independent, experimental entertainment game like Mind Alone offers new possibilities for the company, like the participation in gaming festivals[1], the study of the game in game design classes[2] or the creation of a stronger presence in specialized media by showcasing a differentiated product. Sioux's CEO defends that it is important for a game company to try new languages and concepts in upcoming projects. Even a game launched to reach a small audience could mean a step further toward building a broader audience for future projects.

Gabriel Romano was the programmer responsible for giving life to Mind Alone in the screens of smartphones and tablets, on Android or iOS platforms. Romano, in an interview about the game [15], said that he opted for Unity because of the flexibility of the language. The community on the web is very collaborative and it is possible to find

[1] In December 2017, Mind Alone participated in the *Game On* festival, in Buenos Aires (Argentina), receiving good reviews from the local media.

[2] During the year of 2018, Mind Alone was studied as a game design case, in the discipline Game Essentials, which is part of the IT course at ESPM College.

solutions for coding problems very fast, when using this open-source language. Romano also says that, in a project like Mind Alone, it is fundamental to receive a detailed document and a prototype from the game design professional. Based on these insights, he was able to program the puzzles with more accuracy and less errors. According to the programmer, each puzzle in Mind Alone is unique. In many games, the designers develop the mechanics and later comes the work of level constructing, based on these mechanics. However, in Mind Alone, Romano explains that, for every puzzle, he studied how to activate certain smartphone or tablet features, during the creation of the eighteen stages of the game.

The most important things to highlight here are the dialogue among all the team and a well-defined chronogram to create a multidisciplinary workflow. With all the teams' minds aligned, Mind Alone was created, tested and produced in six months.

Below, we discuss some final ideas.

5 Final Thoughts and Conclusions

In this article, we had the opportunity to discuss a complete game design project for mobile platform. Despite being a free mobile game, Mind Alone is an important tool for Sioux studio to showcase their work and participate in game designing contests and gaming fairs. The game is also a relevant case to be studied in classrooms and it fosters discussion about how independent, experimental/artistic games can be created. Furthermore, it allows us to digress on how the gaming industry is plural in this sense. The strategy of distributing a free game may guarantee other forms of profit, like posts in specialized gaming websites, discussions in academic articles, prizes in gaming contests, etc. It is worth reinforcing that, for a game company, it is essential to explore new languages and always offer different products to the audiences, in order to keep them engaged.

We understand that, more than ever, creating a mediatic product like a game requires multidisciplinary work and research, so that a compelling form of entertainment can be offered to different types of players. As Flanagan [16] points out, videogames are today legitimated as "forms of media, human expression, and cultural importance". This way of thinking offers some answers about how broad the gaming industry became in the last 40 years.

There is evidence that never before have individuals pursued ludic experiences so much, looking forward to having some moments of detachment from their chaotic quotidian experiences, from the pressure of multiple working hours, or the accelerated routine of big urban centers. To some extent, people are trying to reach places of catharsis, where dreaming and fiction offer a way to escape, and mobile platforms (like smartphones) take the lead in this setting. Based on Huizinga's [17] thoughts, people are searching for different "magic circles" in the landscape of daily life. All the time, people are resigning trivial things from their lives and games are protagonist in this scenario; games are full of meaning in this sense and the time dedicated to entertainment becomes a "sacred" time for many audiences.

It is important for companies like Sioux, or even independent studios, to understand how these moments in a "magic circle" occur in the quotidian of certain audiences, so that these moments can be explored through entertainment products like games.

By discussing the creative process, game/puzzle design and the business model structuration of Mind Alone, we hope to demonstrate the strength of the relationship between players and gaming companies in the contemporary digital gaming ecosystem. We claim it is of utmost importance to use a methodological process, even for small productions. We have been able to assess the importance of working with a consistent methodology and can thus envision the iterative process applied to bigger projects. We hope we can contribute to the field of gaming studies and that this paper fosters the development of future projects and inspires new relevant discussions.

The Brazilian gaming market, emergent as it is, reveals itself as a privileged ambient in which these game design processes can be observed. We welcome the opportunity to present this relevant discussion as a means of contributing to the ongoing efforts in exploring the gaming market in contemporary culture. For the best comprehension of this article's content, we invite all the readers to download Mind Alone and experience its narrative and puzzles.

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Digital Game Enjoyment: A Literature Review

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Abstract. A review of the literature on digital game enjoyment or what makes digital games enjoyable is presented, organized by topic. A literature search resulted in 61 relevant peer-reviewed research articles or papers. No limits were put on the research methods used or date of publication. The reviewed literature spanned from 1980 to 2017. The research was organized into the following topics: Measuring and Understanding Digital Game Enjoyment, Uses and Benefits of Digital Game Enjoyment, Flow, Immersion and Engagement, Challenge and Competition, Player Experience of Need Satisfaction and Self Determination Theory, Motivations to Play Games, Games User Research Methods, Game Design, Game Player Demographics, Game Addiction, and Violence in Games.

Keywords: Enjoyment · Flow · Intrinsic motivation · Digital games · Computer games · Video games · Literature review

1 Introduction

Understanding digital game enjoyment and what leads to that enjoyment is critical for those who want to design interactive experiences for enjoyment, whether for Game Design, Serious Games, or Gamification.

IJsselsteijn et al. [1] presented a literature review and theory paper discussing how digital games are different from productivity applications. Mekler, Bopp, Tuch, and Opwis [2] summarized previous studies on digital game enjoyment, but their search was limited to quantitative studies from 2008 to 2012.

There has yet to be a sufficiently comprehensive summary of the literature on what makes games enjoyable. This paper aims to fill that gap in the literature. A review of the digital game enjoyment literature is presented without constraints on the date of publication or whether the research methods used were quantitative or qualitative.

2 Method

A review of the literature was done by searching Web of Science, Science Direct, ACM's digital library, ABI/Inform ProQuest, PsychArticles, EBSCO's Academic Search Complete, Information Science & Technology Abstracts, Business Source Complete, Education Research Complete, ERIC, Taylor & Francis Online, Sage

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Journals, and Google Scholar using the following keywords and phrases: game enjoyment, game and enjoyment, “Intrinsic motivation” AND games, gamification OR gamified, flow AND “video games”, flow AND “computer games”, games user research, game user research, “player experience”, game AND fun, systematic review computer games, determinants of enjoyment in games. Results with the most number of citations from each search were exported into a spreadsheet.

The first 100 results relevant to the topic of digital game enjoyment or what makes digital games enjoyable were manually selected. The number of citations for each result was checked with Google Scholar on September 1st, 2017 and included in the spreadsheet. 7 results were excluded because they were books or book chapters, not peer-reviewed academic research. Two results were excluded because they were considered duplicates with other articles already included.

From the remaining results, the 61 peer-reviewed journal articles or conference papers with more than 40 citations were reviewed. This cutoff was chosen to focus on the most influential peer reviewed research on the topic. No limits were put on the date of publication, and the reviewed papers spanned from 1980 to 2017.

The 61 articles or papers were summarized and sorted into categories to organize them by topic. What follows is that literature review, organized by topic. Two of the papers were literature reviews, and have been included in the introduction above.

3 Literature Review

Relevant research articles and papers were selected through the process described in the Method section above. This review of the literature has been organized into the following twelve sections: Measuring and Understanding Digital Game Enjoyment, Uses and Benefits of Digital Game Enjoyment, Flow, Immersion and Engagement, Challenge and Competition, Player Experience of Need Satisfaction and Self Determination Theory, Motivations to Play Games, Games User Research Methods, Game Design, Game Player Demographics, Game Addiction, and Violence in Games.

3.1 Measuring and Understanding Digital Game Enjoyment

Developing a Measure of Computer Game Enjoyment with Card Sorting and Factor Analysis. Fang, Chan, Brzezinski, and Nair [3] created a measure of computer game enjoyment. Their questionnaire measure asks participants to report affective, behavioral, and cognitive responses that indicate enjoyment. Their initial items were derived from Nabi and Krcmar’s theory of media enjoyment [4]. The items were reviewed by 20 professional game designers and developers for feedback. Sixteen game players participated in an exploratory card sorting procedure, where items were sorted into groups and each group was labeled with a category name. Twenty-three game players then conducted a confirmatory card sort to sort the items into the categories. A follow-up online survey was completed by 508 game players, and factor analysis of the survey data confirmed the construct validity of the measure.

The measure that Fang et al. developed was based on a theory of media enjoyment, not specifically a theory of computer game enjoyment. For that reason, some of the items in their measure may have fit better with enjoyment of a passive viewing experience rather than an active game-playing experience. For example, the Behavior component of their measure focused on talking to oneself, making loud comments, or swearing while playing the game. These behaviors do not necessarily indicate enjoyment. A player speaking to themselves or swearing could be enjoying themselves or could just as easily be frustrated and not enjoying themselves.

Media Enjoyment as Affect, Behavior, and Cognition. Nabi and Krcmar [4] presented a theoretical model of media enjoyment, with Affective Reactions, Cognitive Reactions, and Behavioral Reactions leading to Enjoyment. It seems they took a basic and broad idea from psychology, the ABC's of psychology – Affect, Behavior, and Cognition – and applied it to the inputs and outputs of media enjoyment. So, thoughts, feelings, and behaviors lead to media enjoyment, which in turn have effects on the person's thoughts, feelings, and behaviors. Nabi and Krcmar did not present any research to support their model. Also, their model is too broad to be useful for design, or to help make video games or other media more enjoyable.

Identifying with Video Game Characters. Klimmt, Hefner, and Vorderer [5] presented a conceptual model of identification with video game characters focused on shifting player self-perceptions to take on the positive attributes of the video game characters they are playing in the game. However, they did not present any original research to support their theory.

Feeling Like Your Ideal Self in Games Makes the Games More Fun. Przybylski et al. [6] conducted experiments showing video games were most intrinsically motivating and had the greatest positive emotional impact when players felt their game-self was congruent with their ideal-self.

For their ideal self, participants were asked to think about the type of person they wished, desired, or hoped to be and respond to a personality inventory about that type of person. For their game self, participants played three games and after each game they were asked to think about how they saw themselves when they were playing the game they had just played and respond to the same personality inventory. Hierarchal linear modeling showed that the convergence between game-self and ideal-self characteristics significantly predicted intrinsic motivation and positive affect, and was negatively related to negative affect. Playing digital games can make players feel closer to their desired personality characteristics, more like their ideal self. When it does, this tends to lead to more enjoyment.

Making Video Game Controls Not Work Makes the Game Less Fun. Klimmt et al. [7] conducted an online experiment to test the impact of perceived effectance and control on video game enjoyment. They defined effectance as perceived influence on the game world. Players played three versions of a *Breakout*-style arcade game online. In the reduced effectance version, the controls would not work a third of the time the player pressed the arrow keys. In the reduced control version, the controls worked normally, but the ball moved much faster than in the standard version, making it harder for the players to keep the ball in play and thus to feel in control of the game situation.

Players of the reduced effectance version reported significantly less enjoyment than other groups. Making the controls not work a third of the time may have had unintended consequences they did not measure, such as decreasing the perceived ease of use or usability of the game's controls. Making the ball move faster may have increased task difficulty, which may have increased enjoyment by making it more challenging. There may have been confounding variables impacting player enjoyment and their results.

It appears they did not successfully isolate and manipulate the variables they intended to manipulate. If the design differences they tested had unintended effects beyond effectance and control, all they showed was that making video game controls not work a third of the time players press buttons leads to less player enjoyment.

The Impact of Two Personality Factors (Sensation Seeking and Self-Forgetfulness) on Computer Game Enjoyment. Fang and Zhao [8] investigated the impact of two personality factors, sensation seeking and self-forgetfulness, on computer game enjoyment. Sensation seeking is a need for varied, novel, and complex sensory experiences and being willing to take risks to have those experiences. Self-forgetfulness is a tendency to concentrate so much that one loses all sense of the passage of time and may forget where they are.

Fang and Zhao found that game players who were higher on these two personality traits were significantly more likely to report behavioral reactions indicating enjoyment when they played role-playing games. Game players who were higher on sensation seeking also reported significantly higher behavioral indicators of enjoyment of both action/adventure/shooting/fighting games and sport/racing games, and cognitive indicators of enjoyment of family and simulation games. The results from Fang and Zhao showed that individual differences such as these personality factors can have a systematic impact on computer game enjoyment.

3.2 Uses and Benefits of Digital Game Enjoyment

This section discusses research on the uses and benefits of digital game enjoyment, including for educational games, games to promote health-related behavior change, games as research tools, and games as therapeutic tools.

Benefits of Video Games. Griffiths [9] discussed the many ways that video games can have a positive impact on those who play them. While Griffiths did not present original research, he gave an overview of the benefits of playing digital games and the literature supporting those benefits. Playing games reduces reaction times, improves hand-eye coordination, and raises the self-esteem of players. Video games have been used as research or measurement tools, to teach skills to autistic children or other special needs groups, to teach children with attention deficit disorders to focus their attention using brain-wave biofeedback, and to assist with physical rehabilitation.

Input-Process-Output Game Model for Educational Games. Garris et al. [10] drew on previous research to develop their Input-Process-Outcome Game Model for educational games, and presented experimental research to support their model. This model shows the content to be learned and game characteristics are the inputs into the process. The process is an iterative, cyclical process of User Judgments, User Behavior, and System Feedback. This cyclical process is the Game Cycle. Then the Debriefing after the Game Cycle leads to Learning as an outcome of reflection on the process.

Garris et al. developed two versions of a navy training simulation of targeting enemy ships from a periscope. A treatment version of the training simulation was designed to incorporate the following game characteristics: Fantasy, Rules/Goals, Sensory Stimuli, Challenge, Mystery, and Control. They made a control version of the training simulation that was designed to provide the same opportunity to target ships but without the game characteristics. The simulation with the game characteristics was rated significantly higher than the control version on each game dimension and it provided significantly more effective training than the control version.

Digital Games as Therapeutic Tools. Griffiths [11] suggested that digital games can be effective therapeutic tools because they motivate patients to succeed at the task, can distract from pain and discomfort, and can help develop social and communication skills among the learning disabled. Griffiths did not present original research on the topic, but provided an overview of the research using digital games as a therapeutic tool. For example, digital games were used along with brainwave biofeedback to help children with attention-deficit disorders learn to focus.

Video Games for Health-Related Behavior Change. Baranowski et al. [12] did a literature review of studies about video games that persuaded players to make health-related behavior changes. They reviewed twenty-seven articles, and found that there were two main ways that these games affected player behavior: goal-setting and story. Some games made the goal of the game the intended behavior change. Others used the story in the game to have characters model the desired behavior, or have the lesson of the story promote the desired behavior change.

Intrinsically Motivating Educational Games. Malone [13] presented research on educational games being used in the classroom. He found that Challenge, Fantasy, and Curiosity were important parts of designing educational computer games that made things fun to learn. Malone asked 65 children in a computer class to rate how much they liked 25 games that their teachers thought were most popular among the students. Malone then rated each game on many different dimensions and analyzed the correlations between these game features and the average ratings the children gave the games. These game features were significantly correlated with game preference: Goal, Computer keeps a score, Audio effects, Randomness involved in game, and Speed of answers counts.

Malone explored why two games are enjoyable using within-subjects experiments by creating multiple different versions of each game. He constructed six versions of the popular game *Breakout* and eight versions of an educational game called *Darts*, varying whether or not certain features were included in the game. Based on this research, Malone developed a framework for intrinsically motivated instruction around three main themes: Challenge, Fantasy, and Curiosity.

Malone emphasized that players should be able to choose their own difficulty level, have multiple levels of goals, be presented with an optimal level of complexity, and that feedback should be both surprising and constructive.

Malone's Heuristics for Designing Educational Computer Games. Malone [14] presented several heuristics for how to make educational computer games fun, or how to make learning fun more broadly. He describes these heuristics as a general taxonomy of intrinsic motivation, organized around Challenge, Fantasy, and Curiosity.

For a game to be challenging, it must provide a goal, and players must be uncertain whether or not they will attain that goal, Malone wrote. Multiple levels of goals allows players of different skill levels to enjoy the same game. For example, having both a basic goal and a meta-goal of reaching the basic goal efficiently. Keeping score and time pressure or speeded responses can help provide multiple levels of goals. Performance feedback must be clear enough to present a challenge but presented in a way that minimizes self-esteem damage.

Malone defines Fantasy as showing or evoking images of physical objects or social situation that are not actually present. Intrinsic fantasy is where the player's actions and skills to take action are presented within the context of the fantasy world. Malone argued intrinsic fantasies are more interesting and educational than extrinsic fantasies.

Malone defined Curiosity as the motivation to learn. Games evoke curiosity by providing an optimal level of information complexity, so they are novel and surprising, but not completely incomprehensible. Sensory curiosity is a desire to experience changes or patterns of sensory stimuli. Cognitive curiosity is a desire to improve one's knowledge. Malone recommended using incompleteness, inconsistency, or unparsimoniousness to increase curiosity and motivate learners to learn.

A Measure of Enjoyment for Educational Games. Fu, Su, and Yu [15] extended Sweetser and Wyeth's [16] model of flow in games to create a measure of enjoyment for educational games. They added a Knowledge Improvement factor to the model, but dropped the Player Skills factor. To validate their measure, they asked 166 college students to complete their questionnaire after they played one of four educational games. Results showed the measure had adequate construct validity and reliability.

It may have been better if Fu, Su, and Yu had said more about the process they used to develop the model underlying their scale and the rationale for the content validity of their scale. Knowledge Improvement may be a desirable outcome, but it was not made clear why it would lead to enjoyment. It was also unclear why they dropped the Player Skills factor, since it seems distinct from Knowledge Improvement.

Using Computer Games in Psychological Research. Washburn [17] discussed the use of computer games as tools for psychological research. Washburn suggested that many of the cognitive tests that psychologists use are artificial, sterile, and too simple, and that game-like tasks can be more ecologically valid, complex, and enjoyable.

The drawbacks of game-based psychological research include programming demands, introducing unintended complexity, and appearing frivolous or less serious than other types of research. Washburn suggests using the term "game-like tasks" rather than computer games when applying for funding to describe serious cognitive and comparative research tests that use elements of computer games.

Washburn compared a cognitive task called the continuous performance task with the same task described as a star wars game to show that research using computer games leads to more motivation and better performance. Participants had significantly faster response times in the game-like condition than in the non-game condition, about 12% faster, with only 3% less accuracy (97% rather than 99% accuracy).

3.3 Flow

Flow is the psychological experience of overcoming optimally challenging obstacles for the sake of the enjoyment they provide.

User-System-Experience Model of Flow in Games. Cowley et al. [18] adapted Finneran and Zhang's [19] Person-Artefact-Task (PAT) model to understand entertainment and flow in games, proposing a User-System-Experience model. Basically, the User interacts with the System, and what results is the Experience. Cowley et al. did not present any original research to test the model they proposed, but reviewed how the existing literature fit with their proposed theory.

Flow in Media Enjoyment. Sherry [20] suggested that media enjoyment could be understood through flow theory. Sherry suggested that interpreting a movie or TV show could be understood as a task with an optimal level of the difficulty of that interpretation driving enjoyment of the media. However, no evidence was presented to support the idea that people watching passive entertainment experience flow, or that the challenge of interpretation is what makes watching movies or TV enjoyable.

Flow is only one route to enjoyment, but flow is distinct from relaxation because flow requires a high level of concentration on overcoming a series of challenging tasks [21]. Perhaps an expert interpreting a complex experimental film could be an optimally challenging task and therefore a source of flow. But passively watching film or television without trying to achieve a challenging goal is by definition a relaxing experience not a flow experience.

GameFlow Model of Player Enjoyment. Sweetser and Wyeth [16] proposed a model of player enjoyment built on flow theory, made up of 8 elements: concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction. They created a list of criteria for each element and used these criteria for expert evaluation of two games, one game with high ratings and one with low ratings from game reviewers.

Because these expert evaluations were conducted only once and by the researchers themselves, no measures of inter-rater agreement could be presented. Sweetser and Wyeth did not empirically validate either these criteria or their model of game enjoyment. Sweetser and Wyeth suggested that because the higher rated game was evaluated more highly on their list of criteria that was a meaningful method to validate their criteria. But since the two games being evaluated were chosen such that one was rated higher than the other by game reviewers, it seems like the researchers knew before they conducted the evaluations which game was rated higher. This lack of a blind evaluation by an independent rater may have biased their results.

As Sweetser and Wyeth pointed out, social interaction is an element of game enjoyment but is not a part of flow theory. They said they included it in their model because "it was highly featured in the literature on user-experience in games." They did not have a sound theoretical or empirical reason to include social interaction in a model of flow in games. It may have been more accurate to call it their model of game enjoyment.

Focus Group Explores Social Processes Leading to Group Flow in Social Gaming. Kaye and Bryce [22] conducted four focus group sessions with four or five people each to understand how playing video games with other people and the social interactions around that lead to group flow. Kaye and Bryce asked the groups about their motivations for playing games, their experience playing games in the presence of other players, and asked probing follow-up questions.

Kaye and Bryce identified several social processes that led to group flow during social gaming: collective competence, collaboration, task-relevant knowledge/skills, complimentary participation, being seen, social connectedness/belonging, social integration, and social networking.

While focus groups are often shunned as research methods that suffer from groupthink and social desirability bias, Kaye and Bryce's study shows that focus groups can be an effective tool for exploratory studies and group brainstorming to identify issues for further research. However, this kind of qualitative research only identifies, discovers, and describes phenomena. Further research is needed that would operationalize and measure the factors they identified and group flow to say with any certainty how these factors relate to group flow.

3.4 Immersion and Engagement

Immersion and Engagement may be thought of as synonymous with Flow, different theories about the same experience, or similar experiences with nuanced differences.

A Grounded Theory Study of Immersion. Brown and Cairns [23] did a grounded theory study of game immersion. They asked seven people who regularly play games to play their favorite game for thirty minutes and then participate in a semi-structured interview. They focused on what immersion and presence mean to the gamers, in their own words.

Brown and Cairns found three levels of immersion: engagement, engrossment, and total immersion. Each level of immersion had different barriers that needed to be overcome to achieve that level of immersion. The barriers to engagement were access to the game, time, effort, and attention. They defined attention as "willingness to concentrate" (p. 1299).

While engagement was about being willing to play the game at all, engrossment was about being emotionally invested in continuing to play the game. The barriers to engrossment were about "game construction", or the quality of the game. Game construction included the visuals, tasks, and plot of the game.

Each lower level of immersion must be reached before the next can be attempted. The next and final level of immersion Brown and Cairns found was total immersion, which they said was the same as presence. Their participants described total immersion as "being cut off from reality", being so detached from reality that "the game was all that mattered" (p. 1299). The barriers to presence were empathizing with the main character or team in the game and atmosphere, which they defined as having game features that were "relevant to the actions and location of the game characters" (*ibid.*).

Quantitative Experiments on Immersion. Jennett et al. [24] took a more quantitative approach to immersion in digital games. Through three experiments, they found that immersion could be measured subjectively through questionnaires and objectively through task completion time or eye movements. They also suggested that immersion was not always a positive experience, but could be accompanied by negative emotions as well. The dimensions of their questionnaire measure of immersion were basic attention, temporal dissociation, transportation, challenge, emotional involvement, and enjoyment.

Immersion in Video Game Stories. Qin et al. [25] developed a measure of the factors of computer game narrative that contribute to immersion in the story of the game. Drawing on previous research to generate items, they developed their questionnaire measure through exploratory and then confirmatory factor analysis. The dimensions in the final version of their measure were: Curiosity, Concentration, Challenge and Skills, Control, Comprehension, Empathy, and Familiarity.

While they attempted to sort these factors into antecedents to immersion, experience of immersion, and effects of immersion, it may have been useful for them to separate the factors by whether they are determined by the design of the game (artifact), the personality traits of the person playing the game (person), or the activity that the person is doing in the game (task). In other words, it may have been better if they had applied the Person-Artifact-Task model [19]. This may have made their work more useful for practitioners.

Literature Review on Engagement in Digital Games. Boyle, Connolly, Hainey, and Boyle [26] conducted a literature search on engagement in digital entertainment games. Their initial search captured 19,776 papers, but their review focused on fifty-five papers that were about engagement in digital games. Boyle et al. categorized the papers they reviewed by what aspect of engagement they focused on, such as the subjective experience or motives for playing, and the study design used, such as quasi-experimental, survey, or qualitative approaches.

The Game Engagement Questionnaire. Brockmyer et al. [27] used Rasch analysis to develop a measure how much individuals typically experience engagement when they play video games. This kind of measure uses items that ask whether the statement applies to their experience and allows participants to answer "Yes", "Sort of", or "No". After pilot studies with 17 children and then 213 middle school students to develop the content of the measure, they surveyed 153 junior high school students. The Rasch rating scale analysis they did sorted the items from most to least "difficult", with more difficult meaning participants were less likely to agree with the statements.

In their second study, Brockmyer et al. had 107 male undergraduate students fill out the questionnaire they developed and then play a game. After 25 min of gameplay, they played a recorded voice for 16 s asking three times if they dropped their keys, each time with increasing volume. The researchers videotaped how participants responded to the recording and coded how participants responded. Regression analysis showed that participants whose Game Engagement Questionnaire scores indicated they tend to get more engaged when they play video games were more likely to ignore the first time the recording asked if they dropped their keys than those whose scores indicated they tend to get less engaged when they play games. But these relationships were not found for the second or third time the recording asked if they dropped their keys. They wrote that how game players respond to hearing an initial statement may be most reflective of engagement. This was an interesting behavioral measure of player engagement, taking as an assumption that the more a person is experiencing engagement, the harder it will be to draw their attention away from the task at hand.

3.5 Challenge and Competition

An optimal level of challenge is one factor that leads to flow. When two players compete against each other, the skill-level of each player becomes the level of challenge for the other player. How do challenge and competition impact enjoyment?

Intrinsically Motivated Players Enjoy Challenges, Extrinsically Motivated Players Enjoy Winning. Abuhamdeh and Csikszentmihalyi [28] used hierarchical linear modeling with survey data from online chess players to show that people who had an intrinsic motivation orientation, meaning they were more motivated by intrinsic motivation, enjoyed more challenging games more than people who were more extrinsically motivated. People who are more extrinsically motivated are more driven by wanting to win the game than by enjoying overcoming challenges, so the easier the game is, the more they enjoyed it. The top quartile of intrinsically motivated people most enjoyed playing against more skilled players, while the bottom quartile on intrinsic motivation most enjoyed playing against less skilled players. Abuhamdeh and Csikszentmihalyi used chess rating as an objective measure of skill at playing chess based on the player's record of previous wins and losses. Relative chess rating was used as an objective measure of challenge or task difficulty, subtracting the player's chess rating from their opponent's chess rating for that game.

Playing Well Against Skilled Opponents Leads to Peak Enjoyment in Online Chess. Abuhamdeh and Csikszentmihalyi [29] studied the effect of optimal challenge on enjoyment in internet chess. Optimal challenge is a level of task difficulty that is not so high that it is overwhelming and not so low that it is boring. By looking at opponents' chess rankings, which are objective records of their past performance, they showed that an optimal level of challenge or task difficulty led to the highest ratings of enjoyment. Specifically, enjoyment was highest when players had a 20% chance of winning based on their opponents' higher chess ranking. They also found that enjoyment was highest when players performed about equally to their opponents. This suggests that playing against more skilled opponents and stretching your abilities to meet the challenge leads to the highest levels of enjoyment. This finding supports flow theory's notion that an optimal level of challenge leads to flow, and enjoyment is a part of the flow experience.

Balancing Outcome Uncertainty with Perceived Competence Maximizes Suspense and Enjoyment in Digital Games. Abuhamdeh, Csikszentmihalyi, and Jalal [30] investigated the impact of suspense and relative score on video game enjoyment. They found an inverted U-shaped relationship between relative score and enjoyment, with enjoyment being highest when participants were ahead of their opponent by 1.5 points. A similar relationship was found between relative score and suspense, with suspense being highest when players were behind their opponent by about 1 point.

Suspense mediated about 36% of the relationship between relative score and enjoyment. A linear relationship was found between relative score and perceived competence. So, a higher score led to higher perceived competence, but scoring higher than one's opponent lowered suspense. Combining these two sources of enjoyment, perceived competence and suspense, accounted for the relationship they found between relative score and enjoyment. Having a slightly higher score than one's opponent makes players feel skilled or competent while maintaining enough uncertainty about the outcome of the game to experience suspense.

Dynamic Difficulty Adjustment to Maintain Optimal Challenge in Video Games. Hunicke [31] created a dynamic difficulty algorithm to dynamically adjust the difficulty of a shooter game based on player performance. The algorithm looks at player health, expected player health based on a cumulative Gaussian distribution, and enemy damage to calculate how likely players are to die in the game. Then, the algorithm uses this information to adjust the difficulty of the game, such as by changing how much damage enemies do, changing enemy health points, or spawning health packs, ammunition, and weapons players can pick up in the game.

The algorithm Hunicke used attempted to keep player health at a mean of 60 with a standard deviation of 15. About every 3 s, the algorithm would decide whether or not to give players 15 health points. Participants were randomly assigned to play a version of the game with or without this adjustment. In the first 15 min of gameplay, players of the unadjusted version of the game died an average of 6.4 times, while players in the adjusted version died an average of 4 times. Perhaps because there were only had 20 participants, these results were not quite statistically significant ($t = 2.09$; $p = 0.0508$).

Hunicke measured player performance (deaths in the game), but did not measure player enjoyment or flow. It would have been interesting to find out if the dynamic difficulty adjustment version of the game led to higher ratings of player enjoyment.

Optimal Challenge Does Not Mean Medium Difficulty Settings. Klimmt et al. [32] conducted an experiment where participants were randomly assigned to play a First-Person Shooter game on either easy, medium, or very hard difficulty settings. Seventy-four participants played for 10 min and filled out a questionnaire.

Participants who played the game on easier difficulty settings reported significantly more enjoyment. Klimmt et al. claimed that these results were not in line with flow theory and attribution theory, which they interpreted as suggesting a medium level of difficulty would lead to the most enjoyment. However, flow theory does not suggest a medium difficulty setting on a game leads to the most enjoyment. Flow theory suggests that an optimal level of challenge will lead to the most enjoyment, a level of challenge that stretches player skills without overwhelming them. Another way to interpret these results is that participants tended to find the easy mode of this game's three difficulty settings to be closest to their optimal level of difficulty, so as the difficulty increased above that optimal level, their enjoyment decreased. So, their results are fully in line with flow theory's notion of optimal challenge.

In their discussion, Klimmt et al. admit that their results may have been "a misinterpretation of objective difficulty levels", and that players may have found the easy setting "actually challenging". Optimal challenge is about subjective perceptions of challenge and skill being balanced and high, not objective difficulty. If someone is first learning to play the game or considers themselves not very skilled, they will find a low challenge level optimally challenging. As perceived skills improve with practice, the optimal difficulty level may increase. This study highlights the difference between optimal challenge in flow theory and a medium difficulty setting on a game.

Competition and Its Impact on Video Game Enjoyment. Vorderer, Hartmann, and Klimmt [33] investigated the impact of competition on video game enjoyment. They defined competition as having an opportunity and necessity to act that affects the subsequent situation. This definition included competing with challenges presented in single-player games and controlled with artificial intelligence. It seems they conflated competition with challenge or task difficulty. In their methods section they called this construct "many possibilities to act and a strong necessity to act (i.e., a challenging/competitive element)" (p. 3).

In a field experiment, one of four hypothetical scenarios were presented to each participant. In the scenarios, the character either had many or few weapons, which manipulated the possibilities to act, and either there were monsters suddenly attacking or no monsters were mentioned, which manipulated the necessity to act. Participants rated the hypothetical situation on a measure of expected enjoyment using Likert scales. Participants rated their expected enjoyment higher when there was a high possibility to act and a necessity to act. However, expected enjoyment of hypothetical scenarios may not generalize at all to actual player experiences and behavior while playing actual video games. Asking about recent past experiences would have been better than asking for speculation about their future expected enjoyment.

3.6 Player Experience of Need Satisfaction and Self Determination Theory

Player Experience of Need Satisfaction (PENS). Ryan, Rigby, and Przybylski [34] developed a model of what motivates people to play digital games and leads to digital game enjoyment based on Deci and Ryan's [35, 36] Self-Determination Theory (SDT). SDT says fulfilling psychological needs for autonomy, competence, and relatedness leads to intrinsic motivation. Autonomy is feeling in control or feeling your actions are freely chosen. Competence is feeling skilled at what you are doing. Relatedness is social belonging and social connectedness.
The Player Experience of Need Satisfaction (PENS) model Ryan et al. proposed includes the three needs of SDT but adds Intuitive Controls and Presence. Intuitive Controls are how user-friendly the controls of the game are, or how easy the controls the player uses to interact with the game are to learn, make sense of, and master. Presence is about feeling like you are actually there in the game, physically, emotionally, and within the narrative of the game.

Ryan et al. presented four studies showing empirical support for the PENS model. The first three studies asked participants to play games from different genres and then fill out a questionnaire. The four study surveyed previous experiences playing massively-multiplayer online games. Results from analyses including repeated measures ANOVA and Hierarchical Linear Modeling supported the PENS model.

Motivational Model of Video Game Engagement. Przybylski et al. [37] described the theory behind the Player Experience of Need Satisfaction (PENS) model. As with Ryan et al. [34], they suggested that fulfilling psychological needs for competence, autonomy, and relatedness motivated people to play video games.

Przybylski et al. discussed research they have conducted suggesting that fulfilling these psychological needs was a better predictor of game enjoyment than violent content. They also discussed their studies distinguishing between having to play versus wanting to play. Their research suggested that people who had their basic psychological needs for autonomy, competence, and relatedness satisfied in their daily life tend to experience more choice about their engagement in video games. They called this distinction between having to play versus wanting to play "harmonious passion" versus "obsessive passion".

Media Enjoyment as Need Satisfaction. Tamborini et al. [38] validated and extended the Player Experience of Need Satisfaction (PENS) model [34]. They conducted a 2×2 between-subjects experiment with a bowling game varying whether players used a traditional controller or a Nintendo Wii motion controller and varying whether they were playing against a human or a computer.

Their proposed model explained 51% of the variance they found in their results. They extended PENS by including Perceived Game Skill as a factor contributing to Autonomy. They argued that players with high game skill would feel more volition in the game, giving them more opportunity to satisfy their autonomy needs. They could have made it more clear how Perceived Game Skill was distinct from Competence, since Competence is basically the experience of feeling skilled.

Experiment Shows Impact of Autonomy and Competence in Exercise Games. Peng et al. [39] conducted a 2×2 experiment manipulating the presence or absence of game features to support autonomy and competence in an exercise game.

The autonomy-supportive features allowed players to customize character appearance, to choose how their character becomes more powerful (hit points, speed, or damage) as they progress through the game, and to choose between a variety of dialog options when speaking with non-player characters. The competence-supportive features included dynamic difficulty adjustment that makes the game easier or harder based on player performance, a heroism meter to give players feedback, and being able to earn achievement badges viewable in an achievement menu.

Each participant played one of the four versions of the game. Participants played the game for 15 min in a lab and then filled out an online questionnaire.

Participant ratings of enjoyment, motivation to play the game in the future, likelihood to recommend the game to others, and their rating of the game were significantly higher when the autonomy-supportive and competence-supportive features were present than when they were absent. They tested these differences with a two-way ANCOVA, controlling for gender and hours of gaming per month.

3.7 Motivations to Play Games

Motivations to Play Online Role-Playing Games. Yee [40] created a model of what motivates people to play online role-playing games. The model had 10 sub-components sorted into 3 main components: Achievement, Social, and Immersion. Achievement was made up of Advancement, Mechanics, and Competition. Social consisted of Socializing, Relationship, and Teamwork. Immersion was made up of Discovery, Role-Playing, Customization, and Escapism.
To develop this model, Yee created a 40-question survey using 5-point Likert-type scales based on Bartle's [41] four player types of achiever, socializer, killer, and explorer. Yee's survey was also based on qualitative information from earlier surveys of online role-playing game players. The results of this 40-item survey were analyzed with exploratory factor analysis using oblique rotation to develop Yee's ten-component model. Running exploratory factor analysis a second time on these ten components was done to group the components together, resulting in the three main components of Achievement, Social, and Immersion.

Bartle's model of player motivations, which he called player types, was generated by dividing up what players do in online games into acting and interacting on other players and the world. Achievers act on the world, socializers interact with other players, etc. This was a purely theoretical construction, not based on research with actual game players. Because Yee started with Bartle's model, and Bartle's model was theoretical and not based on research, Yee's model may be incomplete, lacking in content validity, or not as conceptually comprehensive as it could have been. Yee noted that earlier qualitative surveys influenced the development of this survey, but did not explain how this earlier research influenced survey item generation.

Demographics and Motivations to Play Online Games. Yee [42] used an online survey of 30,000 online game players to explore the demographics, motivations and experience of players of massively-multiplayer online role-playing games (MMORPGs). Yee found a wide range of ages play these games, and that motivation to play was strong across ages (hours of play per week correlated with age at $r = -.04$).

Yee created a questionnaire of motivations to play MMORPGs based on qualitative data from open-ended online survey items, from online forum discussions, and from Bartle's [41] player types. Exploratory Factor Analysis of online survey responses to this questionnaire found eight factors: Relationship, Manipulation, Immersion, Escapism, Achievement, Lead, Learn, and Solo/Group.

As with Yee's [40] other article published the same year, the items that went into this analysis may not have captured the full range of motivations to play games. Bartle's [41] player types were theoretical and not based on research with actual game players. Yee's findings about MMORPGs may not generalize beyond MMORPGs.

Motivations to Play Predict Actual Behavior in World of Warcraft. Billieux et al. [43] surveyed 690 *World of Warcraft* players, focusing on their motivations for playing the game, and then tracked their in-game behavior for 8 months through the game's official database. To measure motivations to play the MMORPG, they used Yee's [40] measure developed for that purpose. Billieux et al. found that several motivations predicted actual in-game behaviors. For example, the more players were motivated by Advancement, Mechanics, Competition, Escapism, Relationship, or Customization, the more hours per week they played the game, with each showing a statistically significant correlation (r ranging from .18 to .37; $p < 0.00028$).

Understanding Why People Play Online Games with the Theory of Planned Behavior. Lee [44] used structural equation modeling with survey data to compare two competing theories of what makes people want to play online games: the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM). Using multi-group causal analysis, Lee found that the TPB model better explained the data that they collected than the TAM model.

Their results showed that Perceived Usefulness (PU) in the TAM model did not significantly predict Perceived Ease of Use, Attitude, or Intention. This seems like a fairly obvious result, that people do not play online games because playing them is useful.

What was more interesting about this study was how Lee integrated flow theory, enjoyment, usability (which they called Human-Computer Interaction), and the Theory of Planned Behavior to make sense of and predict what makes people want to play online games. To summarize some of the paths in Lee's research model, Human-Computer Interaction and Social Interaction contribute to Flow Experience, which in turn contributes to Attitude and Intention, Attitude contributes to Intention, and Intention contributes to Behavior. Each path in the model was statistically significant.

Motivations to Continue Playing Online Games in Korea. Choi and Kim [45] proposed and tested a model of why people continue to play 16 online games in the Korean market. They proposed that interaction with the system (Personal Interaction) and interaction with other players (Social Interaction) lead to optimal experience or flow, which in turn leads to customer loyalty, or an intention to play the game again in the future. They said three elements of the system design contribute to personal interaction: goal, operation, and feedback. The operation is about the instruments that players can use to help them achieve their goal. Communication Place and Communication Tools contribute to Social Interaction. Communication Place refers to the virtual world where players can gather together. The results of their SEM analysis using LISREL supported their proposed model that Personal and Social Interaction contribute to Optimal Experience or Flow, and that Optimal Experience or Flow in turn contributes to Customer Loyalty.

Motivations to Play Arcade Games in 1985: Mastery and Competition. Morlock, Yando, and Nigolean [46] surveyed 117 university students, asking them about what motivated them to play arcade video games. They found that those who played games frequently were motivated to compete with others and to master the games.

Top 3 Reasons Scottish University Students Play Games: Challenge, Curiosity, and Fantasy. Hainey et al. [47] surveyed 2226 Scottish university students about their computer game playing habits and their reasons for playing games. To assess their reasons for playing games, participants were given descriptions of each part of Malone and Lepper's [48] framework and asked to rate how important each part was for them. The framework included challenge, fantasy, curiosity, control, cooperation, competition, and recognition. Challenge, Curiosity, and Fantasy were the three most important reasons participants gave for why they played computer games, while Competition and Recognition were least important.

Hainey et al. also asked participants, “If you had the opportunity to use computer games for learning in your programme at University, how would you rate each of the following reasons in terms of importance in learning?” Challenge, curiosity, and cooperation were the most important reasons to play computer games in higher education to those surveyed, while recognition and fantasy were least important.

Limiting the reasons for playing games to Malone and Lepper’s framework may have limited the range of responses participants were able to express in this study. It may have been better to ask an open-ended question to elicit other reasons participants play games.

The Playful Experience (PLEX) Framework Supported by Interview Data. Korhonen et al. [49] interviewed 13 video game players to develop an initial framework of playful experiences. They drew on previous research to generate a pool of experiences, pleasures, emotions, elements of play, and reasons people play games. Then they interviewed players of three games: *Grand Theft Auto IV, The Sims 2,* and *Spore*. They coded the transcripts from the interviews with their playful experiences framework. They found that all of the categories in their framework were mentioned by players of at least two of the three games that were played. The categories in their framework were: Captivation, Challenge, Competition, Completion, Control, Discovery, Eroticism, Exploration, Expression, Fantasy, Fellowship, Nurture, Relaxation, Sadism, Sensation, Simulation, Subversion, Sympathy, and Thrill.

Korhonen et al. pointed out that their framework is not fully comprehensive and suggested some additional categories they had under consideration: disgust, humor, cuteness, identification, and tragedy. There is some subjectivity in the coding of interview data, and a risk of confirmation bias if the interviewers know the categories. It may have been better if they had used a more bottom-up approach to generate their initial categories and had used more than one coder so they could present inter-rater reliability statistics for the coding of the interview transcripts.

Children’s Motivations to Play Video Games. Olson [50] surveyed 1,254 middle school children to evaluate what motivates them to play video games. The top three reasons female students agreed with for why they play electronic games were “it’s just fun”, “like to compete w/others & win”, and “challenge of figuring things out”. The top three reasons male students agreed with were “it’s just fun”, “something to do when bored”, and “challenge of figuring things out”.

Olson could have said more about how they came up with the reasons they used in their survey. In particular, “it’s just fun” does not tell us much about why it is fun. It creates circular logic: it is fun because it is fun.

Motivations to Play First-Person Shooter Games. Jansz and Tanis [51] did an online survey of 751 Dutch people on what motivates them to play First-Person Shooter (FPS) games. Respondents were asked whether or not they were part of an online group that play together, and if they were in an amateur or professional group. Professional players were significantly more likely to be motivated by

Competition and Challenge than the other groups. Players who were a part of a group were significantly more likely to be motivated by Social Interaction than non-group members.

Jansz and Tanis could have said more about how they chose the motivations they measured. In particular, Enjoyment seems too broad to be included as a motivation.

Motivations to Play Social Network Games. Lee, Lee, and Choi [52] surveyed 324 US college students about why they play social network games. Factor analysis of the survey data revealed six motivations: passing time/escapism, entertainment, challenge/competition, self-presentation, fantasy/role playing, and social interaction.

Lee, Lee, and Choi explored the relationship between these motivations and behavioral intentions such as an intention to play social network games, to visit friends to play the games, to send friends gifts in the games, and to purchase virtual goods. Different motives predicted different behavioral intentions. For example, being motivated by Self-Presentation significantly predicted intention to purchase virtual currencies or goods in social networking games.

Hedonic Motivation Systems Model. Lowry et al. [53] proposed a model of hedonic-motivation systems (HMS), systems used for pleasure rather than productivity. The final structural equation model they presented shows Perceived Ease of Use contributing to Perceived Usefulness, Curiosity, Joy, and Control; Perceived Usefulness, Curiosity, and Joy in turn predict Behavioral Intention to Use, while Curiosity, Joy, and Control predict Immersion.

Usefulness is a holdover from the study of productivity applications. This part of the Technology Acceptance Model may not generalize to games for entertainment. The constructs in the HMS model were not specific enough to be useful for design. It is unclear how one would design for usefulness or if usefulness is important to game players. Curiosity was defined as experiences that arouse sensory and cognitive curiosity, but it was not made clear what those experiences were.

3.8 Games User Research Methods

Heuristics to Evaluate the Playability of Games. Desurvire et al. [54] did a heuristic evaluation of a game prototype and a user study of the same prototype with 4 participants, and compared the results from the two methods. They found that the heuristic evaluation found more issues than the user study, but that the issues found in the user study were more specific to the game being studied, its interface, terminology, characters, and wording.

Desurvire et al. suggested that heuristic evaluation may be most useful in the early stages of game development before the prototype allows much interactivity. They suggested heuristic evaluation be used along with rather than instead of user testing.

Playtest Method for Assessing Player Perceptions. Davis, Steury, and Pagulayan [55] introduced the playtest method for assessing player perceptions of digital games as a formative research method to improve game designs. The playtest method combines surveys with playing the game in a controlled lab environment. Participants play the first hour of the game and then fill out a questionnaire to rate the overall fun, graphics, controls, sound, story (if the game has a story), and other elements of the game. These questionnaires include not only Likert-type rating scales, but also open-ended questions to understand the reasons participants have for the ratings they gave.

They recommend 25–35 participants for the playtest method. This sample size was based on a power analysis of the statistical tests used in their previous research. Having a larger sample size than typical usability tests allows for comparisons between groups, such as between different versions of the same game or between their game and a similar game from a competing company. Playtests allow for statistically significant comparisons of player perceptions across groups, perceptions informed by the first-hand experience of playing the game in a controlled lab environment.

Intrinsic Skill Atoms as a Lens for Gameful Design. Deterding [56] presented a method for gameful design or gamification he called the lens of intrinsic skill atoms. This involves identifying the inherent, skill-based challenges of the activity, removing extraneous challenges through automation or improving usability, and then restructuring the remaining inherent challenges into nested, interlinked feedback loops of goals, actions, objects, rules, and feedback that create motivating experiences.

The skill atom is a feedback loop between user and system that users engage in to overcome a challenge using their skills. Deterding defined the rules of the system to mean the actions that users can take and how those actions affect the system state.

Deterding then presented these steps for gameful design: (1) strategy, (2) research, (3) synthesis, (4) ideation, and (5) iterative prototyping. Deterding described two case studies applying the lens of intrinsic skill atoms method. For each case study, Deterding described how each of the five steps of gameful design were done. The first case study was a project for a European online dating platform focused more on ideation, and the second was for an online social network that focused more on evaluation.

3.9 Game Design

The Mechanics, Dynamics, and Aesthetics (MDA) Framework. Hunicke, LeBlanc, and Zubek [57] presented a conceptual framework for understanding games they called the MDA framework, standing for Mechanics, Dynamics, and Aesthetics.
Mechanics are all actions players can take within the game and all components of the game, such as algorithms and data. The Mechanics along with the content of the game such as the levels and assets support gameplay Dynamics. The Dynamics are how the Mechanics respond to player actions and other events over time. The Aesthetics are the desirable emotional responses players have when interacting with the game. Hunicke et al. presented the following taxonomy of 8 game aesthetics: Sensation, Fantasy, Narrative, Challenge, Fellowship, Discovery, Expression, and Submission. They emphasized that Aesthetics includes but is not limited to this taxonomy.

MDA is a conceptual model to bridge the gap between the mechanics and interactive systems of games and the emotional experience of players. Hunicke et al. did not present empirical research to support this model. Instead, they gave an example of how the MDA model could be applied to game design. They discussed three iterations of a game design, each with different target audiences. For each iteration, they described the Aesthetics, Dynamics, and Mechanics they would consider.

3.10 Game Player Demographics

Griffiths et al. [58], Williams et al. [59], and Griffiths and Hunt [60] surveyed game players, and found that people who play games are diverse along dimensions such as age and gender. Williams et al. found a median average age of 31 years-old compared to a median age of 35.4 years-old among the general population. 42% of those Griffiths and Hunt surveyed were female. The Entertainment Software Association releases annual reports showing a similar trend towards diversity among players [61].

3.11 Game Addiction

Wanting to Play Versus Having to Play Video Games. Przybylski et al. [62] integrated Self-Determination Theory and a two-factor model of passion. The two-factor model of passion distinguishes between harmonious passion, which is wanting to play the game, and obsessive passion, which is feeling like you have to play. Participants were surveyed about a favorite video game they had played for at least one month. Hierarchical regression modeling of the survey data showed that trait need satisfaction – people feeling that their basic psychological needs for autonomy, competence, and relatedness were met – was positively associated with harmonious passion, and negatively associated with obsessive passion. So, players whose basic psychological needs were already met were more likely to play games because they wanted to rather than because they felt that they had to or were compelled to play.

Harmonious passion was associated with enjoyment, but not hours per week of play. Obsessive passion was associated with more hours per week of play, higher tension, and less game enjoyment. This study demonstrated that video game enjoyment driven by intrinsic motivation and wanting to play is a distinct phenomenon from compulsive or disordered video game play driven by feeling like one has to play.

Designing Digital Gambling Machines to Maximize Profit. Schull [63] describes an ethnographic study in Las Vegas of people playing digital gambling machines, and the designers of those games. Schull discussed how changes in the design of these games has led to more rapid extraction of money from players and led to players feeling a deeper sense of immersion or flow. For example, changing from a pull-handle to push-button machines allows players to rest their hand on the button, doubling the rate of play from 300 to 600 games per hour. The core of what makes gambling machines effective are random number generators that determine wins and losses, using a pattern B.F. Skinner called a variable intermittent ratio reinforcement schedule.

Several elements of digital gambling machines get players “in the zone”: being alone, not being interrupted, speed, choice, and tempo. Schull used quotes from player interviews as evidence for each of these elements.

It would have been better if Schull had differentiated between gambling and gameplay. Perhaps having money at stake makes the game more addictive, while an engaging game design leads to flow and enjoyment even without gambling money.

User-Experience Design Factors That Predict Addiction to MMORPGs. Hsu, Wen, and Wu [64] developed a questionnaire measure of user-experience design factors they hypothesized would predict addiction to MMORPGs. 418 Taiwanese college students responded to the measure online along with a previously-validated questionnaire measure of game addiction. Regression analysis showed that Role-Playing, Belonging, Reward, Obligation, and Curiosity predicted addiction to MMORPGs.

3.12 Violence in Games

Autonomy and Competence Predict Enjoyment Better than Violent Content. Przybylski et al. [65] conducted an online survey and two lab studies. Multiple linear regression analysis of the survey data showed that how much the games fulfilled players' psychological needs for autonomy and competence explained more of the variance in enjoyment, presence, interest in playing a sequel to the game, and recommending the game to others than how violent the games were.
In their third study, participants were randomly assigned to play either a violent or non-violent game for twenty minutes and fill out a questionnaire. In-game autonomy and competence explained much of the variance in enjoyment, presence, and desire to play the game in the future. Players with high trait aggression who played the violent game were more likely to want to play the game again in the future.

The Impact of Moral Disengagement Cues on the Emotional Experience of Violent Video Gameplay. Hartmann and Vorderer [66] conducted experiments on how moral justification and consequences impact the emotional experience of playing a first-person shooter game. In the morally justified condition, players were UN soldiers attacking a torture camp to restore humanity, while in the morally unjustified condition players were paramilitary forces in the torture camp continuing to torture and defend the torture camp. When players shot opponents in the consequences condition, blood was shed and dying characters screamed and fell to the ground. In the lack-of-consequences condition, a "ping" sound played and characters vanished.

Fighting for a just cause led to significantly less guilt and negative affect, but not significantly more enjoyment, than fighting for a morally unjustified cause. Enjoyment was higher when consequences were shown in the just condition, but higher when consequences were not shown in the unjust condition. Players who thought it was "just a game" reported significantly less guilt.

Technological Advancement in Video Games Increases Player Involvement, Arousal, and Presence. Ivory and Kalyanaraman [67] conducted a an experiment on the impact of technological advancement and violent content on physiological arousal and questionnaire measures of arousal, presence, involvement, and aggression. Playing newer games resulted in more presence, involvement, physiological arousal, and excitement than playing older games. No significant differences were found between the experience of players of the violent and non-violent games.

4 Conclusion

For those who wish to design interactive systems for user enjoyment and intrinsic motivation, the literature reviewed above is a good starting point. More empirical research must be done on the sources, uses, and benefits of digital game enjoyment.

Qualitative research is needed to discover design differences and other factors that lead to enjoyment. For example, a recent card sorting study identified 32 sources of enjoyment in digital games [68]. Quantitative research is needed to understand how these factors influence and relate to each other. Controlled experiments are needed to operationalize the sources of enjoyment into concrete design differences and to establish causal links between factors. For example, controlled experiments can test the causal links between sources of enjoyment and enjoyment, and between enjoyment and the benefits of enjoyment or the desired outcomes associated with serious games such as learning, persuasion, or behavioral outcomes.

There is much research to be done to build a science of digital game enjoyment that can be used to reliably engineer enjoyable experiences.

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Social Spending: An Empirical Study on Peer Pressure and Player Spending in Games

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Abstract. This study explores the relationship between a player's spending habits and peer pressure with regards to optional purchases in online multiplayer games. We hypothesized that there is a positive correlation between player spending and the number of friends the player has playing the same game. The study was conducted via a survey, collecting the information on spending habits the size of their friend lists other relevant data. We concluded that there could be a positive correlation between player spending and peer pressure in modern Multiplayer Online Battle Arena and team-based First-Person Shooter games, but more research is required, as there were limiting factors to this study. The games used in this study were *League of Legends*, *Defense of the Ancients 2*, *Team Fortress 2*, and *Overwatch*. The findings can potentially be used to design games that encourage more playing with friends and family to increase per player revenue.

Keywords: Computer games · Digital games/online games · Player personality · Characteristics and demographics · Profit · Peer pressure · Per player spending

1 Background

Modern day games have many ways to generate revenue. However, there are very few sources of research to determine how exactly one can increase the effective profitability of their games. The goal of this study was to find if there is a relationship between the level of social engagement of players and the amount of money the players spend on purchasing in-game content.

Multiplayer Online Battle Arena (MOBA) is a genre of games that originated from a subgenre of real-time strategy games in which a player controls a character in one of two teams with the aim of defeating the enemy team, usually through player-vs-player combat.

Frederiksen [5] surveyed players and looked at the reasons why players buy skins in MOBA for the MOBA game *League of Legends*. Frederiksen found that players who play more with real friends bought virtual items more frequently and spent more on virtual items. Frederiksen also found that attention craving has a positive effect on the frequency and the amount of money spent on virtual items in freemium MOBA games. Frederiksen established that this is related to the peer pressure factors this study

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explores as this indicates that players want to express themselves and there may be a larger motivation when the player can express themselves with their friends instead of anonymous individuals.

Although our work explores Frederiksen's [5] third, fourth and eighth hypotheses on a smaller scale, our main focus is finding the correlation between peer pressure and player spending, instead of finding the reasons why players spend money on games in general.

Hsu and Lu [10] conducted a survey on flow experience, social influences and player retention in games where they explore social norms as a factor. Their findings concluded that people play online games due to *critical mass* - a predetermined amount of other people playing the game set by the player. The study also found that social norms and flow experience had an influence on the general acceptance of playing video games. However, this work does not consider social factors in explaining information technology (IT) usage. This study addresses social factors in order to create a more holistic picture of social influences in adoption and retention for games.

Shin and Shin [16] conducted a survey study on pre-existing expectations and their influences on playing games. The study explores the internal influences on why people play and pay for social network games. Our work adopts many elements of the survey design, which is using similar methods to collect data and accounting for the same background variables that may influence the results. Also, in our work, we apply the survey design into gathering data on external influences on why people pay for games.

Musabirov et al. [15] explored player experiences related to cosmetic items in *Defense of the Ancients 2 (DOTA2)* via collecting community discussion data from Reddit.com, a social news and discussion website. Their findings concluded that the e-sports aspects of the game heavily influenced the collecting practices of the players. The main factors found to have the most influence on a player's collecting were rarity of the item, brand recognition, perceived aesthetic value, and authenticity of the item. Authenticity was a factor, because a pro-player's autograph could be added onto a character in game for aesthetic purposes. Our work also investigates *DOTA2* and player collecting, but we look at how much the social factors influence player spending.

Toups et al. [17] explored the collecting behaviours of players in digital games concerning in-game and meta-game collecting. They identified 10 possible factors as to why players would collect anything in a game. They concluded that in-game collections were more valued than meta-game collections, especially in-game collectables that influenced the game's mechanics. Our work explores whether peer influence has any factor on player collecting, a factor that was only briefly considered in this study.

In Guo and Barnes's [7] work on player purchase behaviour in virtual worlds via *Second Life*, additional variables in player purchase behaviours were identified when the players had the ability to communicate with other players. In their case, *Second Life* was a game that had messaging channels for trade and other non-trade channels. Their findings created a theoretical model that included intrinsic, extrinsic, and social influences that predicted player purchase patterns with 45% accuracy. Our work explores how much weight social influence have on an individual's purchase behaviours in online games.

Guo et al. [6] developed a topic model, Latent Dirichlet Allocation, to take in a multitude of text information, such as discussion threads and documents. The model then produces a list of topics, determined by the frequency of those words appearing in each document. This allows to user to sort the text into topics relating to their research topic. Guo and Barnes [8] also developed a new model to predict player intent on purchasing virtual content with real world money. Their model uses a combination of past models and theories, which include the Technology Acceptance Model, Theory of Planned Behaviour, Theory of Reasoned Action, Web Trust Model, and Unified Theory of Acceptance and Use of Technology. They considered aspects of each model and narrowed down to 10 specific factors that influence player purchase behaviour. However, their work is preliminary and therefore lacks weighting or empirical data to prove the accuracy and reliability of the model. Our work attempts to measure how heavily the "social influence" factor in such models affects purchase behaviours.

Bartle [2] discusses the reasons why, in recent years, has the Massively Multiplayer Online Game (MMOG) genre has seen a steady decline in players. In his work, he mentions that one of the causes is due to a player type imbalance between the four basic player types of *achievers*, *killers*, *socializers*, and *explorers*. Our work focuses on how the industry can add additional social tools to their games to increase the appeal to social gamers (socializers).

Livingston et al. [13] studied why players gave value to their characters in the game *World of Warcraft*. They identified nine different ways in which a player values their characters. Two of those values were *sociability* and *social communication*. Sociability, in this work, is defined as the ability to communicate with other players. Social communication is a value derived from accomplishment and social recognition of those accomplishments. One of the factors we recognized was the ability for players to express their self-images through the game.

Ducheneaut et al. [4] explored how MMOGs were over-estimated in their prevalence in social activities. Using *World of Warcraft*'s longitudinal data, they concluded that MMOGs mostly provided shallow amounts of social engagement, such as finding teammates to complete a mission. However, their finding did reveal an exception to guilds when each of the players' levels are within a small range. This study leads us to believe, and eventually, test how those in a small community, like guilds, may influence a player's purchasing habits, as the player would value the opinions of their guildmates more strongly than the rest of the player population.

Kim et al. [11] investigated the purchase behaviours of members in social networking communities (SNCs). They analysed Cyworld, an SNC, using Customer Value Theory as a base to develop a conceptual framework of customer values in SNCs. The three general dimensions of model consisted of functional, emotional, and social value. Our work over lapses their work in evaluating consumer purchase intent, but in the context of games as opposed to SNCs with a focus in the social values of the players.

Lenhart et al. [12] looked at the gaming habits of teenagers and civic activities. In their work, they state that half of all teenagers who play online games, play with other players they know offline. Our work uses games that have teenagers as their target audience. Therefore, we can use the information from Lenhart to make assumptions on player gaming habits.

Alha et al. [1] studied player opinions of the free-to-play model of video games. They interviewed 14 game professionals to understand the general attitude and ethical problems with the free-to-play model. Overall opinions varied, but the general attitude towards this model was positive. In our study we use games from both the retail and free-to-play models of revenue. If there was a large bias towards one model, then our results may have been skewed and affected our conclusions.

Hamari et al. [9] investigated the reasons why players purchase in-game content. They explored six possible factors that might have been the underlying reasons. Unobstructed Play, Social Interaction, Economical Reasoning were the three factors found to be positively associated with player spending. One of the reasons for the choice of our games is their lack in obstruction of play: the purchased content is purely for aesthetic purposes. Therefore, going by Hamari's model, we can assume social interaction to be the main factor in player purchase behaviours.

Westerlund and Baxter [18] investigated the opinions of professional players of *DOTA2* and *Team Fortress 2* on the cosmetic items available in these games. They interviewed 10 professional players, five from each game, and categorized their comments into four main categories: Aesthetics, Identity, Perception, and Economy. For the majority of the findings, they were consistent with earlier research, namely that the items are obtained for self-expression. In this work, however, two players noted how some of the cosmetic items have high or low contrast to the background environment of the games, which may make the player using the cosmetic item "*distracting and hide other important elements"* or make it harder to pick up on visual cues. However, Westerlund and Baxter investigated the cosmetic items of the two games and did not find an item that fulfilled the criteria. This is an important finding, as many of our participants were surveyed during a gaming event, which implies more competitive players than the average sample. If cosmetic items did have an impact on gameplay, players might have chosen to purchase the cosmetic items for a competitive advantage over their peers.

Yamamoto and McArthur [19] discuss how players value virtual cosmetic items in a marketplace where players can sell or buy these cosmetic items from other players. They used *Counter Strike: Global Offensive* as their study game, which has a key and crate system similar to *Overwatch* and *League of Legends*. Based on their findings, the two main factors that determine an item's value are the supply and demand of the item and the overall design of the cosmetic item. These findings add on to the findings of Kim et al. [11], to create a more holistic model of the factors that influence a player's purchasing patterns, in the context of virtual items.

Minchev and Schmitt [14] interviewed 12 players of *League of Legends* to find why players purchase virtual cosmetic items. Their findings conclude that "personal satisfaction" was the most important factor in purchasing the cosmetic items available in the game. However, Minchev and Schmitt state that social and pragmatic factors are less influential than previously thought.

2 Research Hypothesis

In this work, we explore the following research hypotheses:

- **H1**: Players' in-game spending is positively correlated with the size of the group the player regularly plays with.
- **H2**: Player's in-game spending is positively correlated to the number of friends, related to the player, playing the same game.

3 Methodology

We collected the data using an online survey. The survey was completed by the students at the University of Ontario Institute of Technology (UOIT). The questionnaire was designed around the following games:

- *Overwatch* by Blizzard Entertainment Inc.
- *Team Fortress 2* by Valve Corporation.
- *League of Legends* by Riot Games
- *Defense of the Ancients 2* by Valve Corporation.

We chose these games due to the similarities in their mechanics, and play styles to their "twin" game, pairing *Overwatch* with *Team Fortress 2 (TF2)* and *League of Legends (LoL)* with *DOTA2*. *Overwatch* and *TF2* are both first person shooter (FPS) games with a focus on team-oriented play and different classes of characters. *LoL* and *DOTA2* are the leading games in the MOBA genre by player count and both are currently investing into the competitive e-sports scene.

In the survey, the participants were asked questions about their gender, occupation and education status, the relationships to the people they play with, number of friends on their friend lists, time spent playing the game in question in relation to player spending, total time invested playing the game, and time invested in the game in the past month. All these measurements were recorded on a Likert scale. Age, average player group size and average number of people the player plays a game session with were measured using a ratio scale.

In the first iteration of the survey participants were asked to rate *closeness* to their groups on a Likert scale of 1 to 5, 1 being "not close at all" and 5 being "very close relationship". However, pilot testing revealed that it was confusing to most participants and therefore we changed the question's format to multiple choice.

Participants were encouraged, but were not required, to consult their purchase history of the respective game to get the most accurate information about their spending. At the time of the study, this was achieved via "privacy.riotgames.com" for *LoL*, "battle.net" account history for *Overwatch*, and the available Steam client for *DOTA2* and *TF2*.

Data was collected via social media, at large gaming events, during undergraduate lectures, and word of mouth.

Participants were also asked for their yearly income, in order to control for disposable income as an influence on the findings.

The calculations based on the data collection are as follows:

- Average player's spending per month vs. average group size
- Average player's spending per month vs. player's friend list size

From the data and calculations, we were able to determine whether there is any correlation between player's spending with per session average group size or player's friends list size. The detailed findings are revealing in the conclusions section.

4 Survey Design

1. Participants were initially asked about their enrollment at the University of Ontario Institute of Technology: part-time, full-time, or not affiliated with the university. Unaffiliated participants were directed to the end of the survey. Their data was not collected.
2. Participants were then asked if they played the game and if they did, how often they played the game per week. Answer options were as follows (in hours):
   a. N/A – I don't play the game
   b. Less than 3
   c. 3–6
   d. 6–9
   e. 9+
3. Participants then were asked if the following applied to them, with regards to the game:
   a. I enjoy playing the game.
   b. I can connect emotionally with other games in this game.
   c. I have made friends through this game.
   d. I regularly invite people I met online to a game with me.
   e. I regularly invite In-Real-Life (IRL) friends to a game with me.
   f. I regularly invite family members to play a game with me.
4. Participants were then asked for their average group size when playing the game, with possible answers being restricted to the game's possible sizes.
5. Participants were then asked about their monthly spending in Canadian Dollars on the respective game using an ordinal scale:
   a. 0
   b. 1–5
   c. 6–10
   d. 11–19
   e. 20–50
   f. 51 or more
6. The final question was asked about the size of the friend's list using the following increments to differentiate between the degree of social ability between players. This question was designed to be in ordinal measurement increments that are easily memorable for participants that were not willing to log into their accounts to check for exact numbers. The options were the following:
   a. Less than 10
   b. 10–50

c. 51–100
d. 100+

Questions 2–6 were asked individually for *Overwatch, Team Fortress 2, League of Legends,* and *DOTA2,* thus extending the survey to 20 questions at this point.

21. Age (recorded on a ratio scale)
22. Gender (Male, Female, Transgender – Female to Male, Transgender – Male to Female, Gender Variant/Non-conforming, other)
23. Program faculty (all participants at this point would have been students)
24. Occupation status (unemployed, part-time, or full-time)
25. Yearly income in CAD, with increments as follows:
    e. 0
    f. <10 000
    g. 10,001–30,000
    h. 30,001–70,000
    i. 70,000+

5 Variables

The independent variables were the average size of the group the player plays with (H1) and the number of friends one has on their friend's list for the game (H2). The dependent variable across both hypotheses was the average player spending measured in dollars. Control variables were: The games, group sizes (independent for hypothesis 1), cost of accessing the game, gender, age, participant's availability to spend time on games, frequency of play, and place of residence.

6 Results

In total, there were 104 responses. Of the 104 responses, 85 were considered valid. Responses were discarded if they met any of the following criteria:

- The participant was not a student at UOIT.
- The participants did not play any of the surveyed games. This also included the possibility of all their answers being the first option, which indicated that the participant just wanted to complete the survey as soon as possible, instead of providing meaningful data.
- All the answers were the last option, which again indicated that the participant just wanted to complete as soon as possible, instead of providing meaningful data.
- The participants took less than 30 s to complete the survey. During the pilot study, we determined that it took 1–4 min to complete the survey on average.

The largest group of participants, 53 of 104 of the totals and 36 of 85 valid participants, were surveyed during LANWAR - a gaming event that took place at UOIT. The event occurred during November 25–27, 2016.

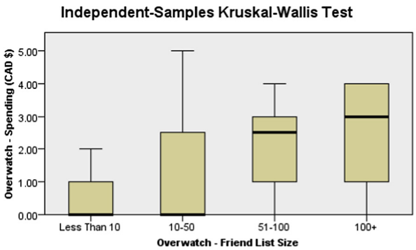
Bonferroni correction was applied to each scenario to counteract the problem of multiple comparisons when testing for correlations between Friend List size and Player Spending. In all the surveyed games the analyzed data was not normally distributed. This violates one of the assumptions for the standard one-way ANOVA test. As a result, we used an Independent-Samples Kruskal-Wallis Test to determine if there was any statistical significance between the variables. The data was analyzed to determine the effect of Friend List size on Player Spending, and Group Size on Player Spending.

6.1 Overwatch

The sample size for this data was 66. The Kruskal-Wallis Test revealed a significant effect of Friend List Size: H(3) = 10.896, $p < 0.05$. See Fig. 1.

A Dunn's post-hoc test revealed that the 100+ group was different from the group of 10 people or less ($p < 0.05$). See Fig. 2.

The Kruskal-Wallis test for the Average Group Size indicated a significant difference: H(3) = 10.843, $p < 0.05$. See Fig. 3.



(a) (b)

Fig. 1. Spending vs. Friend List Size in *Overwatch*.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Less Than 10-10-50	-5.498	6.586	-.835	.404	1.000
Less Than 10-51-100	-17.041	8.045	-2.118	.034	.205
Less Than 10-100+	-19.285	7.047	-2.737	.006	.037
10-50-51-100	-11.543	6.816	-1.693	.090	.542
10-50-100+	-13.787	5.603	-2.461	.014	.083
51-100-100+	-2.244	7.262	-.309	.757	1.000

Fig. 2. Spending vs. Friend List Size in Overwatch- post-hoc test results.

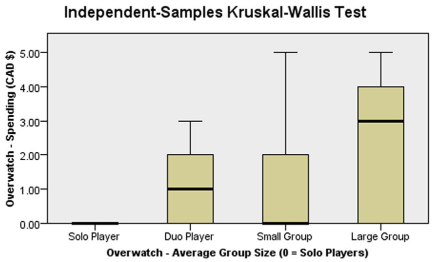


Fig. 3. Spending vs. Average Group Size in *Overwatch.*

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Solo Player-Small Group	-13.500	13.494	-1.000	.317	1.000
Solo Player-Duo Player	-15.000	14.763	-1.016	.310	1.000
Solo Player-Large Group	-27.250	13.447	-2.026	.043	.256
Small Group-Duo Player	1.500	7.810	.192	.848	1.000
Small Group-Large Group	-13.750	4.884	-2.815	.005	.029
Duo Player-Large Group	-12.250	7.729	-1.585	.113	.678

Fig. 4. Spending vs. Average Group Size in *Overwatch* - post-hoc test results.

A Dunn's post-hoc test revealed a significant difference between the players who play in small groups and those that play in large groups, $p < 0.05$. See Fig. 4.

6.2 Team Fortress 2

The sample size for this data set is 42. The Kruskal-Wallis Test on the effect of Friend List Size revealed a significant difference: $H(3) = 12.340$, $p < 0.01$. Figure 5.

A Dunn's post-hoc test revealed that the sample groups of those who had less than 10 people on their friend lists were different from those who had between 51–100 ($p < 0.01$) and those who had more than 100 ($p < 0.05$). See Fig. 6.

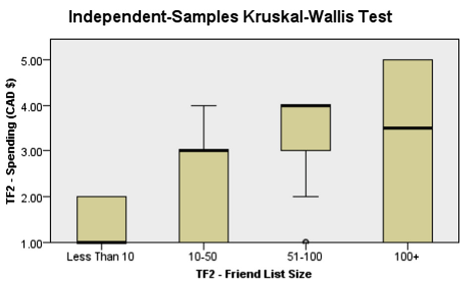


Fig. 5. Spending vs. Friend List Size in *TF2*.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Less Than 10-10-50	-6.833	5.565	-1.228	.219	1.000
Less Than 10-100+	-15.133	5.424	-2.790	.005	.032
Less Than 10-51-100	-15.798	5.044	-3.132	.002	.010
10-50-100+	-8.300	5.424	-1.530	.126	.756
10-50-51-100	-8.964	5.044	-1.777	.076	.453
100+-51-100	.664	4.888	.136	.892	1.000

Fig. 6. Spending vs. Friend List Size in *TF2* - post-hoc test results.

The Kruskal-Wallis Test on effect of the Average Group Size revealed a significant difference: $H(3) = 10.843$, $p < 0.01$. Figure 7.

A Dunn's post-hoc test revealed that the sample groups of players who play in small groups were different from those who play in large groups ($p < 0.05$). See Fig. 8.

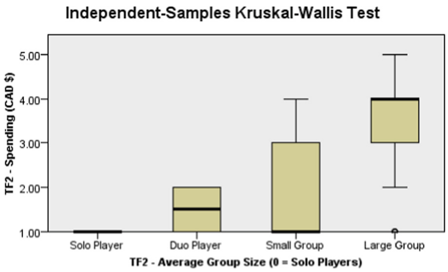


Fig. 7. Spending vs. Average Group Size in *TF2*

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Solo Player-Duo Player	-4.750	11.805	-.402	.687	1.000
Solo Player-Small Group	-6.812	8.854	-.769	.442	1.000
Solo Player-Large Group	-20.386	8.718	-2.338	.019	.116
Duo Player-Small Group	-2.062	8.854	-.233	.816	1.000
Duo Player-Large Group	-15.636	8.718	-1.793	.073	.437
Small Group-Large Group	-13.574	3.879	-3.500	.000	.003

Fig. 8. Spending vs. Average Group Size in *Overwatch* - post-hoc test results.

6.3 Pairing Overwatch and Team Fortress 2

The sample size for this combined data set was 108. The Kruskal-Wallis Test on the effect of Friend List Size revealed a significant difference: $H(3) = 22.615$, $p < 0.001$. See Fig. 9.

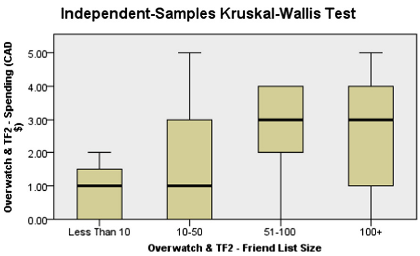


Fig. 9. Spending vs. Friend List Size in *Overwatch+TF2*.

A Dunn's post-hoc test reveals the following significant differences:

- Less than 10 Friends/100+ Friends: $p < 0.01$
- Less than 10 Friends/51–100 Friends: $p < 0.001$
- 10–50 Friends/100+ Friends: $p < 0.05$
- 10–50 Friends/51–100 Friends: $p < 0.01$

For more details see Fig. 10.

The Kruskal-Wallis Test on the effect of the Group Size indicated a significant difference: $H(3) = 23.754$, $p < 0.001$. See Fig. 11.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Less Than 10-10-50	-8.417	8.557	-.984	.325	1.000
Less Than 10-100+	-31.786	8.983	-3.539	.000	.002
Less Than 10-51-100	-34.104	9.289	-3.671	.000	.001
10-50-100+	-23.369	7.731	-3.023	.003	.015
10-50-51-100	-25.688	8.085	-3.177	.001	.009
100+-51-100	2.318	8.535	.272	.786	1.000

Fig. 10. Spending vs. Friend List Size in Overwatch+*TF2* - post-hoc test results.

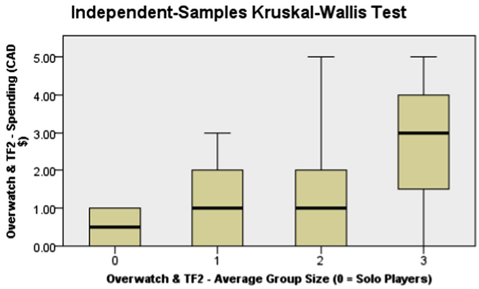


Fig. 11. Spending vs. Average Group Size in Overwatch+*TF2*.

A Dunn's post-hoc test revealed that the sample groups of players who play alone were different from those who play in large groups ($p < 0.05$). The test also revealed a significant difference between small and large groups ($p < 0.001$). See Fig. 12.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Solo Player-Duo Player	-13.556	18.438	-.735	.462	1.000
Solo Player-Small Group	-15.953	16.039	-.995	.320	1.000
Solo Player-Large Group	-42.615	15.920	-2.677	.007	.045
Duo Player-Small Group	-2.398	11.247	-.213	.831	1.000
Duo Player-Large Group	-29.060	11.077	-2.623	.009	.052
Small Group-Large Group	-26.662	6.324	-4.216	.000	.000

Fig. 12. Spending vs. Average Group Size in Overwatch+*TF2* - post-hoc test results.

6.4 League of Legends

The sample size for this combined data set was 71. The Kruskal-Wallis Test on the effect of Friend List Size indicated a significant difference: $H(3) = 14.669$, $p < 0.05$. See Fig. 13.

A Dunn's post-hoc test reveals that the sample groups of those who had less than 10 people on their friend lists were different than those who had between 51–100 ($p < 0.01$) and those who had more than 100 ($p < 0.05$). See Fig. 14.

The Kruskal-Wallis Test on the effect of the average Group Size indicated no significant difference between the average player's Group Size and Player Spending.

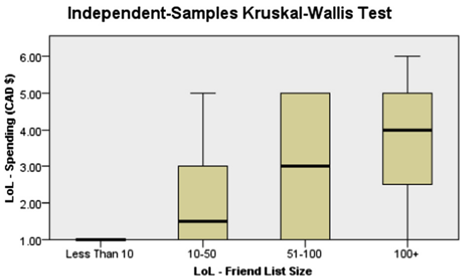


Fig. 13. Spending vs. Friend List Size in *LoL*.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Less Than 10-10-50	-14.375	9.676	-1.486	.137	.824
Less Than 10-51-100	-24.441	9.845	-2.483	.013	.078
Less Than 10-100+	-30.185	9.421	-3.204	.001	.008
10-50-51-100	-10.066	6.384	-1.577	.115	.689
10-50-100+	-15.810	5.709	-2.769	.006	.034
51-100-100+	-5.744	5.991	-.959	.338	1.000

Fig. 14. Spending vs. Friend List Size in *LoL* - post-hoc test results.

However, it should be noted that the sample size for solo players (Group Size of 0) only consists of two participants and the sample size for duo players (Group Size of 1) only consists of three participants. Therefore, a definite conclusion cannot be reached with regards to correlating group size and player spending in *League of Legends*.

6.5 DOTA2

The sample size for this combined data set was 45. A Kruskal-Wallis Test on the effect of Friend List Size revealed a significant difference: H(3) = 27.774, $p < 0.001$. See Fig. 15.

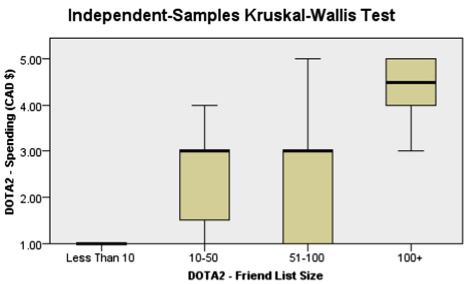


Fig. 15. Spending vs. Friend Size in *DOTA2*.

A Dunn's post-hoc test revealed that the sample groups of those who had less than 10 people on their friend lists were different from to those who had more than 100 people on their friend lists ($p < 0.001$). The test also reveals significant difference between the 10–50 group and 100+ group ($p < 0.05$), and a difference between 51–100 group and the 100+ group ($p < 0.005$). Figure 16.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Less Than 10-10-50	-11.000	6.196	-1.775	.076	.455
Less Than 10-51-100	-11.750	5.492	-2.139	.032	.194
Less Than 10-100+	-27.536	5.492	-5.014	.000	.000
10-50-51-100	-.750	5.492	-.137	.891	1.000
10-50-100+	-16.536	5.492	-3.011	.003	.016
51-100-100+	-15.786	4.684	-3.370	.001	.005

Fig. 16. Spending vs. Friend List Size in *DOTA2* - post-hoc test results.

The Kruskal-Wallis Test on the effect of the Average Group Size indicated a significant difference: $H_3 = 10.843$, $p < 0.01$. See Fig. 17.

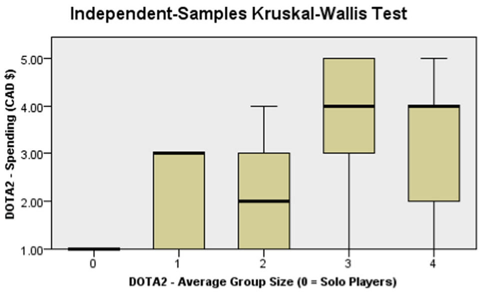


Fig. 17. Spending vs. Average Group Size in *DOTA2*.

A Dunn's post-hoc test with adjusted significances revealed no significant correlation between player's Average Group Size and Player Spending.

However, it should be noted that the sample size for solo players (Group Size of 0) only consists of three participants. Therefore, a definite conclusion cannot be reached with regards to correlating group size and player spending in DOTA2.

6.6 Pairing League of Legends and DOTA2

The sample size for this combined data set was 113 The Kruskal-Wallis Test on the effect of Friend List Size of indicated a significant difference: $H_3 = 36.919$, $p < 0.001$. See Fig. 18.

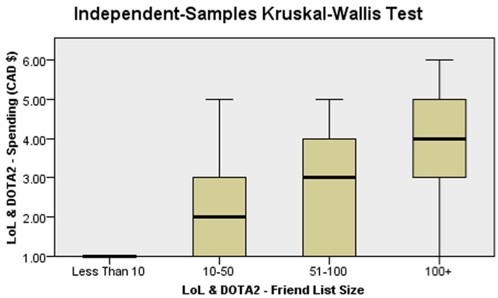


Fig. 18. Spending vs. Friend List Size in *LoL+DOTA2*.

The Dunn's post-hoc test revealed significant differences as follows, after adjustments. See Fig. 19.

- Less than 10 Friends/51–100 Friends: $p < 0.005$
- Less than 10 Friends/100+ Friends: $p < 0.001$
- 10–50 Friends/100+ Friends: $p < 0.001$
- 51–100 Friends/100+ Friends: $p < 0.05$

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Less Than 10-10-50	-25.143	10.620	-2.368	.018	.107
Less Than 10-51-100	-35.919	10.455	-3.436	.001	.004
Less Than 10-100+	-56.268	10.072	-5.587	.000	.000
10-50-51-100	-10.776	8.250	-1.306	.191	1.000
10-50-100+	-31.125	7.757	-4.012	.000	.000
51-100-100+	-20.349	7.531	-2.702	.007	.041

Fig. 19. Spending vs. Friend List Size in *LoL+DOTA2* - post-hoc test results.

The Kruskal-Wallis Test on the effect of Average Group Size revealed a significant difference: $H(3) = 11.298$, $p < 0.05$. See Fig. 20.

A Dunn's post-hoc test with adjusted significances failed to reveal any significant difference between Average Group Size and Player Spending.

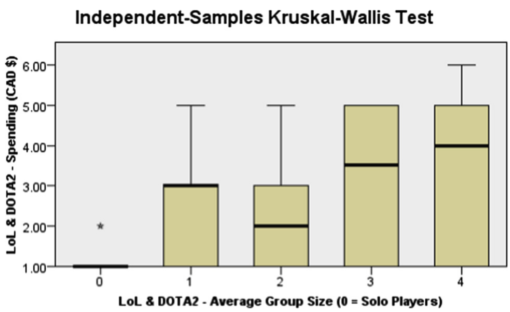


Fig. 20. Spending vs. Average Group Size in *LoL+DOTA2*.

However, as mentioned before, it should be noted that the sample size for solo players (Group Size of 0) only consists of two participants and the sample size for duo players (Group Size of 1) only consists of three participants for *League of Legends*. The sample size for solo players (Group Size of 0) only consists of three participants for *DOTA2*. Therefore, a definite conclusion cannot be reached with regards to correlating group size and player spending in *League of Legends* and *DOTA2*.

7 Discussion

For *Overwatch* we found a significant difference between “Less than 10 friends” and “100+ friends” groups, which suggests a positive relationship between a player’s friend list size and their spending. Although the results for the test do indicate a correlation, the correlation shown in the test is weak and may require more data to avoid a false positive.

The results for the test on the average group size in *Overwatch* also indicates a relationship between the size of each player’s group sessions and their spending, except for the small group sizes (3–4 players per group). These results appear in the support of our hypotheses.

The results for *TF2* were also in support of H1, where we found a difference between two groups. These differences were between the smallest and the top largest groups.

As originally expected, the limited pool of participants gave us a large margin of error when it came to the higher extremes in player spending. This is especially prevalent in *TF2* and *Overwatch* when studied individually.

When data for those two games were combined the results were stronger. For the friend list size, a significant difference was found between the two smallest groups and the two largest groups. For the average group size, we found differences between the solo and large groups and small group and large group. This also supports our hypotheses.

For *LoL* we found a significant difference between “Less than 10 friends” and “100 + friends” and between “10–50 friends” to “100+ friends”. This supports our first hypothesis. It is worth mentioning that for this game there was a larger amount of data that we were able to collect, likely due to the larger player base.

However, there was not enough data points in each group to perform proper tests for H2 for *LoL*, namely the “solo” and “duo” groups, which only had one and two data points respectively.

For *DOTA2* we found a significant difference each time every other group was compared to the “100+ friends” group. Due to a small sample size, however, this could be a false positive.

The was a lack of data points for each group to perform proper tests for H2 for *DOTA2*.

When we combined the data points for *LoL* and *DOTA2* the post hoc test revealed four significant differences (out of six) for the first hypothesis, indicating that the more friends the players have, the more money they spend.

However, after combining the data from *LoL* and *DOTA2* for group sizes, there is still a lack of data to perform tests, as we still did not have enough data for "solo" and "duo" groups. This could be since the majority of our participant data was collected at a gaming event that involved tournament play. As a result, most of the participants were likely from teams, rather than single or partnered players.

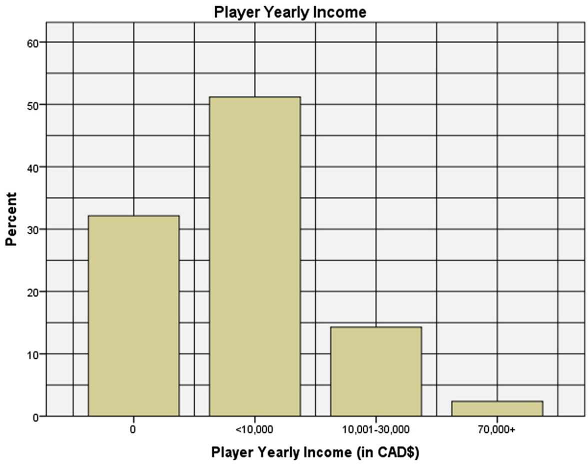


Fig. 21. Overall player income.

Although player income was suspected to be a large factor, most participants reported less than $10,000 per year from employment (Fig. 21). Interestingly, a large percentage of participants still paid for content that did not affect their gameplay. Only seven of the valid participants were part-time students, therefore there is insufficient enough data to determine being under part-time study is a factor in the results. Other variables that we were unable to determine as factors, due to lack of data, were program of study and employment status.

One last variable that was controlled for was gender. The results of the study indicated that gender identity was not a significant factor in affecting player spending in this study, as the average difference between females and males was less than 5%.

8 Limitations

The limitations of the study are as follows:

- Geography: All the surveyed participants were students at the University of Ontario Institute of Technology. Seven were part-time students. Therefore, most participants are from Ontario, Canada.
- Age: Most particiapants were between the ages of 18 and 23.
- Employment Status: 39 unemployed, 37 part-time employed and seven full-time employed.

- The surveyed participants mostly consisted of enthusiast gamers, because one of the paths to distribute the survey was at LANWAR, a local gaming event where students bring their computers onto the campus to play over a 48-h period.
- All the measurement scales were ordinal aside from "age" and player's average "group size".

9 Conclusion

We can conclude that within the limitations of this study, there is a positive relationship between a player's friend list size and their monthly spending in the game. In every tested game with adequate sample sizes, and in the combined cases, we found at least one case of significant differences between a player's friend list size and the player's average spending per month. However, we cannot conclude a definite cause-and-effect relationship between the two variables. For instance, a player could have a large friend list simply due to high overall play time with the game, therefore giving the player more time to accumulate more friends and become more invested into the game, which may result in a positive relationship between play time and player spending. Thus, we believe more research is required to reach a generalized description for the public as a whole.

Although there are cases with no significant differences, as noted before, those cases also have very few samples in the small group sizes. Therefore, we determined those results were inconclusive.

Two cases that should be noted are the *DOTA2* standalone and combined tests for group size. After Bonferroni corrections were applied to compensate for multiple comparisons, there was no significant difference in spending between group sizes. This could be due to low sample sizes of DOTA2's data influencing the overall results, resulting in a false negative.

Player income, with regards to the sample group, does not seem to have an influence in player spending throughout all the games tested. The explanation for this could be that the majority of participants reported less than $10,000 as their yearly employment income. This indicates that they are almost certainly receiving money from other sources, such as loans and/or family support. In most scenarios, this means that players are willing to spend money that they did not earn to purchase in-game content. Therefore, we can conclude that player spending is not directly influenced by their employment income.

To summarize, there is a possible positive relationship between a player's friend list size and their spending between all four games studied, with regards to the population of gaming students at UOIT. There could also exist a possible positive relationship between a player's average group size, the average number of people the player plays a game session with, with regards to *Overwatch* and *Team Fortress 2* for the population of gaming students at UOIT. However, we cannot determine if this is the case for *League of Legends* and *DOTA2*, due to insufficient data.

The results of this study could have an implication that implementing social features into the games can help game developers to increase their revenue.

10 Future Work

In the future we plan to expand the study to include more genres of games to come to a broader conclusion. Additionally, we plan to expand the survey to include the general gaming public, instead of being restricted to just the student population at UOIT. Future work could also involve interventional studies to minimize observer interference and reliance on self-reporting via in-game metrics.

To expand on data collection, Cummings and Sibona [3] argue that crowdsourcing surveys may be a viable alternative to collecting survey data. The data collected via this method eliminates the issue with most of the generalizability issues we found in our study. However, the quality of the data may be compromised if there is still an insufficient number of samples to find a reliable average.

Guo et al. [6] developed a topic model, *Latent Dirichlet Allocation*, to take in a multitude of text information, such as discussion threads and documents. The model then produces a list of topics, determined by the frequency of those words appearing in each document. This allows to user to sort the text into topics relating to their research topic. When our work is expanded to include collecting large quantities of data, we can use this model to assist in sorting out the relevant information.

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The Effects of Immersion in a Virtual Reality Game: Presence and Physical Activity

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Abstract. This study explored the effects of immersion in virtual reality games on physical exercise performance. Traditional exercising was compared with a VR exercising set up. In the experiment, subjects were asked to play a cycling game with a stationary bike on different immersion levels. The non-VR group played the game with traditional PC set-up on a flat screen while VR-group played the game in a full VR setting using the Head-Mounted Display. The input remained the same to eliminate other possible effects on the result. The travel distance within the game was recorded and analyzed. The results showed that subjects within the VR set up showed a longer travel distance as well as a higher level of presence and psychological arousal. That is to say, this study provided the evidence of VR exercising games can increase user's physical exercising performance.

Keywords: Health · Exercise · Virtual reality · Biking · VR workout · VR bike

1 Introduction

Lacking physical exercises have become one leading factors of people's healthy nowadays. According to World Health Organization, insufficient physical activity is one of the leading factors that can cause death. [1] On the other hand, people are spending more time on video games. The idea of "combining entertainment with exercise" has become more and more popular. [2]

Various computer games have been used as a tool to conduct physical exercises. Rivaling traditional exercising, the fundamental assumption generated by these exergames is that the game engages users to interact with the game content while doing the exercise at the same time. During game play, the sense of doing tiring exercise reduces thus making doing exercises a joyful activity. A lack of enjoyment is known as the biggest enemy to physical exercises. Researches have shown that such exergames are capable of making the physical activities more enjoyable, therefore, increase their effectiveness and sustainability. [3]

VR exercising games, in particular, have the ability to embody a user into the actual game play itself. From previous studies [4–6], VR exercising games are thought to be

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more effective in increasing user's motivation and exercising performance. Many scholars found [7, 8] that the degree of immersion could affect the level of psychological processes of accepting VR as the real world.

For those reasons, this paper aimed to explore the possible influence of VR exercise games inducing user's exercise motivation and physical performance. We hypothesized that the immersive virtual environment could induce a higher level of presence(immersion) at user's perspective, so users can more focus on the situation of exercising in the game

1.1 VR Exercising Games

Typical VR exercising games (VR health games) aimed to replicate a traditional sport or physical exercise using the motion sensor inside a virtual reality system. In other words, body movement of the user acts as an input device of the game. Take Vir-zoom, a VR biking game, as an example. The user controlled their game behavior via a stationary bike designed specifically for the game. The leg's cycling movements controls the moving forward in the game while the body leaning left or right (captured by the motion sensor) is used as the turning mechanism within the game. By replacing controller with body movements, the user is expected to gain physical exercise benefits while playing the game. While current VR exercising games cannot reproduce the same level of physical movement as traditional physical exercising, the benefits of them are to provide interactive media content. These interactive media content engage users' activity and involvement thus turn into better physical exercise outcomes.

The interactive media content as well as the realistic replication of these exergames are likely to increase immersion of users. Studies have found that immersive game content can increase user's enjoyment of the exercising experience. [9] As enjoyment is a critical factor in increasing physical exercising outcomes, the VR exercising games seems to be promising in future exercising environments.

2 Immersion in the Virtual Environment

Immersion is a psychological feeling of being inside the virtual environment [10]. Conceptualized as a mental state of being involved in the game, immersion is also a multifaceted concept involving media (medium), users and contexts. [11–13] Users feel immersed with VR content based on themselves and social contexts as well as the hardware contributed to this experience. That is to say, the level of immersion heavily depends on the capability of the hardware. The more capable the hardware is to replicate the real world, the more possible that the users feel immersed within the virtual environment.

Within the realm of VR exercising games, a more immersive experience would therefore require better suited hardware. Take stationary bike as an example, an HMD VR set up is thought to be more immersive than a traditional 2D set up as they provide wider range of sensory channel even though the users work on the same stationary bike. The underlying reason is that the VR HMD provided a wider field-of-view than a traditional 2D set up therefore a user's immersion of vision is greater influenced.

With that being discussed, with other elements of the exercising controlled, the VR set up is capable of delivering more immersive experience.

As an ongoing procedure, an immersive experience can be judged by its level of immersion. [14] Higher level of immersion therefore affect the experience in ways such as user's presence, arousal and other related elements. Studies have also shown that higher level of immersion can have a positive effect on the enjoyment of the whole experience in exercising which is proven to be an essential factor in the outcomes of physical exercises. [3] At this point, it can be predicted that higher level of immersion may have positive effect on physical exercise outcomes.

2.1 Presence: Are You Really There?

Presence and immersion are closely related to one another. Some scholars treat presence and immersion as a synonymous concept [15] which indicates that adding presence to the concept of immersion is only a confusion. Yet, Immersion can also be treated as a synchronicity of media, user, and contexts where presence is only a human consciousness of being there. Based on Slater and Wilbur's study [16], presence is a function of user psychology of recognizing being inside a virtual setting while immersion as the quality of this experience.

To form presence, scholars treat it as a two-step process [17] of perceiving this virtual environment as a plausible space via spatial cues than experience his or herself inside this space [18]. As defined in Wirth et al.'s study [17], presence is "a binary experience, during which perceived self-location and, in most cases, perceived action possibilities are connected to a mediated spatial environment, and mental capacities are bound by the mediated environment instead of reality". Therefore, the presence level indicates a person's perception of this virtual environment as an actual space and his ability to act in this process.

In Bailey et al's [19] study, researchers observed the level of presence to reflect the immersion level. A sense of "being there" in the VR realm indicates a user's sense of their body being inside the virtual environment instead of the physical environment. [13] The presence level is a sign of immersion. With higher level of immersion, a higher level of presence may be observed.

Hereby, we hypothesize that:

H1. Higher level of immersion of a VR exercise game will increase the user's sense of presence in the exercise environment.

2.2 Arousal

Arousal is a psychological and physiological state which are affected by the individual's level of attention and readiness for physical response [20]. That is to say, if an individual focused his or her attention on the content, the likelihood that this individual has a higher level of arousal is expected. While exercising naturally affect user's arousal by forcing individuals to focus on the physical activity, there are possibilities to increase user's arousal level by making them more focused on the exercising activity. As suggested by other scholars, the realism generated by video games (such as graphics and sounds) gets user's attention thus make users more focused on the content.

VR exergames replicates real-world physical activity and add interactive contents which draw user's attention. Studies have proven positive linkages between immersion and attention to the content. Therefore, higher level of immersion (which can be observed by measuring people's level of presence) may have a positive effect on user's attention then increase user's level of arousal.

As VR exercising games increase user's presence and generate a much more realistic environment than a traditional set up, a higher level of user arousal is expected in VR exercising games.

Therefore, we hypothesize that:

H2. VR exercising games will increase user's arousal level than traditional 2D set up.

H3. User's presence level in VR exercising games will increase user's arousal level in a VR exercising set up.

2.3 Physical Exercising

Whether user enjoyed doing physical exercising as well as whether they pay attention to the training process can have a huge impact on the final outcome of the exercising. As discussed above, VR exergames provides a higher level of immersion therefore increases user's presence and arousal.

Physical exercising outcomes can be affected by the media platform and content. It is highly anticipated that a better physical exercising performance is affected by the level of immersion in a Virtual Reality game. By reproducing physical activity using sensors and other visual cues, the actual exercising performance generated by the user might increase.

Therefore, we hypothesize that:

H4. User's exercising performance will increase in high immersive virtual reality exercising game. (Fig. 1.)

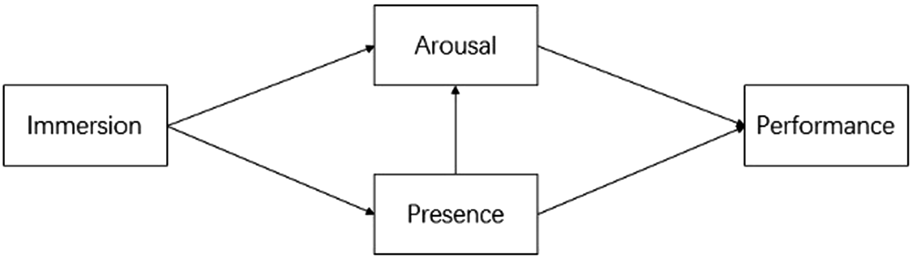

Fig. 1. Research model of the study

3 Method

A between-subject experiment design was used to test our hypotheses: whether the different levels of immersion (standard 2D set up or VR set up) affect people's exercise performance. The Subjects were divided into two groups with different level of immersion, non-VR exercising group (with 2D flat screen), and VR exercising group (wearing a Head-Mounted Display). Both groups played the same VR biking game (VIR zoom) under different experimental settings yet on the same stationary bike which is used in VIR zoom game. The non-VR group played the game with traditional PC set-up on a flat screen while VR-group played the game in a full VR setting using the VR Head-mounted display (Vive) developed by HTC. The input remained the same to eliminate other possible effects on the result.

3.1 Apparatus

Two level of immersion was operationalized using two set up: a virtual reality set up using HTC VIVE representing high level of immersion and a flat screen set up representing low levels of immersion. The head-mounted display system requires less than 10 ft from the sensor to recognize user's movement. As this study require a certain amount of workout, a cycling game developed by VIR zoom was used. The input was the same on both set up. The cycling system is capable of adapting to both conditions as well.

3.2 Measurements

Presence. Presence was measured using the ITC-SOPI questionnaire [21]. A total number of 12 items was measured including factors of "Sense of Physical Space," "Engagement," and "Ecological Validity." The subjects rated their level of agreement on a ten-point scale from 1 (strongly disagree) to 10 (strongly agree). Example items include: "I had a sense of being in the scenes displayed," "I felt that the characters and/or objects could almost touch me," and "I felt I was visiting the places in the displayed environment."

Arousal. Arousal was measured using the Perceived Arousal Scale [22] which contains 24 items such as "Active," "Energetic," "Exhausted," and "Inactive." Subjects rated their level of agreement on a ten-point scale from 1 (strongly disagree) to 10 (strongly agree).

Physical Exercise Performance. Physical Exercise Performance was measured by distance of travel.

Travel distance. Travel distance in the game was also recorded using the include display within the game. The result was recorded after each section of the game in kilometers.

3.3 Procedure

Subjects were randomly divided into two groups. Each subject was asked to finish a demographic questionnaire regarding their age, gender and race. Each subject was then asked to play the same stage of VR cycling game VIR zoom for 10 min. After 10 min, the travel distance of each subject within the game was recorded. After the cycling section of the experiment, subjects were asked to complete a questionnaire assessing their level of presence and arousal within the game.

4 Results

4.1 Subjects

A total of 32 subjects participated in the experiment. They were randomly assigned to the VR (n = 16) and non-VR (n = 16) groups. Mean age of the subjects was 22.3125 (SD = 1.99).

4.2 Hypothesis Testing

Hypothesis 1 predicted that the level of immersion would increase user's feeling of presence. To test H1, the presence level within the VR group was compared to the ones within the non-VR group. The presence level of users in a VR set-up (7.63) was higher than a non-VR set up (7.49).H1 was supported.

Hypothesis 2 predicted that the level of immersion would increase user's feeling of arousal. To test H2, the arousal level within the VR group was compared to the ones within the non-VR group. The arousal level of users in a VR set-up (6.00) was higher than a non-VR set up (5.70). H2 was supported.

Hypothesis 3 predicted that the higher level of presence would indicate higher level of arousal. To test H3, a Pearson's R correlation was calculated between the user's arousal level and the user's presence level within the VR group. There was a positive correlation between user's arousal level and user's presence level ($r = .522$, $p < .05$). The higher user fell presence in a VR exercising game, the higher arousal level they might have playing VR exergames. H3 was supported.

Physical exercise performance is measured using travel distance within the game. To test H4, the mean of the travel distance within the VR group was compared to the mean of the travel distance within the non-VR group. The travel distance within the VR

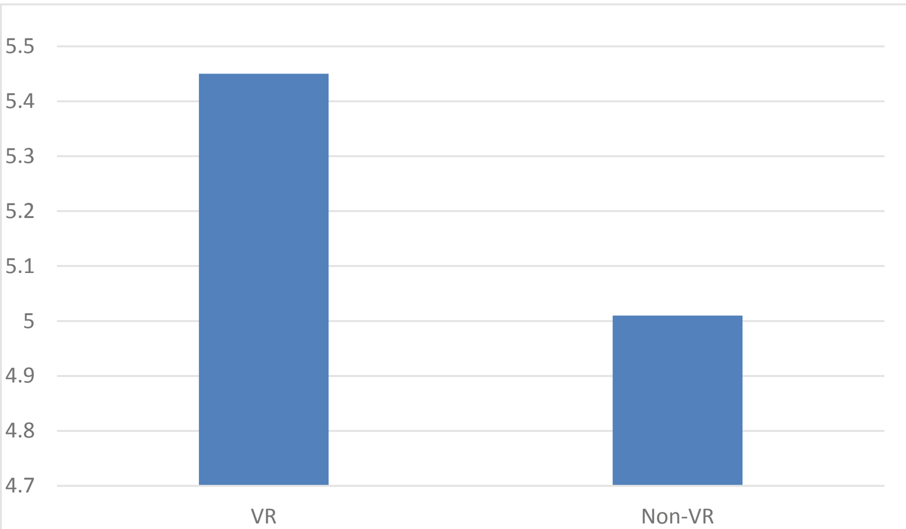

Fig. 2. Travel distance difference between two groups

group (5.45) is significantly higher than the travel distance within the non-VR group (5.01). (Fig. 2.) H4 was supported.

5 Discussion

The results showed that subjects reported a higher presence level when playing the biking simulation game in a virtual reality environment. This result confirmed that the virtual environment did generate a higher level of presence and immersion when users are playing exergames. When users are playing exergames, the possibilities are, they think of themselves as in the real exercising situation rather than a computer-generated game. While this study did not test whether other factors within the virtual reality games have impact on user's presence, it is quite clear that the presence and immersion level are higher within the VR exergames.

A higher level of arousal was found in subjects within the VR exercising group. This indicates the possible linkage between higher level of immersion with higher level of arousal. With higher level of arousal, users may have higher level of attention and readiness to the activity. As discussed in previous sections, higher level of arousal may have a positive linkage with the physical exercising outcomes. Since this study measured arousal using self-reported data, whether biological arousal can also be observed is not known at the current stage of the study. This may be confirmed in a future study.

Longer travel distance was also found in VR settings as one of the indicators of higher exercise performance. While there are individual differences between subjects in their actual exercise capability, the result is promising as more subjects within the VR group has a longer travel distance than those who are in the non-VR group. The longer distance travelled within the game indicates a higher motivation level to do exercises. The longer distance traveled, the possible better physical exercise outcomes can be.

6 Conclusion

The current study provided the evidence of virtual reality's ability to increase user's exercise performance. As a tool, virtual reality is capable of delivering interactive and immersive exercising game experience. The more immersive the experience is to the user, the better outcome the users can get from the whole process. Current study is not sufficient in backing up virtual reality as an effective exercising tool. Limitations include possible flaw in self-reported data as well as insufficient sample size. However, the trends of virtual reality increasing exercising performance is significant based on the current data.

More application of virtual reality in gamifying physical exercises is foreseen as it provides a higher exercise performance within the same level of time. A future study will include physiological measurements to have more accurate physical activity data.

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Serious Games

Check for updates

Development and Usability of a Low-Cost Kinect Game to Promote Movement Competence in Children with and Without Intellectual Disability

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Abstract. Many children fail to meet recommendations for daily physical activity (PA). Skills like jumping and hopping indicate movement competence may positively shape PA trajectory. Because these skills are learned, it is important that children are exposed to them early. This paper presents the development and usability assessment of a low-cost 2.5D Kinect scroller obstacle avoidance game that integrates player ability and makes game object spatial properties editable using a text file. Seven children (age ± SD: 5.7 ± 1.5 years; height: 117.3 ± 12.4 cm; mass: 24.4 ± 8.0 kg) participated in the assessment. The game was developed using Unity game engine. The input device was Kinect v2. The objective of the game is to negotiate obstacles along the travel path and cross the finish line. Participants avoided obstacles by jumping, hopping, ducking, and sliding. Participants answered questions related to gameplay difficulty, discomfort, and desire to play the game again. Eighty six percent of participants had positive general impressions of the game, 14% reported feeling dizzy or experiencing pain/discomfort during gameplay, and 86% reported jumping as the difficult movement during gameplay. All participants reported that they would play again and felt the game could help them. It is concluded that young children found the game appealing and physically beneficial. Since the game is intended to help children practice joint stiffness regulation and improve their movement competence, future assessments should determine the longitudinal effect of exposure to the game on these parameters.

Keywords: Locomotor skills · Kinect · Movement competence · Leg stiffness · Physical activity

1 Introduction

Reducing excessive body weight is linked with improved adverse cardiometabolic outcomes in children [1]. Regular physical activity (PA) is a common and effective strategy to prevent and control excessive weight gain [2]. Unfortunately, the majority of typically developing children in the United States fail to meet recommendations for

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daily physical activity [3]. Hispanic-American children are even less active at home and during recess at school and are more affected by overweight and obesity compared to their non-Hispanic White American peers [4–6]. Relatedly, pediatric obesity at a proxy predominantly Hispanic elementary school in Corpus Christi, Texas was more than twice the national rate [7]. Due to factors like motor skill deficits, children with Intellectual and Developmental Disabilities (IDD) can face challenges when it comes to executing and enjoying success, especially during goal-oriented PA. These challenges can persist through adulthood [8, 9], if unaddressed.

Movement competence is a critical determinant of PA and active play among children [10]. Therefore, it is important that children are exposed to diverse opportunities to develop movement competence early in life. Movement competence is the development of adequate motor skills and abilities necessary to successfully perform movements that are fundamental to a variety of PA [10]. Unlike walking, which naturally emerges, locomotor skills like hopping and jumping (also indicators of movement competence) are often acquired through context-specific exposure, instruction, structured training, and practice. Proficiency at these locomotor skills invariably involve optimal leg stiffness regulation. Leg stiffness regulation is the control of the spring-like behaviour of the lower limbs during bouncing movements like running and hopping [11–13]. While adults may voluntarily undertake movement competence-based training delivered through traditional instruction (e.g., plyometric exercises in a gym or recreational facility), children may be less responsive to such structured delivery and training modes. Gamifying movement competence-based training engages and motivates children; therefore, it is a viable delivery mode [14, 15]. Studies have shown the effectiveness of virtual reality (VR) games at increasing muscle strength and agility and enhancing PA and motor competence, including postural stability, among preadolescents with and without Down syndrome [15, 16]. Resultantly, schools and clinicians have explored teaching and therapeutic methods that incorporate motor skills using VR games that children enjoy [15, 16].

Gesture-based gaming (i.e., Exergaming) on platforms like Wii (Nintendo, Kyoto, Japan) and Xbox 360 (Microsoft, Seattle, Washington) [15], have broadly targeted PA without specifically addressing fundamental locomotor skills. Using a depth camera (Kinect) as the input device, Microsoft released several gesture-based games, including KINECT SPORTS and KINECT ADVENTURES! Although these games involve deploying skills like running and jumping, movement demands are not informed by the player's physical ability. Further, these games lack a mechanism for the player or their parent/caretaker to alter the spatial layout and type of game objects, in order to focus attention on specific skills. These factors may be limiting for younger children with and without motor skill deficits, especially considering that exposing children early to movement contexts that facilitate leg stiffness regulation and movement competence may positively shape their PA trajectory [8, 17].

The purpose of the work is to assess the usability of a low-cost obstacle avoidance game developed to motivate children to deploy and practice locomotor skills (e.g., jumping and hopping), which facilitate leg stiffness regulation. In its current state, the game prototypes two novel game development ideas: (1) prompting input related to a player's physical performance, in order to establish game difficulty, and (2) making respective game level features (e.g., obstacle layout and presentation sequence) modifiable by the player (if old enough) or a parent/caregiver without any requisite technical or coding background.

2 Materials and Methods

2.1 Participants

Seven children (6 males and 1 female) (age ± SD: 5.7 ± 1.5 years; height: 117.3 ± 12.4 cm; mass: 24.4 ± 8.0 kg; BMI: 17.2 ± 1.9 kg/m^2) were recruited, in order to assess the usability of a 2.5D scroller obstacle avoidance game. This study was approved by the Texas A&M University – Corpus Christi Institutional Review Board. A parent or legal caretaker signed an informed consent form, and the children signed an assent form prior to participating.

2.2 Procedures

Participants' height and weight were measured (non-shod) using a seca 286 dp ultrasonic measuring station (seca, Hamburg, Germany). Participants warmed up for two 2 min by running in place at a light pace. To begin the usability assessment protocol, participants stood in front of an MSI gaming series computer laptop screen and adjacent Kinect v2 motion-tracking sensor. To minimize comprehension errors, on-screen instructions were read out loud to participants by the principal investigator (PI). System calibration required participants to stand still with their arms to their sides for 3 s. They were prompted to jump as high as they could, in order to establish gameplay difficulty. During gameplay, participants avoided obstacles in their travel path by jumping, hopping, sliding side to side, and ducking. Obstacles included boulders, rivers, and streams. An on-screen health bar indicator showed health depletion updates whenever the player contacted an obstacle in the game. Players could acquire health-enhancing resources scattered throughout the game by deploying some of the same movements previously mentioned, e.g., jumping and sliding from side to side. Participants practiced playing the game, in order to familiarize themselves with the requisite movements. The game was restarted, once participants indicated understanding game objectives and associated movements. The game automatically transitioned to levels 2 and 3, if a player crossed the finish on the respective preceding level.

Gameplay terminated when a player completely depleted their health in the game or crossed the last finish line. Participants had three attempts to reach the finish line on each level. Participants were subsequently asked the following questions as adapted from Komlódi et al. [18]:

1. How was the game?
2. Did you feel dizzy or want to throw up?
3. Did anything hurt during the game?
4. What was easy during the game?
5. What was difficult during the game?
6. Use one word to describe the game?
7. Would you play it again, if you had the chance?

8. Would you tell your friends to play it?
9. Do you think the game can help you?
10. How can the game help you?
11. How could we make the game better?

Questions 1 and 6 asked participants about their overall sense of the game. Questions 7 and 8 assessed participants' feelings about playing the game again, if presented the opportunity. Question 2 assessed any sense of disorientation during gameplay. Question 3 assessed any sense of physical discomfort. Questions 4 and 5 assessed participants' perceived gameplay difficulty. Questions 9 and 10 assessed whether participants felt that the game could benefit them. Parents were asked to rank their participating child's PA behavior as either "never active," "rarely active," "sometimes active," "often active," or "always active." Participant's responses were recorded by the PI on an ad hoc questionnaire.

2.3 Game Development

Considerations for Movement Capture Device. The primary gameplay objective is to constrain the player to deploy skills, namely jumping, hopping, sliding (i.e., from side to side), and ducking, in order to avoid a range of obstacles along a rectilinear travel path. Augmented Reality (AR) and VR systems often involve donning a head-mounted display, can pose challenges like motion sickness, are cost prohibitive, and may require additional input devices like hand-held controllers. Therefore, the Microsoft Kinect v2 was adopted as the input device for this game (Fig. 1) [19].

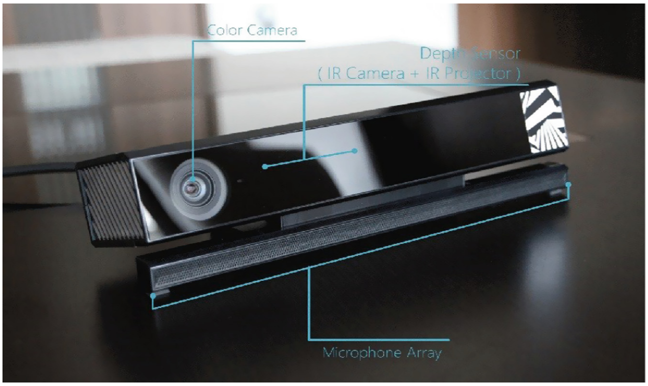

Fig. 1. Microsoft Kinect v2 sensor

System Design. Scripts are written in the Unity game engine (Unity Technologies, San Francisco, CA) to support the current game features. Communications between Unity, Windows, and Kinect v2 sensor are facilitated using Microsoft software development kit (SDK) and Kinect for Windows Unity Pro package v2.0 (Fig. 2). Player movements are converted to basic motion in the script. The main game logic is designed by writing ad hoc scripts and linking them to the project file. Each script file has Start and Update functions, which are individually incorporated into each script file. Start functions are called at the beginning of the game and update functions are called at every frame. Levels are designed using a text file that defines the play environment. Levels are developed at the beginning of the game by reading these text files. A Microsoft adapter that acts as a power source and USB 3.0 port converter is paired with the Kinect v2.

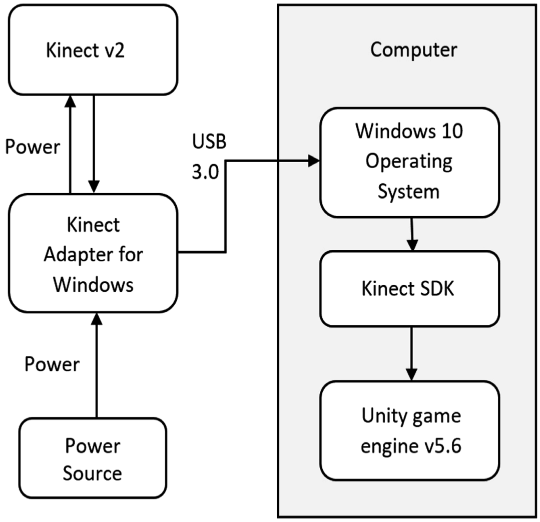

Fig. 2. The system design flow

USB 3.0 is used to handle the high amount of data transfer from the Kinect to the computer. The Kinect v2 sensor is connected to an external source by installing the Kinect Adapter for Windows module and associated drivers. The flow of input from the Kinect to the Unity game engine is shown in Fig. 3.

Movement Capture. The player must jump, hop, slide and duck in various sequences and combinations in order to reach the finish line. These movements are captured by the Kinect device as both RGB and depth images and sent to the computer via USB 3.0. The images are processed by the Kinect drivers installed with the SDK. Kinect for Windows Unity Pro package v2.0 processes the data and gives the positions of the body nodes of the player (Fig. 4). The joints are accessed in the game script by calling the in-built Kinect for Windows Unity Pro package v2.0 functions. This data is collected for every frame. The game measures the position of the base of the spine (HIP CENTER of the individual (Fig. 4). Based on the position and movement of this joint, the game engine determines the motion of the in-game character.

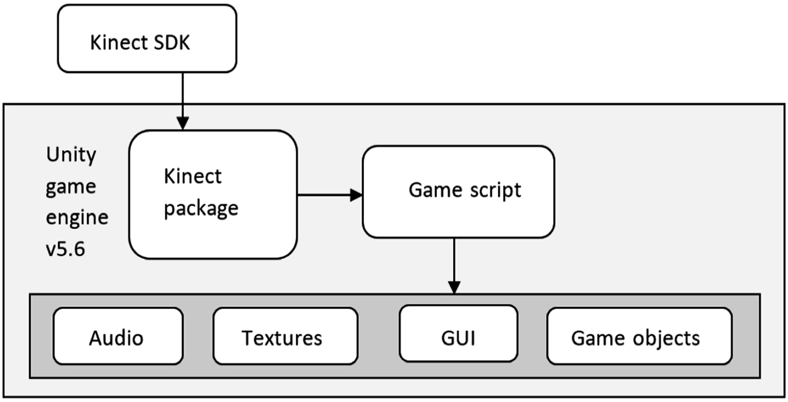

Fig. 3. Kinect input flow chart from Kinect to Unity game engine

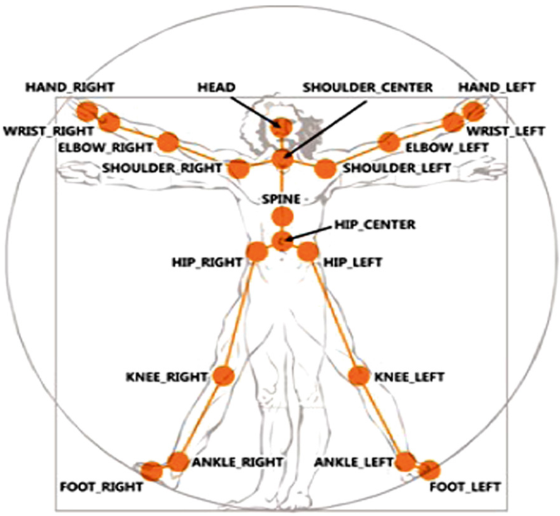

Fig. 4. Body joints detected with the help of Kinect input

2.4 Game Design

The design of the game consists of menu screens, gameplay, UI elements, game objects, textures and Audio.

Screens: There are 10 screens: Main Menu, Finding Center (which locates the base of the player's spine), Setting Difficulty, High Scores, Level Start, Pause Menu, Game Over, Game-play UI, Finish, and Lost Life. Every screen has a Kinect Tracking status indicator on the top center of the screen. A red square at the top of the screen indicates that the Kinect is not tracking the child. Green indicates that it is tracking.

Main Menu: The Main Menu has three buttons: Start, High Scores and Exit, along with an Audio Toggle option shown in Fig. 5. The Start button will take the user to the

Finding Center screen, which uses the Kinect to determine the base of the player's spine. Selecting High Scores will take the player to the High Scores screen. The Audio Toggle mutes and unmutes the audio. Every button has an event handler function, which is called to disable or enable UI screens and game objects. The Exit button quits the game.

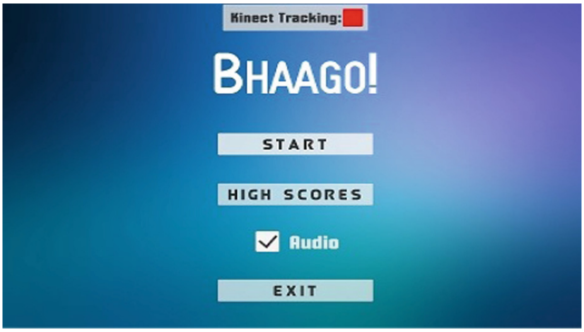

Fig. 5. Screen shot of the Main Menu

High Scores: This screen displays the top five scores and maximum height jumped by previous players (Fig. 6). Pressing the Main Menu button returns the player to the Main Menu.

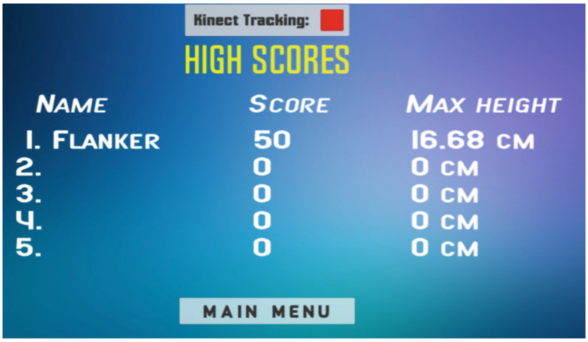

Fig. 6. A screen shot of the High Scores screen

Finding Center: The Finding Center screen appears as soon as the player presses the Start button on the main menu screen (Fig. 6). This interface gives the player 3 s to calibrate their center position. It does so by receiving input from the Kinect for 3 s. The timer is paused when the Kinect cannot track the player. As soon as the 3-second period ends, the center position is calculated by averaging all the positions obtained during this time. Jump threshold and duck threshold are calculated from this calculated height position. These thresholds are used to identify if the player is jumping or ducking. The game then moves to the Setting Difficulty screen after all these calculations (Fig. 7).

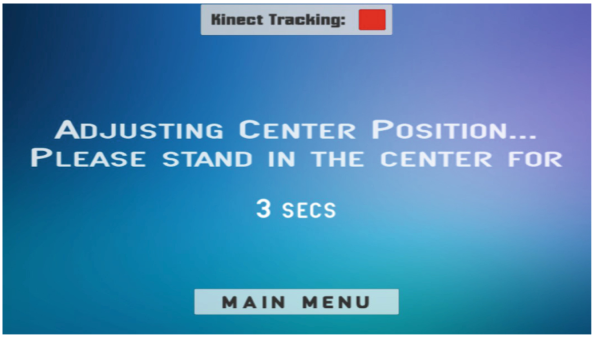

Fig. 7. The Finding Center screen, showing time remaining for the Kinect to track the player

Setting Difficulty: This screen prompts the child to jump as high as possible (Fig. 8). The maximum height jumped is used to manipulate the requisite minimum jump height, duck height, and sensitivity required to slide sideways, thereby presenting a dynamic difficulty feature. Pressing the Start button on this screen takes the player to the Level Start menu screen. The player must jump a minimum of 10 cm to start the game.

Fig. 8. A screen shot of the Setting Difficulty, using the maximum distance jumped by the player

Level Start: This screen is displayed for 2 s with a countdown sound, thereby notifying the player that the level is about to start. Pressing the Start button, Restart button, and crossing the finish line (except on the last level), starts the game on the first level, the same level, and the next level, respectively. Gameplay starts after this screen times out.

Gameplay: The Gameplay UI screen includes three boxes (sections). The first box from the left displays the player's lives, health, shield (i.e., invincibility power-up), and score. The second box shows the current level. The third box on the right end, displays the maximum height jumped by the player in that game session (Fig. 9). Figure 10 depicts the logic of game play.

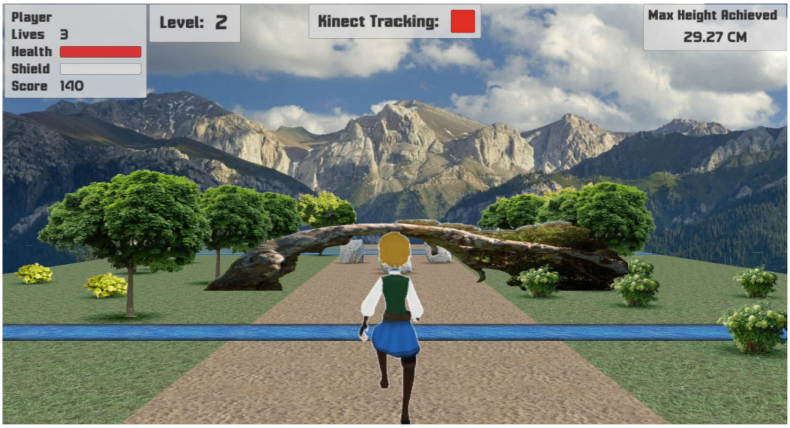

Fig. 9. A screen shot of the game-play, showing UI elements

Pause Menu: The Pause Menu appears as soon as the player presses the Escape button on the keyboard (Fig. 11). This menu has three options: Resume, which continues the game; Restart, which resets the game on Level 1; and Main Menu, which returns the user to the Main menu. The logic flow for the pause screen is shown in the Fig. 12.

Lost Life: This screen displays nothing. It is used to pause the game for 1 s. It helps the child to show that the player lost its life. The number of remaining lives decreases by one, when the player's health completely depletes. The game is over, when lives decrease to zero.

Finish: The Finish screen appears as soon as the player arrives at the finish line on a level, as shown in Fig. 13.

Game Over: The game is won when the player crosses the finish line on the final level (Fig. 14). It shows the game score, maximum jump height, and the Main Menu button. The flow of this screen is shown in Fig. 15. If the player wins the game with a score higher than the current fifth highest score, a box appears with a message to input the player's name. This name is displayed on the High Scores screen in a descending order of score magnitude.

Gameplay Design. The in-game character appears at a distance in front of the camera. The ground is divided into tiles (rows and columns) as denoted in a level design file (a text file input to the game engine). Each character in the level design file describes the type of each tile. Each level has 15 columns, with the middle three columns as the path containing obstacles and the remaining tiles displaying grass and other environmental objects. By default, the character continuously runs forward. The player must jump,

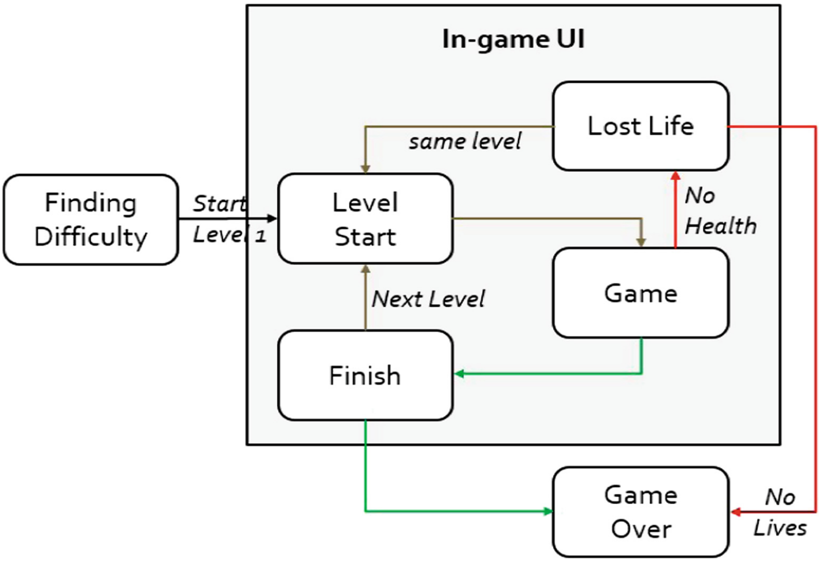

Fig. 10. The flow of the game-play UI screen

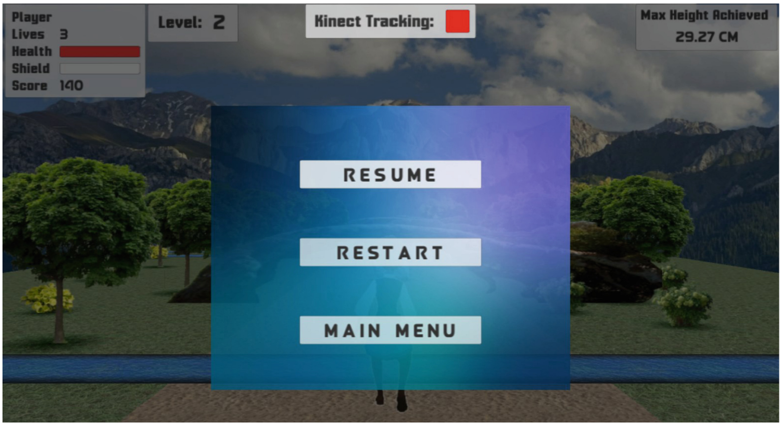

Fig. 11. A screen shot of the Pause Menu screen

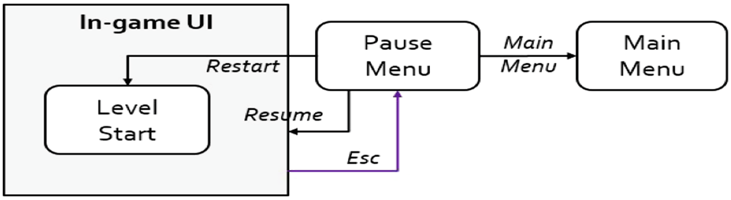

Fig. 12. The flow of the Pause Menu screen

Fig. 13. A screen shot of the player reaching the finish line

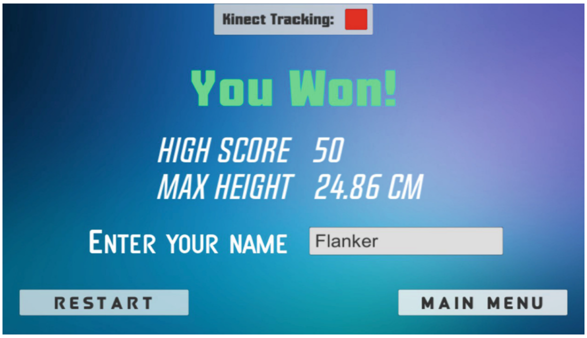

Fig. 14. A screen shot of the game over screen, when the player wins and achieves a High score

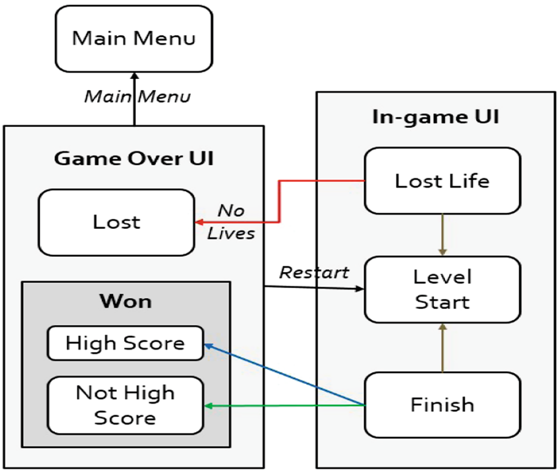

Fig. 15. The flow of the game over Screen

hop, duck, or slide sideways to avoid obstacles. The background scenery remains distant, although it appears to approach.

Game Objects. This game has 11 game objects: Player (in-game character), Back camera, Tile, Scenery, Stones, Logs, Trees, Bushes, Crocodiles, Health power-up, and Invincibility power-up. This game is rendered in 2.5D (i.e., objects are planes in a 3D space with different sizes and respective sprites). All game objects have a pivot point at their respective centers. The X, Y, and Z axes correspond to the medial-lateral, superior-inferior, and anterior-posterior planes, respectively.

Player: This is the game's protagonist. This object is moved with respect to the inputs received by the game. It has three sprite images with UV animations for running, jumping, and ducking. The height of the player is 5 units above the ground (which has a value of zero) and a width of 2.5 units. The running and ducking animations are created by rotating through 12 sprites.

Back Camera: This is the default game view. It follows the player at a distance of 20 units on the Z axis and is raised by 5 units on the Y axis.

Tile: Tiles are used as the ground. This game object is based on the level design file. There are ten tile types: path, lava, water, river, stone, log, tree, grass, bush and finish. Each type has its own unique texture. Game objects are also assigned to each item based on its type. These assigned game objects take the tile's position. Grass, bush and tree types are used for the environment and appear on the sides of the path. River, water, pond, stone and log are used for obstacles. Finish is used to end the level.

Scenery: This object remains in front of the player and increases slowly in size as the player progresses to create a parallax effect.

Stone: This game object is assigned to tiles that are designated as stone type in the level design file. The stone appears in the center of the tile, facing the player on the Z axis. It has a height of 2.5 units. The player must avoid this tile by jumping up. Colliding with it will lower the player's health. One of two textures is randomly chosen.

Log: This has the same properties as stone but appears with a gap underneath. The player must duck under it to avoid collision. Each log occupies three tiles.

Tree and Bush: These are used to enrich the game environment. They are on either side of the travel path. Textures are randomly chosen.

Health and Invincibility: These are power-ups. Health replenishes the players health to full and invincibility makes the player invulnerable to any collision for some distance.

Implementation. The game is developed using a C# script with instructions to change screens, change height parameter, change audio volume, load levels, start and end the game, move objects, calculate collisions and save high scores. The Unity C# script file has two main functions: start and update. The start function in every script file is called at the start of the game. The update function is called every frame. Attaching the script file to an object indicates the object's script file.

Level Design. Level design files contain information on the position and type of each tile on the map. It is designed to be easily modified by a non-programmer (Fig. 16). Every two lines of text and characters present the information for one row of tiles in the game. Two lines were used in the code for every row in the game, so that power-ups could be implemented without conflicting with the main tile type. For example, a power-up can appear on a river tile. The first line in each pair of lines indicates the tile type (i.e., path, river, water, lava, tree, bush, stone, finish, and log). These are represented by **p**, **r**, **w**, **t**, **b**, **s**, **f**, and **l**, respectively. The second line indicates whether there is a power-up and if so, whether it is Health or Invincibility (denoted by h and i, respectively). Apart from these notations, we used 3 other notations for randomizing objects. ‘0’ denotes either a tree or a bush, chosen at random. Similarly, ‘1’ denotes a stone or water, and ‘2’ denotes a log or river across the specified row.

```
0.  gggggg...gggggg
    ---------------
1.  gggbggw..gggggg
    ---------------
2.  ggggggw.sggbggg
    ------i--------
3.  ggtggg...gbgggg
    --------h------
4.  ggbgbg.l.gggtgg
    ---------------
5.  gggbgg...ggbggg
    ---------------
6.  rrrrrrrrrrrrrrr
    ---------------
7.  ggbggbs..gggbgg
    -------h-------
8.  gggtgbpppgggggg
    ---------------
9.  gggbggpppgggtbg
    --------i------
10. ggtgbg...gggtgg
    ---------------
11. gggbgg.f.gggbgg
    ---------------
```

Fig. 16. Example of a level design text file

Path Tile: These tiles are denoted by “.” in the level design file. This is the safe tile for the player to run.

River Tile: The river tile has the only animated texture, which mimics a flowing river. The time taken for the texture to completely move across the tile is set to 1 s. Therefore, the river flows at a speed of 15 units per second; the size of a tile is set to 5 units.

Water and Lava Tiles: Water occupies one tile. Lava occupies six tiles, so it covers the entire path. Stepping on these tiles is taken as a collision. Static maps are used on these textures for a more realistic feel of water.

Stone Tile: When a tile is set as stone, another plane with a stone image is placed at the center of the tile. The player must jump over these to avoid a collision.

Log Tile: A log tile covers the entire path; so, it is only denoted in the middle row. No other types of tiles can appear in this row.

Finish Tile: This tile delineates the finish line. Contacting it ends the current level and starts the next level, except on the final level where contacting this tile wins the game.

Bush and Tree Tiles: These tiles are primarily aesthetic and do not occur on the path.

Health and Invincible Power-Ups: Health power-ups replenish the player's health to the maximum level. Invincibility power-ups make the player invulnerable to any collisions for a certain distance. The power-up objects are disabled as soon as the in-game character collides with them and takes the power-up.

Positions: Each tile measures 5 units. The central tile in each row is centered on the X axis. All tiles immediately border their neighbors.

Levels: Level files are denoted by the level name followed by an integer for the level number starting at 1. For example, the level 3 text file is called level3.txt. These level text files are placed in the Assets/Levels folder in the main game folder before building the game.

Input: The Kinect sensor is used to monitor the player's position with a mouse and keyboard used for game navigation and High Score input. For optimal performance, the player needs to stand about 110 cm away from the device.

Calibration: As soon as the player presses the Start button, the Kinect continuously measures the position of the base of the player's spine. The measurements are averaged over 3 s. The jump and duck thresholds are adjusted from this position.

Actual Input: Once the game has found the start position, the game UI moves to the Setting Difficulty screen. The input is filtered by averaging three successive positions to reduce jitter. On the Setting Difficulty screen, the player is prompted to jump as high as possible. A minimum height of 10 cm is required to start the game. This difficulty factor impacts the jump speed, duck, and slide distances. This game is designed by keeping the maximum height reached by the player as 30 cm, for which the game character can jump at a maximum speed of 25 units per sec. So, to determine the difficulty level, this jump height (in cm) is divided by 30 to give a difficulty factor of 1.

This difficulty factor is adjusted to the present child's height by dividing with the designed height of 30 cm. If the difficulty increases, then the child has to jump higher for the same result in the game.

2.5 Player Movements

Camera & Scenery: As described previously, the back camera is placed behind the player and faces in the positive Z axis direction. It follows the player only along the Z axis. Such placement of the camera creates a third person perspective; therefore the game is defined as a 2.5D game rather than a 2D game. Every plane, except the tiles in this game, face the negative Z axis because the back camera, which faces the positive Z axis, is the default view. As every object faces the camera, object textures can be seen. In addition to the tiles and game items, a large plane with a mountain backdrop texture is placed in front of the in-game character. This plane also moves as the player progresses along the Z axis. This creates a parallax effect that gives the illusion that there are mountains in the distance.

Run: By default, the in-game characters speed is set to running. For every frame, the in-game character moves a set distance along the positive Z axis, away from the origin. This is the pace of the game.

Jump: For the in-game character to jump, the player must exceed a jump threshold, which is calculated as soon as the start position is computed. These threshold values can be reduced by reducing the Kinect ratio slider in the options menu. If the player exceeds the jump threshold, then the speed of the jump is calculated by dividing the distance between the latest and the last stored position with the time difference of the two positions. The difficulty factor is applied to the speed by dividing the speed with difficulty factor. If the difficulty factor is high, then the speed will be less than normal.

Duck: Similar to jumping, the averaged input position is checked with the duck threshold, which is by default set to 11 cm below the starting position. If the player goes below this threshold, the in-game character ducks. Ducking ends when the player exceeds the duck threshold and the state of the in-game character is set to running again. Similar to jumping, the distance moved by the player is divided by the difficulty factor, so the in-game character moves less than normal for the same movement on a higher difficulty setting.

Slide: Sliding is calculated for each frame. The distance between the averaged input position and the starting position is calculated along X axis and converted to in-game units. This distance is used to move the in-game character to that position along the X axis (negative X axis for the left side and positive X axis for the right side). Similar to ducking, the difficulty factor determines the magnitude of the in-game character's sliding movements. In-game character movements are restricted to the game-play area. This prevents any erratic inputs from the Kinect device.

Hop: A hop is achieved by placing consecutive rows of river tiles closer together such that jumping over one is immediately intervened by jumping over the next. This spatial constraint necessitates a hopping sequence.

Other objects. To optimize game efficiency, only 30 rows of tiles are instantiated at the start of the game. Similarly, only 15 objects of each type are instantiated at the start. Tiles that are programmed to have objects in them choose from the unassigned instantiated objects depending on the object type. Power-ups are treated differently in the code to allow a tile to have both an object and a power-up. As the player progresses, the tiles and objects that are behind the in-game character at a distance greater than one tile are unassigned. These reset in the furthest row from the character with the next row from the level design text file. This way, the efficiency is improved by always showing a limited number of objects on screen. When a new row exceeds the number of lines in the level design text file (that is, rows that appear beyond the finish line), then the game generates tiles beginning again from the first row. This creates the illusion of objects even beyond the finish line.

Collision. Collision is only checked between the in-game character and the objects. Since the player path comprises only the middle three rows only collision with those are checked. When the in-game character is in the running state, the character is always in contact with the ground and the distance between water, pond, river, stone and log tiles are checked. While jumping, the in-game character is not in contact with the ground, so only the stone and log tiles are checked for collisions. Figure 17 shows how these constraints are checked in a 3D space, even though the player and the stone are planes.

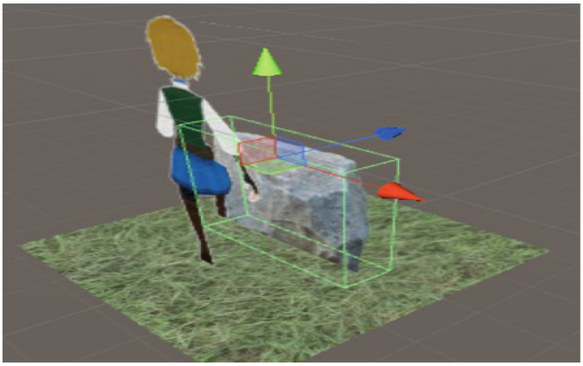

Fig. 17. An example of an imaginary collision rectangle over a stone (plane)

Duck: Collisions for water, pond, river, stone tiles are checked similar to the running state. However, height is also checked for the log. If the in-game character's height from the ground tile is more than 30% of the player's original height, then a collision is recorded.

Power-Ups: Collisions are checked along the Z axis regardless of the player's state. The player can finish or obtain power-ups by contacting the tile.

Hit: Player health decrements by 25%, if they are Hit. The complete depletion of health results in the player losing a life. The current level restarts after each complete depletion of life, up to three times. The game terminates after the third complete depletion of life in the same game.

3 Usability Assessment Results and Discussion

Questionnaire responses were analyzed and delineated as positive and negative comments. Responses were also explored to identify participants' recommendations for improvements. Participants were between 4–8 years old. Therefore, some of the participants' verbal responses seemed incomplete. On question 1, 86% of participants had positive general impressions of the game. Examples of responses include, "I liked it," and "it was good." One participant said the game was "okay," and cited that graphics and a glitch episode while completing a ducking task during gameplay. On question 2, 14% of participants reported feeling "a little dizzy" during gameplay. On question 3, 14% of participants reported experiencing pain or discomfort. They stated: "my feet hurt a little bit actually." On question 4, 43%, 43%, and 14% of participants reported ducking, jumping, and sliding as their perceived easy task, respectively, during gameplay. On question 5, 86% of participants reported jumping, jumping over water and lava, and jumping immediately from a ducking position as the difficult tasks. Interestingly, 14% reported the entire game as difficult.

On question 6, 86% of participants used adjectives like "perfect," "love it," "awesome." One participant described the game as "decent." On question 7, 100% of participants stated that they would play again, if they had the chance. On question 8, 86% of participants stated that they would recommend their friends to play the game. The only participant who answered “no” to recommending the game to their friend previously described the game as “awesome.” Therefore, it is plausible that the participant may have misunderstood the question. On question 9, 100% of participants reported feeling the game could help them. On question 10, 71% of participants articulated specific ways that the game could help them. Examples include “it makes me exercise and jump; run; my dad always jogs,” “by doing more exercise and get to more levels in the game,” “it can help me jump higher and faster and duck.” One participant stated that they did not know. On question 11, participants made several recommendations, including, “maybe change the graphics and change the character,” “making it easier to win,” “making it easier by not having the lava crack so wide; you have to jump really high for those.” On question 12, 42%, 29%, and 29% of participants were described (by their parents) as always active, often active, and sometimes active, respectively.

All the participants were able to deploy the requisite movements (i.e., jumping, ducking, sliding, and hopping) for gameplay. In consistence with the expectation that age mediates motor skill development, Fig. 18 shows a linear relationship between the maximum height jumped and age. Interestingly, one four-year old participant (whose parents reported him as always active) jumped approximately as high as eight year-old participants during gameplay (Fig. 18). Although participants’ PA structure and content are not available for this assessment, the approximate parity between the four and eight-year olds’ performances may in part underscore the mediating role of exposure to specific movements within PA. This assessment was not intended to compare participants’ performances. Rather, it aimed to establish the usability of the game among children aged four to eight years. Participants had three attempts to complete each level, after which gameplay terminated. None of the participants progressed beyond the second level. These player gameplay progression outcomes may have differed, if participants had more opportunities to play the game outside the constraint imposed by the assessment structure and schedule.

4 Limitations

The current game prototypes a design concept to accommodate ambulatory children across a wide range locomotor skills. The effectiveness of the game at improving leg stiffness regulation and movement competence needs to be investigated using a longitudinal design. Also, none of the children in the current sample had IDD. It remains unclear how a child with IDD will perceive the game. Although the current implementation is highly flexible and makes game objects editable, it does not dynamically generate levels; rather, it uses a fixed set of levels. Games of this nature can become repetitive, and the child may eventually lose interest. This game features a random generation of similar obstacles prior to each level. Future designs should implement different asset packages at random for different levels, in order to facilitate long term engagement. Although they remain commercially available, Microsoft has discontinued Kinect v2. However, its Project Kinect for Azure promises improved image sensing

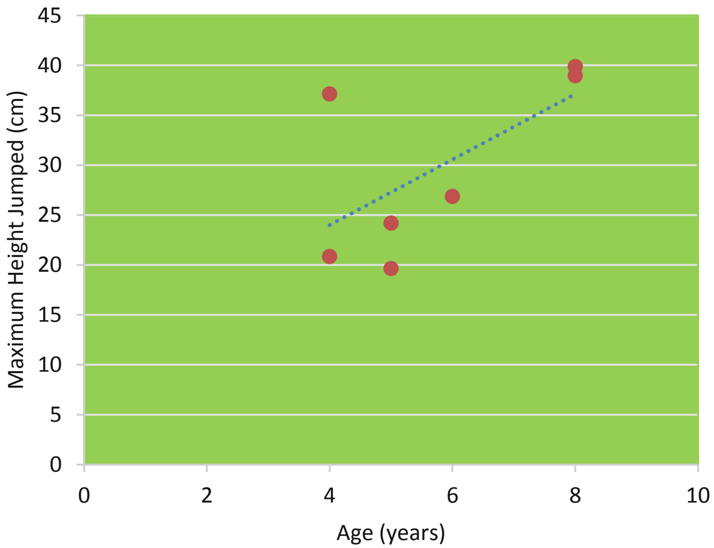

Fig. 18. Plot showing the relationship between the maximum height jumped and age

technology (e.g., spatial skeletal tracking and object recognition) for applications, including game development.

5 Conclusion

The capacity to set gameplay difficulty based on the player's physical ability (i.e., maximum jump height) and customize the spatial organization of game objects makes this game suitable for ambulatory children across a range of parent-reported PA levels. Players and parents can implement these customizations according to locomotor training needs or sheer preference, without any requisite background in coding. While the game is not intended to replace PA or active play outdoors, participants affirmed that the game could help them and would play again, if they had the chance. Therefore, the game will present children additional opportunities to practice regulating leg stiffness by deploying skills like jumping and hopping, even when being outdoors may not be feasible (e.g., in the event of adverse weather). Input from participants suggests that future design explores improved game graphics. Results of the usability assessment suggests that children aged 4–8 years found the engaging and potentially beneficial with regards to promoting locomotor tasks like jumping.

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Games for a Good Cause: Serious Games in Social Development and Medical and Rehabilitation Therapy

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Abstract. Playing games has often been associated with negative behaviors like playing and not taking things seriously or even wasting time. However, more recently researchers started looking at the positive impacts of playing games or what became to be known as serious games. This study examines the major publications in the usage of serious games in therapy, training, and behavior development. The study analyzed the most cited papers in the field and evaluate what has been done so far.

Keywords: Serious games · Therapeutic games · Game design

1 Introduction

Salen & Zimmerman defined the game design process to emphasize the relationship of the game with its player, when they wrote "*Game design is the process by which a game designer creates a game, to be encountered by a player, from which meaningful play emerges*" [1]. Games have been used in different environments outside the entertainment and fun fields. Majority of the initial research that was conducted on video games was to evaluate the negative impacts of playing digital games. However, there was also an interest in the positive impacts of computer games [2]. This research attempts to evaluate the previous research conducted on the usage of serious video games for therapeutic and training purposes.

2 Methodology

This paper is an attempt to survey the field and evaluate all the publications of usages of serious games. The initial idea was to search certain keywords on the major databases. The keywords were a combination of Hedonic, Serious, Educational, Learning, Therapeutic. They were combined with each of the following keywords: Game, Gamification, User experience, play experience, User behavior, Education, Training, Technology, Technical, IS, System, Business, Marketing, Management, Service, E-Commerce, Online, Streaming, HCI, Communication, Social, Adoption, Enjoyment, Entertainment, Multimedia, Game play. The 75 unique combinations of these keywords were then searched for on the major scientific databases including: ACM, IEEE,

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PsycInfo, ABI, Science Direct, and Science Citation Index. The top 100 results were then exported to an Excel sheet with about 7500 search results. Reviewing these articles wasn't doable while keeping the research up to date. So, a decision was made to use the same keyword combinations and instead of the different databases, a single "Google Scholar" search was performed, and the 10 most highly cited results were exported for review. However, that would still be a long project with about 750 articles to be reviewed. So, we decided to reduce the number of keywords and use the 4 most important keywords: Therapeutic Games, Training Games, Serious Games, & Educational Games. The search for these keywords was performed on Google Scholar and the top 25 most citied papers were collected for each keyword search (total of 100 articles were downloaded and evaluated).

The final review was conducted, and this paper is the general outcome of evaluating the most highly cited papers related to therapeutic, serious, and training games on Google Scholar.

3 Previous Research

Computers, technology, & the internet are becoming a normal part of life for millions of people especially children [3], and with that there has been an increased interest in utilizing those technologies for health purposes. For years, video games were associated with entertainment and fun. However, interest in other types of games has been increasing recently. Serious games for instance, is one of the areas were video games have caught researchers interest, specifically serious games in therapeutic sessions [4, 5]. "*Game-based methods and concepts and game technology are combined with other ICT technologies and research areas applied to a broad spectrum of application domains ranging from training, simulation, and education to sports and health or any other social relevant topic or business area*" [6].

Many researches have attempted to define serious games over the years, however one of the most comprehensive definitions is the one introduced by the Guardiola and co-authors [7] where they define serious games as: *"A serious game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome. But a serious game is combined with a defined real life objective"*. They explain that the main difference between a regular video game and serious games is when designing serious games there is an attempt to impact the real life of the player.

Video games are used to help motivate patients & develop skills, and they are being used in physiotherapy, occupational therapy, & psychotherapy [4, 8, 9]. Nearly 30 years ago, Gardner [10] argued that children's repertoire of problem solving strategies can be observed better through integrating commercial video games in child's psychotherapy. And McCallum confirmed that: *"Computer games and personalized health share the ability to place the individual in the center of the action, they provide challenges that match the skills of the player"* [11].

In their article [6] the researchers discuss exergames: *"which are a combination of methods and concepts of serious games, adaptation and personalization, authoring* *and sensor technologies"*. They proposed a framework for serious games in sports and health aiming to motivate players to sustain regular workouts and improve into healthier lifestyles.

Previous intensive research was performed by Swank [12] where they explored the use of games in relation to the theoretical structure of social learning, cognitive behavior, psychoanalytic, and gestalt theories from many of the classical studies within the literature. They state that the origins of gaming in therapy go all the way back to the 70's, but games can be one or a mixture of these types:

- Games that involve physical skill, and the outcome relies on participants' gross and fine motor skills
- Games of strategy, which focuses on rational problem solving
- Games of chance, which results in outcomes uncontrolled by the participants

Swank [12] argued that it all depends on the therapists' judgment on which type of game they should use with each patient. Depending on what kind of therapy is anticipated, the type of game can be defined. Each game would have some therapeutic components within it, and those components could be:

1. Games can enhance the therapeutic process by assisting with reducing resistance present during the beginning stage of therapeutic process including the anxiety of entering therapy
2. Games create a natural environment allowing clients to relax which enables the expression of feelings with less conscious
3. Games assist in creating a safe place promoting a relaxed atmosphere, which leads to the development of natural communication
4. Games allow players to learn and try out behaviors to determine whether they are socially acceptable or no

There has been an attempt to design an evaluation method for games used in therapy. Mader and co-authors [13] introduced a new model to analyze therapeutic games. They introduce a game called: "Le Village Aux Oiseaux", which was built through a partnership between 4 game makers and 2 research labs, with the intention to help the therapy of Alzheimer's patients. This game was the basis for the design model they introduced later on in their research. The objective behind this model was:

- They wanted to analyze existing therapeutic games to find their interesting features
- The model is intended to facilitate the game designer's work during the design process.

The model is simply based on the relationship between the therapy, the player, & the game, and their underlying relations and its importance in designing games for therapy. In order to properly evaluate each game, the researchers suggest that the analysis focuses on each of the 3 main elements and ask the following questions [13]:

– Therapy: the most important element of therapy within the model is: What the therapy can improve? What is intended and what is expected?
    - Expected short-term therapeutic value: e.g. burning calories, improving attentional network

    - Expected long-term therapeutic value: e.g. definitive recovery, life-long supporting therapy
    - Scientific proof of efficiency: e.g. long-term effects demonstrated, to be evaluated, discussed
    - Scientific references: Do similar useful games features have been scientifically evaluated in other games?
- Player: the most important element of the player within the model is: to understand what the target is able to do and learn regarding its health condition.
    - Age range
    - Gender
    - Particular conditions: e.g. early states of the Alzheimer disease, motor control loss in upper limb
    - Abilities: Regarding their age and particular conditions, which are the knowledge and abilities (i.e. motor control and cognitive functions) of the player? Are they likely to present other particular conditions?
- Game: the model proposes to analyze the gameplay of therapeutic games from the challenge (goals, feedbacks, scores, and difficulty) and variability perspectives.
    - Input system: How does the player interact with the game?
    - Output system: How does the game convey information?
    - Goals: Are there appealing goals? Are they short, mid or long-term goals?
    - Feedbacks: Which means are used to communicate with the player? Are they informative on the player performance or progression?
    - Score: What does the score mean? (e.g. player performance, player progression, health improvement) Is the score informative on the progression towards mid or long-term therapeutic goals?
    - Difficulty: How is the difficulty level chosen? (e.g. adaptive, manually chosen by the player, manually chosen by another person) If adaptive, how does it work? Which parameters of the game are modified by the difficulty level?
    - Variability: Does the game propose enough variability? (e.g. the player is always doing the same sequence of actions, the player learns regularly to master new patterns, the player can choose his own path within the game, the player has to create new strategies to progress)
    - Usability: What are the minimal abilities and knowledge necessary to play the game? Does the game features tutorials and explanations?
    - Expected positive side-effect: What can the game provide to the player that is not part of the therapy itself?
    - Reported serious uses: Have the game or analyzed features been used for another serious purpose?

3.1 Video Games in Rehabilitation Therapy

Occupational therapy practices change over time, especially with the vast evolution of science and technology, *"Technological advancement continually influence our current practice and occasionally they create new tools for intervention"* [14]. In virtual reality the individuals have the opportunity to forget about the surroundings, where technology is able to provide a natural environment, allowing the patients to focus on the task in the simulated environment [15].

In their paper, Halton [14] discusses how virtual environments work as simulators and how beneficial they are overall. They present some of the challenges in these environments based on the previous literature. Finally, it introduces the Nintendo Wii as a practical example of Virtual Environments, it talks about practically using the Wii at the Glenrose Rehabilitation Hospital. They finally present how beneficial it is for therapy if rehabilitation, engineering, computer science, and industry would partner together to create something ultimate.

On the other hand, video games are also being widely used in brain injuries rehabilitation. In their article [16] the researchers discusses how can the design of simple video games have a positive impact on stroke rehabilitation patients. Their target patients in the study were the upper limb stroke rehabilitation patients. Their idea is to develop custom low-cost video games that can be deployed at home, as most of the video games used in rehabilitation revolve around a functional activity. However, it has been argued that integrating games into virtual reality environments can be highly motivating to patients. From the game design theory, the researchers have identified two main design principles that are related to rehabilitation:

1. Meaningful Play: a clear relation between the user's action and the system's outcome.
2. Challenge: have a balanced challenge level so it is not too easy that makes it boring, nor too difficult making it impossible to win and lose interest.

The researchers were able to design few simple games, test them, and analyze the results. The analysis showed positive impact on patients using these simple game designs with clear goals.

Using games doesn't serve to only improve the rehabilitation process, but the researchers [17] also argue that the journey of motor skills rehabilitation can be very boring to patients, especially the elderly ones. The researchers performed a comprehensive search on all different design criteria created in the past literature, criteria included:

- Designing for stroke rehabilitation:
  - Adaptability to motor skill level
  - Meaningful tasks
  - Appropriate feedback
  - Therapy - Appropriate
- Designing to entertain the elderly:
  - Appropriate cognitive challenge
  - Simple objective/interface
  - Element of social activity
  - Appropriateness of genre
  - Creation of new learning

After compiling the list of papers that meet the search criteria, they evaluated the commercially available used games in rehabilitation and performed an analysis of how these games comply with the design criteria. The majority of these games scored high on their criteria, which indicates that using games in therapy can actually engage patients into the rehabilitation process.

In their paper, [18] the researchers discuss the usage of games in stroke rehabilitation patients and how a portion of stroke patients can expedite their rehabilitation journey through performing 100 s of daily reputations of motions with their affected limbs. they discuss the possible impacts of strokes on different people and how different patients react to different rehabilitation techniques differently. Most of these techniques are based on certain motion activities the patient will perform on daily basis to enhance their affected motion abilities. The objective of their research is to create a game authoring system in which therapists can create or customize games for use by individual patients. Based on the initial analysis they performed in correspondence with therapists, it showed that the main concern is the lower extremity rehabilitation in post-stroke rehabilitation to re-gain mobility while in the rehabilitation, however the upper extremity rehabilitation can happen in sessions after discharge or while at home. They analyze current gaming platforms available in the commercial market and what games therapists are currently using in post-stroke rehabilitation. After many brainstorming sessions with the therapists, they identified 3 main attributes in the space of rehabilitation game design:

- Social Context
- Type of Motion required
- Cognitive Challenge

They finally share some of the lessons learned while conducting this study when it comes to designing games for post-stroke rehabilitation:

- Making games playable for a broad range of stroke patients
- Ensuring that games are valuable for a therapeutic perspective
- Making games fun and challenging

Another study to verify the usage of video games in long-therapy for post-stroke patients was the research introduced by Alankus et al. [19]. They focused on the complications and the problems that could happen when the patient is performing therapy alone (at home), where people with limited motion often compensate for the lack of motion in one joint by moving another one. This eventually creates another problem rather than solving the original one. The objectives behind this study were:

- An iterative, formative study of a method for detecting torso compensation.
- A validation study that quantifies our torso compensation method's error as compared to a motion capture system.
- An iterative, formative study of a game design, requiring therapeutic exercise and eliciting natural compensation.
- An iterative, formative study of in-game compensation feedback mechanisms that discourage compensation.
- A summative study comparing compensation behavior in versions of our game with five different operant- conditioning strategies for reducing compensation.

The outcomes of their research were a methodology to reliably sense compensatory torso motion in the context of shoulder exercises done by persons with stroke as well as designing and experimenting evaluation of operant-conditioning-based strategies for games that aim to reduce compensatory torso motion.

An interesting study was conducted by Cheng et al. [20], where the researchers argue that different game design patterns affect the impact on brain injury rehabilitation. They discuss that brain injury therapists use a mixture of commercial and specifically designed games in their therapy. They mainly look at the design elements (that usually impact the patients' engagement with the game) and at how much those games meet the therapy objectives and goals. They explain that there is a big gap in the literature when it comes to research conducted on the impact of game designs in brain injury therapy. This paper argues that research on game design patterns is beneficial because [20]:

1. *"Game design patterns have the capacity to capture the information about brain injury rehabilitation needs in a fixed structure to facilitate expansion of game design knowledge"*
2. *"Patterns have the ability to distill abstract game design knowledge from a large amount of data about how well existing games worked in therapy into a set of coherent and tangible exemplars"*
3. *"Patterns as a common language can serve as a valuable tool to facilitate effective communication and mutual understanding among game designers and therapists"*

They collected data from a dataset that contains 566 games therapy cases and analyzed them to generate a list of 14 efficacy-centered game design patterns. These patterns focus on game design considerations when addressing therapeutic goals in brain injuries rehabilitation.

3.2 Video Games in Pain Management

Many studies have used video games as a distractor in managing pain. The idea behind it is that distraction consumes some degree of the attentional capacity that otherwise would be dedicated to pain perception [9]. In their paper [21], the authors discussed how video games can be used as distractors in pain management, especially in children, and argued that:

- Videogames are likely to engage much of a person's individual active attention because of the cognitive and motor activity required.
- Videogames allow the possibility to achieve sustained achievement because of the level of difficulty (i.e. challenge) of most games during extended play.
- Videogames appear to appeal most to adolescents.

Another attempt to use video games as a distraction in managing pain was the research introduced by Parry et al. [22], where they argue that interacting with video games like the Nintendo Wii & Play Station Eye Toy encourages range of motions while distracting from pain. Their objective was to evaluate the specific demands of interactive video games in relation to use in burn therapy goals and how will that determine their therapeutic benefits and guide their use in burn rehabilitation. They study the upper extremity motion of 24 healthy children while interacting with 2 interactive games (that have been used in burn therapy in the past). Their analysis supported the idea that interactive video games offer activities with therapeutic potential to improve range of motion for burn patients.

3.3 Video Games in Training & Skills Development

A recent study [23] analyzed how playing video games can enhance visual attention and identified an: *"Increased ability to process information over time and an increase in the number of visual items that can be apprehended"*. It also discussed spatial distribution, which: *"enhanced allocation of spatial attention over the visual field"*. The study found a positive correlation between playing video games and visual attention processing. Note that virtual reality video games that include a simulation training, can potentially help in acquiring complex real life skills, where skill transfer wouldn't require force feedback if the visual information compensates [24].

In their paper [24], the researchers discuss the contribution of playing video games on the surgical skills surgeons develop while performing laparoscopic surgeries and suturing. The hypothesis was that younger surgeons might acquire surgical skills faster than their older colleagues due to their past video games exposure. Previous studies have also shown that exposure to video games can lead to better skills in video endoscopic procedures. 31 surgeons have participated in this study, all from the same hospital. After analyzing the results, there was a significant positive relationship between playing video games and enhancing surgical skills in a laparoscopic environment [24].

3.4 Video Games in Behavior Development

A recent suggestion was made to utilize appealing video games to develop the moral level of the youth [25, 26]. Thoma and the co-authors [27] assumed that moral development is related to moral behavior. However it is argued that behavior values are developed by the youth through their interaction with other youth groups [25, 28]. It is also argued that "*basic moral norms and principles are structures arising through experiences of social interaction*" [29]. And thus, individuals are influenced by natural behavior norms and are likely to want to belonging in a group, allowing us to determine in high context the individual's behavior based on the groups moral behavior [30].

In their paper [31], the researcher discusses how they used the "Moral Development Measure MOTEC" [32] in measuring the effects of playing a video game for a period of time on moral development. Then the moral levels were categorized according to Bull's theory of four stages of moral development [33]. The study used 6 indices of moral development, and 3 of those indices (moral stages, punishment, and post transgressional reactions) revealed a positive effect on the participants [31].

The researchers in article [34] points the difficulty therapists face in engaging with adolescents who experience increased mental health problems. Unfortunately, most of those patients don't receive therapy help, and if they do, only few of them would fully engage with therapists. A report from the US General Surgeons [35] discuss the main reasons for these difficulties as:

- Feeling that no person or service could help.
- Feeling the problem was too personal to tell anyone
- Feeling they could handle the problem on their own

The researchers describe the work done in building a 3D game based on a therapy design model that will help adolescents with mental health problems to fully engage with therapists. They suggest that computers can assist in the communication between therapists and teenagers. They build the game and test it in a session with few candidates. They divided the approach into 5 therapeutic conversational strategies:

1. Setting Goal: knowing what do we want to achieve?
2. Recognizing Exceptions: assessing the patient in case the symptoms are not present to repeat the activity/task when it is more acute
3. Coping: help patients learn new techniques in dealing with their problems
4. Identifying resources: Help identify resources to help with therapy like family and friends
5. The Miracle Question: "Imagine you woke up tomorrow and the problem was solved, how would your life be different?"

Additionally, the researchers [36] discuss how a specially designed game was used for cognitive behavior therapy with children who come into treatment for various mental health problems. They attempted to evaluate the applicability and appropriateness of the game and 124 therapists were asked to answer a questionnaire on their impression of the "Treasure Hunt" game after using it for 3 months. Next, 42 of those therapists volunteered to participate in further evaluations and sent questionnaires to 218 children in whose therapy the game Treasure Hunt was used. The analysis showed a positive impact on the children that used the game in therapy.

4 Conclusion and Final Thoughts

The usage of commercially available games in therapy, training and education started almost half a century ago. Since then, practitioners agreed that although they are able to use those commercially available games, there is a need to design specific games that can assist more effectively in therapy, education, & training. The high cost of designing such games seems to be the main barrier to such action. Nevertheless, there are few successful attempts where game designers joined forces with therapists and designed specific games to support rehabilitation therapy. However, those initiatives were limited in scope and didn't generate any major awareness.

Annex A

See Table 1

Table 1. The number of citations as of Feb 24th, 2019

Citation	Number of citation
Salen, K., K.S. Tekinbaş, and E. Zimmerman, Rules of play: Game design fundamentals. 2004: MIT press	6833
Connolly, T.M., et al., A systematic literature review of empirical evidence on computer games and serious games. 2012. **59**(2): p. 661–686	1653
Bremer, J.J.C. and A.P. Clinics, The internet and children: advantages and disadvantages. 2005. **14**(3): p. 405–428	83
Annema, J.-H., et al. Videogames in therapy: a therapist's perspective. In Proceedings of the 3rd International Conference on Fun and Games. 2010. ACM	85
Sawyer, B. and P. Smith. Serious games taxonomy. in Sides from the Serious Games Summit at the Game Developers Conference. 2008	331
Göbel, S., et al. Serious games for health: personalized exergames. In Proceedings of the 18th ACM international conference on Multimedia. 2010. ACM	197
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Schultheis, M.T. and A.A.J.R.p. Rizzo, The application of virtual reality technology in rehabilitation. 2001. **46**(3): p. 296	505
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Flores, E., et al. Improving patient motivation in game development for motor deficit rehabilitation. in Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology. 2008. ACM	214

(*continued*)

Table 1. (*continued*)

Citation	Number of citation
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Alankus, G. and C. Kelleher. Reducing compensatory motions in video games for stroke rehabilitation. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 2012. ACM	33
Cheng, J., C. Putnam, and D.C. Rusch. Towards efficacy-centered game design patterns for brain injury rehabilitation: A data-driven approach. In Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility. 2015. ACM	11
Redd, W.H., et al., Cognitive/attentional distraction in the control of conditioned nausea in pediatric cancer patients receiving chemotherapy. 1987. **55**(3): p. 391	257
Parry, I.S., et al., Commercially available interactive video games in burn rehabilitation: therapeutic potential. 2012. **38**(4): p. 493–500	31
Green, C.S. and D.J.N. Bavelier, Action video game modifies visual selective attention. 2003. **423**(6939): p. 534	2489
Rosser, J.C., et al., The impact of video games on training surgeons in the 21st century. 2007. **142**(2): p. 181–186	644
Sherer, M.J.C.J. and Behavior, Peer group norms among Jewish and Arab juveniles in Israel. 1991. **18**(3): p. 267–286	14
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Thoma, S.J., et al., Describing and testing a moderator of the moral judgment and action relationship. 1991. **61**(4): p. 659	121
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Realizing User Privacy and Security Issues in Edutainment e-Solutions

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Abstract. Edutainment set a unique approach for incorporating learning enriched with dynamic platforms of multimedia end enjoyment. Computerized systems built with edutainment philosophy represent an extended mechanism for wider user space and educational functionalities. Similar to other computer applications and systems, cybersecurity remains an obvious challenge for system users operators. In this paper, we review general categories of cybersecurity challenges that can affect edutainment systems. We also suggest practical recommendations that should be considered by designers and operators to improve cybersecurity resilience of edutainment systems.

Keywords: Edutainment · Cybersecurity · Identity and access management

1 Introduction

1.1 Edutainment

In the last 10 years, there has been an increase of Internet social network applications, an increase in the number of users of the internet, and an increased number of connected merchants, products, and services. More connectivity means changing environments that would lead to different user experience in different fields in the real world: education institutions, healthcare providers, financial companies, marketing agencies, etc. All of this had led to the convergence of different areas of technology that eventually created new hybrid technologies. Terms like gamification and edutainment are becoming commonly used by major software vendors and application providers with considerations in their next upgrade, or maybe already offering an add-on bundle on their existing platforms to add a "fun-flavor".

The term "Edutainment" was first introduced by [1] were defined it as: "is a hybrid genre that relies heavily on visual material, on narrative or game-like formats, and on more informal, less didactic styles of address". However [2] had a different definition: "Technology heavily laced with entertainment but essentially lacking in rigor or value".

1.2 Applied Edutainment

Edutainment is simply merging technology, entertainment, and education. Technology is more than just machines that stores data, execute commands, and display results. In their report [3] explained how they look at technology as: "The new technology is not

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just an assemblage of machines and their accompanying software. It embodies a form of thinking that orients a person to approach the world in a particular way. Computers involve ways of thinking that under current educational conditions are primarily technical. The more the new technology transforms the classroom into its own image, the more a technical logic replaces critical, political and ethical understanding. The discourse of the classroom will center on technique, and less on substance. Once again 'how to' will replace 'why'."

So, implementing technology in the classroom is part of the journey into making learning more fun and interactive. However, there is always the fear of associating education with fun and entertainment. As [4] argue that if the technology is implemented in education without cautiously examining the environment then learning becomes an obstacle that needs to be overcome. "such an approach doesn't promote learning; it trivializes the learning process." [4].

1.3 Common Edutainment Models

There have been many attempts to evaluate technology's role in education, more specifically game-based learning. In his model Ehrmann [5] introduces the Flashlight framework, where he attempts to assess the relationship between 3 main constructs: The technology, the activity that uses the technology, and the education outcome. Another attempt was the CIAO! framework introduced by Jones et al. [6] where the researchers examined the context, the interaction between the learners and technology, and the attitudes and outcomes. However, what all of these attempts had in common is the intention to consider technology in general.

On the other hand, one of the major comprehensive models in edutainment is the game-based learning framework introduced by De Freitas, Oliver, and education: "The model requires the practitioner to consider four main dimensions in advance of using games and simulations in their practice" [7]. The 4 main dimensions of the framework should be considered when evaluating the environment that the tutor will undertake before implementing and game/technology into space.

- 1st dimension is: **Context,** where factors like historical, political and economic contextual factors as well as the availability of specific resources and tools are considered.
- 2nd dimension is: **Learner,** where attributes like age, how individuals learn in their learning backgrounds, styles, & preferences are considered.
- 3rd dimension is: **Internal Representational World,** which is simply the mode of presentation, the interactivity, the levels of immersion, and the fidelity used in the game or simulation [7]
- 4th dimension: **Process of Learning,** and this includes both during the course of formal circular-based learning and during the informal learning. This dimension focuses on the practitioners' reflection on methods, theories, models, and framework used to support learning practice.

"The four dimensions together provide a framework for a consideration of both existing and future educational games & simulations, and may also be applied to other forms of e-content where immersive spaces are used” [7]. What makes this model unique compared to other models is:

- Its’ flexibility and ease of use
- Ability to help practitioners to reflect upon their own learning process
- Support for tutors aiming to develop practices and tools into the classroom
- Identify how software tools can support curriculum content most effectively

Learner Specifics Challenge Conflict Progress	**Pedagogy** Adaptation Assessment/Feedback Debriefing/Evaluation Instructions/Help/Hints Safety
Representation Action-Domain Link Control Interaction (Equipment) Interaction (Interpersonal) Interaction (Social) Location Problem-Learner Link Representation Sensory Stimuli	**Context** Fantasy Goals/Objectives Language/Communication Mystery Pieces or Players Player Composition Rules Theme

Fig. 1. Game-based learning framework [7]

2 Cybersecurity Prospective

In this paper, we limit our research to studying cybersecurity challenges and mitigations to computerized forms of edutainment systems, including web apps and handheld or wearable consumer devices. In a simplistic form, cybersecurity is defined as processes, practices, and technologies designed to safeguard computing systems and infrastructure from malicious and destructive activities from – typically unauthorized – users [8]. Cybersecurity generally extends to cover all modern computing domains, such as communication networks, backend database and storage systems, and frontend application interfaces [8, 9].

We believe studying cybersecurity factors in the context of edutainment systems not only helps elimination of possible disruptive impacts to educational experiences, but also provisions prospects for founding effective and scalable educational solutions with farther outreach and deeper user penetration. Such a study becomes further critical when realizing - through prior research – that significant number of online social networks and e-learning platforms’ users are categorized as youth and adolescence

[10], a fact that practicality may subject edutainment systems to adhere legal, industrial, or environmental compliance mandates [10–12].

In subsequent sections, we continue this study by examining common categories of cybersecurity risks that can have a direct impact on edutainment systems. We then survey research work in human-computer interface (HCI) domain aimed to identifying cybersecurity elements that can help improving user experience without jeopardizing system usability aspects. Afterward, we propose an architectural framework that aligns typical edutainment systems' functional requirements as well as corresponding cybersecurity controls (Fig. 1).

2.1 Common Forms Cybersecurity Challenges

This section summarizes common forms of cybersecurity challenges that potentially can have a direct impact on edutainment systems. The analysis considers the forms of challenges mainly based on the source of threat, nature of the potential impact.

In general, prior research works [13, 14] classify cybersecurity into four categories:

- Disclosure: unauthorized access and release of proprietary and private information
- Deception: contaminating information to have incorrect representation or meaning
- Disruption: affecting the availability or quality of information and services
- Usurpation: malicious control of system components.

However, we restrict analysis in the following sections to potential cybersecurity challenges having direct and relevant impacts on edutainment system including cyberbullying, privacy invasion, network intrusion, and malware.

Cyberbullying

Prior research shows that very common forms of cybersecurity risks directly related to edutainment systems while used by relatively young users occur in the form of bullying. Similar to the physical form of bullying, cyberbullies basically aim at disrupting youth while interacting with e-learning applications, through means of peer-to-peer or group chat tools, eventually deterring the users away from their rightful learning platforms [10, 15].

Invasion of Privacy

In the context of information security, invasion of privacy is typically characterized as malicious and unauthorized practices leading to access or disclosure of personal or proprietary information. [12, 16–19]. In the context of edutainment, privacy issues can directly relate to a wide variety of user experience issues, such as disclosure of system users private information, performance records, or financial data. [12, 20]. It's also common that sectors of enterprises seek to access other forms of private user information – like user geolocation, types of software and hardware systems they own, and other contextual data – in targeted marketing campaigns, practices often deemed privacy-invasive. [12, 17, 21, 22].

Network Intrusion

A common risk to all computer systems – including edutainment ones – is malicious network activities conducted by unauthorized attackers [13]. Cybercrimes conducted through network intrusion generally aim at unauthorized access and disclosure of private or confidential data, or to sabotage and affect the availability of offered services, a category of attacks normally referred to as denial of service (DoS) attacks [13, 23]. Providers of edutainment systems clearly need to factor in suitable network security controls [24, 25] to overcome such types of cybersecurity challenges when implementing networked systems.

Malware

Computer viruses and trojan horses have traditionally been regarded as a major method of committing cybercrimes for malicious purposes of destruction of computing resources, identity theft, or disclosure of private or proprietary information [13]. Clearly, risks of malware can have a direct impact on edutainment systems and its users by affecting their availability or quality of service.

Ransomware is a modern variance of malware, where attackers victimize users by obtaining unauthorized access to their computer systems and then rendering critical data files inaccessible, normally by transforming them into formats that the users can no longer read. In order to have the files restored to their original formats, attackers extort the victims to pay monetary ransoms, under the promise attackers will restore the data to its original quality [26–28]. Like other forms of malware, ransomware's possible impact on edutainment systems is likely to be destructive and impairing.

2.2 Cybersecurity Requirements for Edutainment e-Solutions

In this paper, we limit the scope of research interest in Edutainment domain to the specific frameworks that can be modeled into computer-based applications, including online web, mobile, or similar forms of apps. This specification allows adapting existing research work to facilitate analysis and further enhancement of Edutainment applicability and solution offering.

To establish relevance to the Edutainment prospective, we first explain computer security basic requirements expected to improve security for e-solutions. Prior research [13, 14, 23, 29–32] recommends the following parameters:

- Confidentiality: secrecy of information as intended to the authorized user
- Integrity: information remains intact of unauthorized alteration while in transit or storage
- Availability: the state at which systems are expected to be available for user consumption
- Non-repudiation: parties in an information exchange cannot deny actions they commit
- Privacy: personal information is not revealed to others without their permission
- Authentication: parties in an information exchange are uniquely identifiable
- Authorization: access to system interfaces or system data is exclusively granted to the intended user(s)
- Auditing: the capability to determine system transactions, users or processes committed the actions, date, and other confirmation data
- Intrusion detection: the capability to detect attempts to obtain unauthorized access by rogue users or processes.

In addition to the outlined security requirements, researchers [30] highlight that "trust" is a critical cybersecurity quality that users expect to experience in computer applications. When this is mapped to the case of system, users develop the sense of security and confidence that such applications are designed to meet the following criteria:

- Convey features: systems should be designed to inform the users on their security features and capabilities.
- Visibility of system status: systems should make their security status observable to their users.
- Learnability: system interfaces should be intuitively designed to enable users to learn how to use them.
- Aesthetic design: that displays relevant security information to users
- Errors: error message should be relevant and provide support to the users to resolve system issues.
- Satisfaction: enable the users to have a satisfactory experience

3 Addressing Cybersecurity Challenges

This section discusses recommendations on approaching the analyzed cybersecurity challenges to facilitate provisioning edutainment services inline with the defined cybersecurity technical and functional requirements.

4 Enforcement of Identity and Access Management

Identity and access management (IAM) is a suite of processes and all underlying technologies for the creation, management, and usage of digital identities in a computing landscape. In practice, it covers the process of establishing the identity of users and govern the activities or services that users can perform or consume. [17, 33, 34]. IAM supports a range of security services including authentication, authorization, and activity auditing.

Incorporating IAM controls into edutainment systems is expected to considerably address its cybersecurity challenges. For instance, implementing strong authentication modules into application interfaces will enable users to be granted secure access preserving experience and confidence in the system. Enforcing granular authorization rules for different categories of system users is critical to reduce or eliminate unauthorized access and disclosure of confidential information. Moreover, IAM can provide the processes and tools to achieve advantages to edutainment systems including:

- System assurance and user trust, as the IAM inherently ensures such qualities are maintained through the authenticity of users and systems.
- Preservation of confidentiality and privacy to system data and user information.
- Ensure data integrity by restricting access to users only if their identities are verified and according to authorization their functional roles.

- Misusers of system resources cannot repudiate their actions as IAM ensures accountability.

In the context of edutainment systems, we suggest a simplified IAM framework typically capable of accommodating relevant cybersecurity requirements:

4.1 Adopting a Secure Computing Model

A major milestone for edutainment system owners to consider is the development and maintenance of a rigid, resilient, and effective security computing model. Centered around a thorough IAM program, such a model should be adopted to address additional security requirements, especially the high availability of system resources to combat the effects of network threats including DoS and malware attacks (Fig. 2).

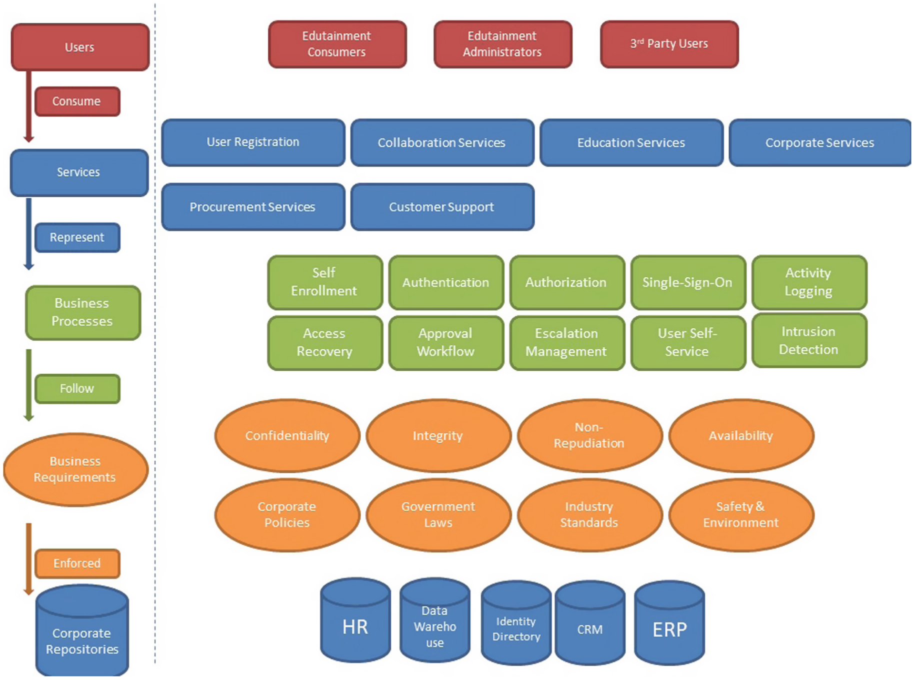

Fig. 2. IAM framework for edutainment systems

An interesting applicable model is the one by Romansky and Noninska [12] who suggest a secure computing model for e-learning applications that follow the National Institute of Standards and Technology's (NIST) visual model for cloud computing. This model features a layered architecture of system backends and application interfaces and draws functional boundaries that address the cybersecurity requirements suggested for edutainment systems. Clearly, this model, shown in flowing figures can be adapted to meet similar functional designs for edutainment systems:

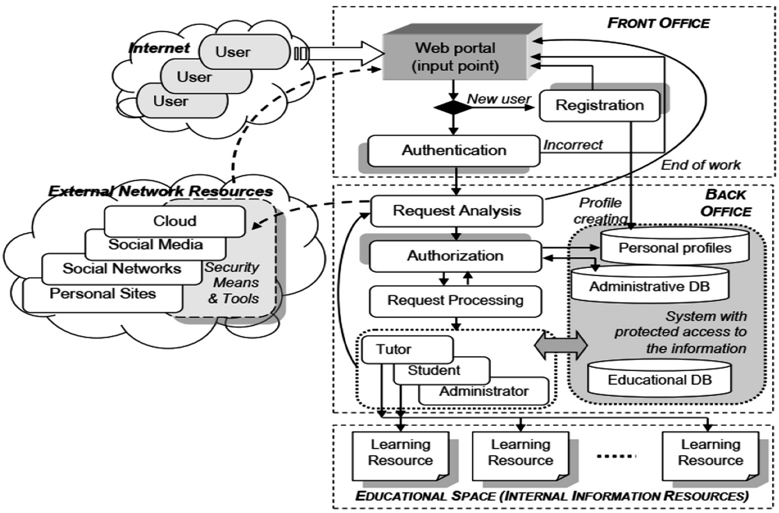

Fig. 3. Architecture of Combined e-learning environment [12]

5 Conclusion

In this paper, we briefly identified edutainment systems and conducted a brief analysis of potential categories of cybersecurity challenges that can impair its values to users. While Edutainment systems can take a variety of forms to deliver its services, online-based solutions follow other computing service models when considering cyber risks (Fig. 3).

Edutainment systems need to incorporate cybersecurity measures in its core designs. Our research presented absolute cybersecurity requirements that developers should embed in edutainment systems to ensure users' sense of trust.

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How a Tangible User Interface Contributes to Desired Learning Outcomes of the Virtual River Serious Game

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Abstract. Serious games are increasingly used to facilitate stakeholder discussion and collaboration. Much attention is given in the game design literature on how to choose and design a serious game's scope, content, mechanics, and link to reality in order to achieve the game's intended learning outcomes. In this paper, we focus on how a serious game's interface and the interaction it elicits contributes to achieving learning outcomes. We do so in the context of the Virtual River, a serious game focused on river management. Following the design and evaluation of a paper prototype of the Virtual River, a design challenge arose as the highly simplified models of reality used was perceived as a black box by non-expert participants, while expert participants perceived it as oversimplified and unrealistic. As hydrodynamic models used in river management practice are in itself perceived by non-experts as a black box, we decided to look for ways to simplify the interaction with such models in the game. Here, we present a tangible user interface for the Virtual River. The interface enables participants to get a better grip on the hydrodynamics of a river system. The system is set up as a discussion platform where the game board and its tangible game pieces help participants express their thoughts and ideas. We argue that using tangible interaction in Virtual River contributes to social learning outcomes by providing hypotheses based on literature and present how we intend to test these hypotheses.

Keywords: Serious gaming · Interaction design · Tangible user interface · River management

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1 Introduction

Serious games are increasingly explored as tools to facilitate stakeholder discussion and collaboration in multidisciplinary settings [1–3]. Serious games are generally referred to as games designed with a purpose other than entertainment, such as training, educating or informing players [4, 5]. More specifically towards the use of games to facilitate discussion and collaboration in a policy-making setting, Mayer [6, p. 825] defines serious games as "experi(m)ent(i)al, rule-based, interactive environments, where players learn by taking actions and by experiencing their effects through feedback mechanisms that are deliberately built into and around the game". By combining role-play with in-game feedback mechanisms, such serious games provide stakeholders with an environment to negotiate, deliberate, and exchange their perspectives on both the problem at hand and its solution in the safe experimentation environment of a game [6–8]. This way, stakeholders learn both about the techno-physical complexity—the system covered in the game, including its underlying physical elements and its uncertainties—and the socio-political complexity—the strategic interactions between stakeholders in the policy arena [2, 6, 7].

As with any product, the design of the game is crucial to achieve its purpose. The game's goal, scope, content and mechanisms require careful considerations. To help designers in this effort, various guidelines exist on how to develop (serious) games and what design choices to consider [9–11]. These guidelines go in-depth on how to set up the rules and content of the game, how to create a link to reality, and how to facilitate play in order to establish intended interaction and learning outcomes. However, these guidelines pay less attention to the interface design and how the interface can contribute to achieving the specific purpose of the serious game.

In this paper, we focus on the design process of the Virtual River, a multiplayer serious game on river management, and argue that the game's tangible user interface contributes to intended learning outcomes. Specifically, we are developing the tangible user interface – an interface that provides physical forms to digital information [12, 13] – to overcome a design challenge that arose from formative evaluation sessions of a Virtual River paper prototype. Specifically, non-expert participants perceived the game and its models as complex, while expert participants found the same models oversimplified and unrealistic. The design challenge therefore relates to incorporating hydrodynamic models, numerical models that calculate water flow, in Virtual River while at the same time offering a way to easily and intuitively interact with these models. In this paper, we use the case of Virtual River's tangible user interface, in development at the time of writing, to combine theory on tangible interaction and social learning to discuss how tangible interaction may not only overcome the design challenge, but also enhance specific social learning outcomes of playing the game.

In Sect. 2, we further introduce river management with a particular focus on the Netherlands and serious games in relation to river management. In Sect. 3, we present the theoretical framework in relation to both social learning and tangible interaction. In Sect. 4, we discuss Virtual River, including its goal, a previously developed paper prototype and its evaluations, and the tangible user interface currently in development. In Sect. 5, we present three hypotheses, based on literature, on how tangible interaction may contribute to specific learning outcomes and discuss how we intend to test these hypotheses. Finally, in Sect. 6, we state some concluding remarks and explain our next steps in the development and evaluation of Virtual River and its tangible user interface.

2 Background and Related Work

2.1 River Management

Rivers are in many ways important to society, from providing a source of water to channels for shipping to habitats for animals and plants. At the same time, rivers can also pose a threat to society as rivers are prone to flooding. Therefore, rivers, especially in low-lying countries, are nowadays actively and carefully managed. However, river management issues are generally multi-scale [14, 15], concern inherent uncertainties [16, 17], and affect multiple stakeholders and agencies [18, 19]. Therefore, decision-making processes need to be adaptive to deal with the uncertainties and need to include the diversity of knowledge and values of all affected stakeholders. To this end, scholars have advocated active experimentation and continuous evaluation, summarized as learning-by-doing, in natural resources management and in river basin management specifically [20–23].

In the Netherlands, a country known for its continuous combat with water, the main priority in river management is flood safety; protecting the hinterland from flooding. The historic approach has been the construction and reinforcement of dikes, but a recent paradigm shift has changed the approach from protection to include resilience by applying intervention measures that create space for water [24–26]. Examples of such space creating measures include side channels, i.e. secondary river channels in the rivers' floodplains, or moving a dike further away from the river to increase the size of the floodplain. While the paradigm shift still holds flood safety as the most important priority, it also focuses on nature restoration efforts along the Dutch rivers. The paradigm shift has therefore also introduced new stakeholders to Dutch river management [18, 19]. However, Dutch river management is predominantly expert- and model-driven. Water managers rely on complex hydrodynamic models to estimate how the river will react to certain intervention measures. The tools used by water managers are perceived as black boxes to stakeholders from non-water backgrounds [27]. In such a setting, serious games could serve as boundary objects; shared objects that may serve as references in discussions and that 'are both adaptable to different viewpoints and robust enough to maintain identity across them' [28, p. 387]. In other words, a serious game—through its interaction design, its physical or abstract representation of reality, and its rules—integrates scientific and political worlds into a shared object in a way that is recognizable yet interpretable by all stakeholders in order to serve as a reference for discussion [8, 29].

2.2 Serious Gaming in River Management

Serious games that integrate scientific and political worlds are increasingly finding their way in the water domain [2, 30–32]. In relation to river management specifically, there are a number of examples of serious gaming approaches to facilitate stakeholder discussion and collaboration [33–40]. For example, Stefanska, Magnuszewski [34] describe the Floodplain Management Game, where players play the roles of farmers, local authorities, or water boards in a small area in the river basin each with their own objectives, such as profit, biodiversity, and control of water flow, often conflicting with those of others. This way, players explore technical problem-solving as well as relational issues. Valkering, van der Brugge [35] developed the Sustainable Delta Game in which players are given the objective to develop collective strategies to limit the probability of both floods and droughts from occurring. As a higher level goal, players learn about the complex interactions between river management, climate change and changes in society. Douven, Mul [40] developed the Shariva game in which players have to make trade-offs between hydropower production in upstream areas and agricultural development in downstream areas. The objective of the Shariva game is to create awareness, to upgrade knowledge, and to design procedures for cooperation in transboundary river basins among water and related professionals.

While these serious games all cover different scopes and learning objectives, they have in common that they provide stakeholders with a means to collaboratively explore both the problem at hand and its solution. In doing so, stakeholders learn about how a river system functions, how management decisions affect certain key performance indicators, and how decisions lead to trade-offs between these indicators—the techno-physical complexity—as well as how other stakeholders look at the problem, how stakeholders prefer to address the problem, and how stakeholders might be willing to compromise—the socio-political complexity.

3 Theoretical Framework

3.1 Social Learning

Serious games—particularly the multiplayer and multi-role serious games following the definition by Mayer [6]—are recognized to offer the necessary collaborative and participative interactions needed to establish social learning [3, 30]. Social learning is considered to be a normative goals and prominent driver to manage natural systems in natural resources management [21, 41–43]. Scholars have yet to find a commonly shared definition for social learning (see [23, 41, 44, 45]), but scholars do share the view that social learning has occurred when a change in understanding is achieved through interaction in collaborative and participatory settings [41, 42, 44, 46, 47]. Collaborative and deliberative interactions between stakeholders are required to achieve social learning, which should ultimately lead to collective action [45, 46, 48]. Changes in understanding may relate to the natural system that is managed, the problem that is addressed, or agreement on either the problem or its solution. Therefore, social learning outcomes relate to the techno-physical complexity of the system, the socio-political complexity, or both. To differentiate between these different forms of social learning, Baird, Plummer [47] offers a typology that contains three types of learning outcomes:

- cognitive, acquisition of new or restructuring of existing knowledge;
- normative, changes in norms, values or paradigms, as well as convergence of group opinion; and
- relational, improved understanding of others' mind-sets, building relationships, and enhancing trust and cooperation with others

The typology is beneficial as it separates social learning outcomes by their nature—cognitive, normative or relational—as opposed to their perceived value—learning may in fact have a negative effect on taking collective action. Moreover, the typology recognizes relational learning as a separate, explicit learning outcome, which is of particular importance to the multi-stakeholder setting found in river management and learning about its socio-political complexity. We therefore used the typology by Baird, Plummer [47] to distinguish between learning outcomes in connection to the literature on tangible interaction.

3.2 Tangible Interaction

Tangible interaction is a theoretically informed interaction design framework that combines physical object manipulation and digitally controlled interactive behavior [12, 13]. As a response to the increasing digitalization of everyday life, tangible interaction starts from the point of view that human beings have evolved to deal with the physical world and that physical objects as a result have a specific cognitive, affective, and social interaction quality. This quality may easily get lost in the transition to purely graphical (screen-based) interfaces [49]. In response, tangible interaction proposes to combine the familiar physical and social world with the digital world in a way that preserves the desired properties of each and that achieves a seemingly "natural" human-computer interaction [50]. A tangible user interface can therefore be defined as an interface that provides physical forms to digital information [12]. Known examples of tangible user interfaces include the reacTable, a musical instrument where users can caress, rotate, and move physical objects on a tabletop surface to create music [51], and Illuminating Clay, where users apply landscape analysis directly by manipulating the clay model of a landscape [52].

Previous research suggests that tangible user interfaces offer qualities to facilitate learning and collaboration (see e.g. [53, 54] for more elaborate overviews), both of particular interest to the design of a serious game. Firstly, by using physical objects as part of the interface's interaction invites hands-on engagement [55–59], providing users with tools to engage in new ways of thinking [60]. Secondly, a tangible user interface invites trial-and-error behavior [61] and experiential learning through exploration, discovery, and reflection [56, 57, 62]. Thirdly, from the perspective of cognition, by using physical objects as external representations eases problem solving as processing the representations does not have to be done in mind, but can simply be inspected in the world [63], aiding users to grasp abstract concepts through the interaction with physical objects [64–66]. Lastly, tangible user interfaces also enable users to engage in collaborative activities [13, 62, 67] – a prerequisite to social learning – by offering a multi-user interface where control is shared [59, 61] and making the actions and activities of other users visible [68, 69]. Specifically, the social-collaborative value of tangible interaction has been emphasized since its initial formulation (see [70]), focusing on how users working with tangible objects in social settings may contribute to creating a shared understanding of the problem at hand [71].

4 Virtual River

As part of the RiverCare research programme [72], we are developing the Virtual River, a multiplayer serious game, which aims for players to experience how the river system functions and what the implications of different management choices and interventions are. In addition, we are particularly focusing on facilitating stakeholders to exchange perspectives following previous research that analyzed the different perspectives held and used by river management stakeholders in decision-making [27]. By playing the Virtual River, players learn about the socio-political complexity as they engage in active collaborations and negotiations with other players playing different river management roles. On the techno-physical complexity, players learn about how management measures affect the system and how such measures impact indicators like flood safety, biodiversity, and costs. Moreover, players learn about the trade-offs that measures present between these indicators.

4.1 Initial Game Design and Paper Prototype

In the Virtual River game, players are given specific roles and tasked to manage a typical Dutch river stretch in turns representing time steps of five years each. Each player role has its own goal, its own budget, and a special rule it can use throughout the game. Players have to make decisions collectively on the whole game area as well as individually on floodplain areas they own. Management interventions for the whole area include applying spatial measures such as creating side-channels or reinforcing dikes. Both these choices increase the discharge capacity of the river stretch, positively contributing to the indicator of flood safety. Spatial measures generally have the added benefit of positively contributing to the indicator of biodiversity. However, to increase the same discharge capacity, spatial measures generally cost more than dike reinforcement—and players need to reach an agreement on how to share the costs either way—and spatial measures need to be constructed on floodplain land owned by players.

Management choices for the floodplain areas relate to how individual players manage the land under their control. For the flood safety indicator, the best option would be to turn all floodplain areas to grass—which has low hydraulic resistance and therefore leads to a high river discharge capacity—and performing active maintenance—in the case of grass, mowing and making sure no other type of vegetation starts to grow. However, for the biodiversity indicator, floodplains with mixed vegetation—including grass, bushes, and trees—that is allowed to grow and develop offers a much wider variety of plant species and a much richer habitat for animals.

Fig. 1. Paper prototype impression with the main game board on the left with a river stretch, game score indicators on the right, and a role card on the left bottom.

Whereas the nature manager, a role in the game, prefers to stimulate the latter, the water manager could be opposed to such arrangements when flood safety is at stake. Therefore, the water manager has a special rule that says that it can enforce other participants to lower hydraulic resistance—basically, remove vegetation like trees and bushes—on their lands whenever flood safety is at stake, a rule that corresponds to reality in terms of the Dutch Public Works Authority's powers.

In a previous design iteration, we developed a board game prototype of the Virtual River to evaluate its scope, game indicators, and initial rules and roles [73] (Fig. 1). Formative evaluations showed that participants found the game engaging and insightful, and that players understood the link to reality. However, participants, in particular non-expert participants, found the game complex and perceived the game's models—calculations on the flood safety, biodiversity, and costs indicators and how players were scored on these—as a black box. This prevented these participants from gaining the techno-physical insights into how a river system functions and responds to changes. However, expert participants questioned the realism of the models behind the paper prototype, finding these instead to be oversimplified and unrealistic.

4.2 Tangible User Interface

Following the formative evaluations of the paper prototype, our focus for the design and further development of Virtual River shifted from addressing the gap in complexity perception between participants to lowering or helping to navigate the game's complexity and removing the perceived black box. Simultaneously, we aimed to increase the link to reality and real-world models. On the one hand, although the paper prototype used a highly simplified cause-effect model for the hydrodynamics of the game, non-expert participants already perceived it as complex and as a black box. On the other hand, experts participants questioned the realism of the model as oversimplified. Simply incorporating a more elaborate model in the next iteration of Virtual River could help solve the latter, but not the first. Moreover, hydrodynamic models are in itself perceived as a black box by non-experts. Therefore, we decided to look for ways to simplify the interaction with hydrodynamic models. To address this design challenge, we looked to tangible interaction and are currently developing a tangible user interface where players are provided with a physical representation of a river stretch that players can alter to directly manipulate a hydrodynamic model.

Fig. 2. SandBox setup and interface (photo from [74]). The SandBox uses a Kinect to measure the geometry of the sand, representing a river stretch. Molding the sand into a new shape changes the schematization used by the hydrodynamic model and a beamer projects the model's output back on the box of sand.

As a basis for the interface, we are using an existing framework called the SandBox, an augmented reality collaborative modeling tool [74]. Inspired by the LakeViz project [75], the SandBox consists of a box of sand, a color and depth camera (RGBD, Kinect), the relevant hydrodynamic model, and a projector (Fig. 2). The sand can be molded by end users to design a river. The sand is measured by the RGBD camera. This information is used to change the schematization (the geometry of the river stretch) of the numerical model. Delft3D Flexible Mesh, a 1D, 2D, 3D hydrodynamic model, is used in this study for rivers, but other models that use the Basic Model Interface [76] are also supported. The model results are visualized on the sand using the projector. The SandBox adds an easy to use interface to real world engineering models and has shown to invite users to experiment and, through trial and error, experience how a hydrodynamic model works and generate understanding of how a river system functions. In a group setting, the SandBox has contributed to enhanced communication between stakeholders.

For the Virtual River, we replaced the sand with game pieces of different heights on a hexagonal grid. We took this approach to retain the full benefit of the SandBox framework, while adding structure that limits the amount of options for players to consider in order to make it suitable for gameplay. In our approach, we are

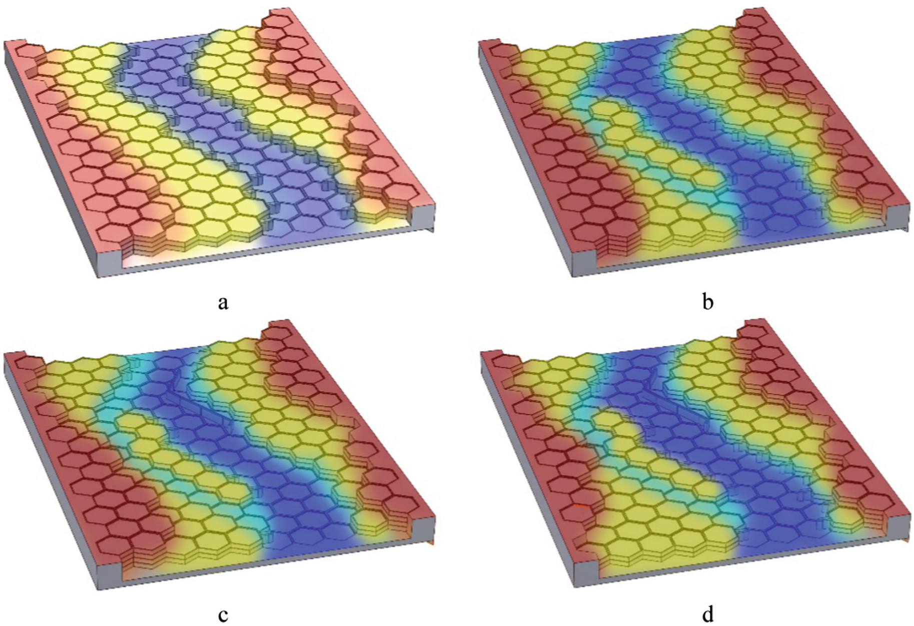
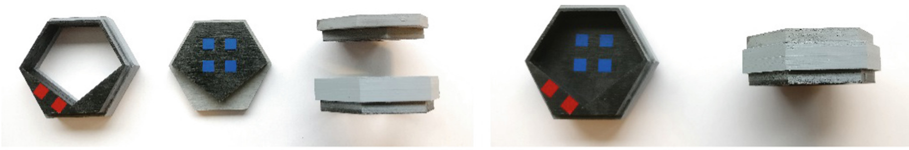


Fig. 3. Game board impression with (a) an initial river basin, in a typical Dutch layout, and elevation projection; (b) game board after the construction of a side-channel, a secondary channel next to the main river channel; (c) game board after constructing a longitudinal training dam, a dam constructed in the main river in parallel to the water flow; and (d) game board after a dike relocation, moving a dike away from the river to increase the size of the floodplains. Water flow is not included in this impression.

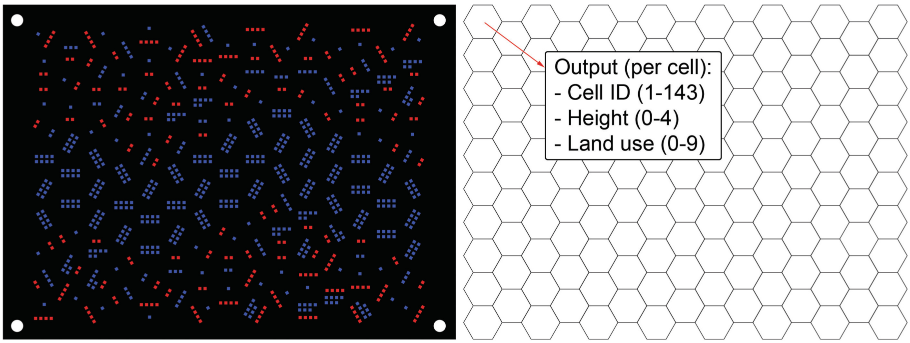
transforming the board from the paper prototype into a 3D game board, where the shape of the game board, based on hexagon game pieces of different heights, correspond to the geometrical shape of a river stretch. The geometrical shape is used as input for a hydrodynamic model and the output of the hydrodynamic model is projected back on the 3D game board (see Fig. 3 for an impression).

To address calibration issues with the Kinect—and to eliminate the possibility of having to recalibrate it during a game session—we developed an alternative method to detect the game pieces on the board based on markers and image processing. Specifically, we constructed the game board on a transparent underlayer and attached colored markers to the bottom of all game pieces. There are two types of game pieces: (1) geometry pieces, different heights of hexagon shaped pieces assigned red markers; and (2) land use pieces, different flat pieces representing different land use that fit on top of the geometry pieces assigned blue markers (Fig. 4). A photograph is taken from beneath the game board and a Python script subsequently calibrates the picture to detect the correct positions of all hexagon grid cells and analyzes the amount of both red and blue markers of game pieces at each grid cell location (Fig. 5).



a b

Fig. 4. The geometry and land use type of game pieces (a), which combined (b) make up the position of one cell.



a b

Fig. 5. (a) Game board with pieces and markers as seen from below. Four red markers indicates that a geometry piece of four levels high is positioned in the grid cell. The four white circles are used for calibration; and (b) possible output of the detection script. (Color figure online)

We are currently developing a prototype for the Virtual River's tangible user interface (Fig. 6). At the time of writing, the physical part of prototype is built and we are in the processes of calibrating and refining the detection script as well as the link to the SandBox framework. As can be seen in Fig. 6, all game pieces are only primed with a grey color and although the geometry pieces can be identified by their actual height, we do plan to see if using a greyscale gradient, where a specific color value between white and grey corresponds to a specific height, can be used to help identification. We intend to test if using different color values do not interfere with the projected visualizations. The land use pieces are not yet identifiable in Fig. 6, these are all flat surfaces. We plan to add icons to match different land uses, for example a tree to represent a forest and a building to represent built environment. These icons could be flat using physical shapes or stickers. Our preference is the first, as physical shapes add concrete representations, in line with our approach of using tangible interaction, as well as help players to more easily grab and move pieces on the board. However, this similarly requires testing whether this interferes, or does not interfere with the projected visualizations as well as the icons remain, or do not remain, identifiable under the projection.

a b

Fig. 6. Game board prototype with (a) the empty board showing the grid and transparent underlayer; and (b) a filled board with game pieces that combined form the geometry of a river stretch.

To summarize, the Virtual River's tangible user interface provides players with a shared gaming environment where players directly interact with a hydrodynamic model by changing the arrangement of game pieces. For example, by replacing higher geometry pieces with lower ones—basically excavating the area—increases the discharge capacity of game area by creating more floodplain areas, effectively creating space for water. By changing land use pieces that have high hydraulic resistance—therefore limiting water flow—with pieces with low resistance similarly increases discharge capacity. Based on the arrangement of game pieces as input, the hydrodynamic model is updated and the resulting output in the form of water flow is projected back on the game board, providing players with instant feedback on their actions.

5 Discussion

Tangible user interfaces have been applied in other tabletop (serious) game settings. Bakker, Vorstenbosch [77] developed Weathergods, a game where players try to earn the favor of weather gods in order to make it rain and save the player's village harvest. Weathergods uses a digital surface in combination with tangible game pieces, physical representations of for example players' avatars, that can be moved between different board positions. Speelpenning, Antle [78] developed physical objects as tangible controllers for the serious game Futura, a serious game where players experience the complexity of planning for a sustainable future. In their approach, players use physical magnifying glasses to open visualization layers in the game that provide players with additional information. Inspired by The Incredible Machine, Leitner, Haller [79] developed the IncreTable where players solve puzzles by combining physical and virtual game pieces. The IncreTable allows users to combine and connect for example physical domino stones with virtual ones. All these applications use a digital surface as a game board in combination with tangible objects. In our approach, the game board itself is formed by physical objects that serve as both the control of the hydrodynamic model and the representation of the river stretch. The approach follows the tangible user interface as an interactive surface genre as explained by Ishii [12], which focuses on supporting collaborative design and simulation.

In the next subsections, we discuss the benefits of the tangible user interface for Virtual River from the perspective of social learning by presenting hypotheses in relation to the three types of social learning outcomes: cognitive, normative, and relational learning (see Sect. 3.1 and [47]). Specifically, the hypotheses are presented from the perspective of the Virtual River's tangible interface, they are provided with arguments from literature on tangible interaction, and they are discussed in terms of intended assessment. The latter is based on earlier work that analyzed the different approaches used to evaluate social learning outcomes [80].

Hypothesis 1: The Virtual River's Tangible User Interface Enables Players to Gain an Increased Understanding of How a River System Functions

The first hypothesis relates to cognitive learning, which covers the acquisition of new knowledge and the restructuring of existing knowledge. The hypothesis also relates directly to our design challenge to incorporate realistic hydrodynamic models in the Virtual River while at the same time offer easy and intuitive interactions with hydrodynamic models. To address the design challenge, we expect that especially non-expert players learn about how hydrodynamic models work and, therefore, how the river system functions. Furthermore we expect that, from the perspective of cognition, the tangible user interface using a physical representation of a river stretch helps players to gain the increased system understanding. This is as part of the information needed during gameplay is not 'kept in mind', but can simply be inspected in the world, what Don Norman famously called 'knowledge in the world' [81]. Furthermore, knowledge in the world allows for 'epistemic action'. Players can use their embodied skills to manipulate the information in the environment, the game board itself, and can use their visual pattern recognition routines to inspect the result – the visualized projection – which together assists in making inferences. Instead of heavy mental gymnastics, players can reorganize the world and then simply 'see' the answer to a problem before them [82]. In other words, in line with the tradition of Distributed Cognition [83], using tangible interaction allows players to 'offload' information into the physical structure of the local environment, releasing the brain of work and making thinking easier [84].

We intend to test this hypothesis by first applying pre- and post-game knowledge measurements, including knowledge on hydrodynamic models. In addition, we intend to compare individual pre- and post-measurements with video recordings of game sessions to observe if the use of the tangible user interface contributed to differences in measurements. Open questions could furthermore be asked directly to players in interviews or questionnaires after game sessions to gain additional qualitive insights into how the tangible user interface enabled learning about the functioning of a river system.

Hypothesis 2: Using a Tangible User Interface in Virtual River Aids Players in Understanding Each Other's Perspectives

The second hypotheses relates to relational learning, which covers understanding others' mind-sets, building relationships, and enhancing trust and cooperation with others. In general, providing players with a shared environment where players engage in collaboration and negotiation creates a setting where players exchange views and opinions. Following the ethnomethodological tradition in sociology [85], the use of tangible objects to express our thoughts makes these thoughts become public. Therefore, we speculate that allowing players to literally see another player think by how they are manipulating the game board, i.e. representing that thought process, provides players with a platform that helps them observe the point of view of others and empathize with it [49, 70]. Moreover, we speculate that these insights could contribute to the converging of group opinion, associated with normative learning, as players may also intervene while observing others, which leads to a shared process of manipulating objects: a collaborative process of sensemaking [70, 71]. Therefore, collaboratively negotiating on how to best structure the physical pieces on the game board may help to not just align the pieces as such, but also to align the different perspectives of the players [86, 87].

To test this hypothesis, we intend to ask players self-reflective questions on what they learned about the perspectives of others after game sessions in either questionnaires or individual interviews. In addition, game session recordings can be analyzed and observations can be compared to the players' answers to these questions.

Hypothesis 3: Using a Tangible User Interface in Virtual River Contributes to Players Building Relationships and Trust

The third hypothesis relates to relational learning as well. While the literature acknowledges that using tangible objects may create a shared understanding of the problem at hand [71], people engaging in collaborative efforts in itself creates a dimension of relationship building and trust formation. Moreover, as Van Dijk and Van der Lugt [87] showed, working together in a physical space helps people to interact nonverbally—look each other in the eye, 'open up' to the other by turning the body, gesture to another to take their turn, and so on. Looking at the same screen together—even if it is a large projection—tends to focus attention to the information on the screen, and away from the actual people using that information and being together in a social situation. While the tangible interaction literature has not often emphasized this aspect, we speculate that in the present context having a tangible river setting that people can stand around, work with, and point to could in this way help building relationship and trust.

We intend to test this hypothesis by applying interaction analysis [88] to recordings of game sessions to analyze both interaction between players as well as between players and the interface. This approach could be complemented with follow-up interviews some time after game sessions to gain insights into if any relationship building led to any cooperation.

6 Concluding Remarks and Next Steps

We are developing a tangible user interface for the Virtual River, a serious game that aims for players to experience how the river system functions and what the implications of different management choices are. In particular, we discussed why we looked to tangible interaction as a way to overcome the design challenge to incorporate hydrodynamic models in Virtual River while providing players with an easy to use interface to manipulate these models. Moreover, we applied a theoretical perspective on why tangible interaction offers benefits from the perspective of Virtual River's learning objectives, captured in three hypotheses. Firstly, we speculate that the Virtual River's tangible user interface contributes to cognitive learning outcomes as it enables players to gain an increased understanding of how a river system functions (hypothesis 1). Specifically, the tangible user interface provides players what an tool to directly manipulate a hydrodynamic model and see the results. At the same time, by using physical representations, the tangible user interface enables players to inspect information 'in the world', releasing the brain of work and making thinking easier. Secondly, we further speculate that Virtual River's tangible user interface contributes to relational learning outcomes as it aids players in understanding each other's perspectives (hypothesis 2). By manipulating the physical game board, players make their though process explicit and other players may be able to observe their point of view and empathize with it. Lastly, we speculate that that Virtual River's tangible user interface contributes to players building relationships and trust (hypothesis 3). Specifically, offering a physical board to stand around, work with, and point to over a screen-based interface may be beneficial to building relationship and trust.

As next steps, we plan to first operationalize the whole interface, including developing and testing representations, icons in either physical or sticker form, for the land use of each game tile. From there, we intend to first run game sessions as formative evaluations; does the game design achieve its design goal and does the interface design effectively overcome the design challenge. Afterwards we intend to hold summative game evaluation sessions that focus on evaluating social learning outcomes of playing Virtual River as well as evaluating how tangible interaction contributes to these outcomes.

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Digital Empathic Games and Their Relation with Mortality: Analysis of Discussion Forums

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Abstract. Digital empathy games have attracted the attention of players since they present topics associated with human frailty, such as death and mortality. Thus this type of game invites users to engage in reflection and they identify with scenes and images of the narrated world. This study presents an analysis of the perception of users of this type of game, in order to identify relevant aspects of its design and evaluation. The object studied by this article is the empathy game Valiant Hearts: The Great War, and user reviews were collected and analyzed through comments found in internet forums. These discussion boards contain user opinions ranging from technical issues and quality to matters related to mortality and death. The research is based on netnography, by means of qualitative and quantitative manual analysis of user comments. In general, the study presented multiple aspects involved in this type of game and generated considerable reflection and future studies.

Keywords: Digital empathy games · Death · Mortality · Internet forums · Discussion forums

1 Introduction

Over the years, digital games have attracted many users and acquired prominence as a lucrative and interactive type of media [1]. Part of their success is attributed to the fact that games are capable of promoting significant interaction with the player and, through its narratives and mechanics, are able to promote complete immersion, allowing the user to experience different realities.

Among the many possible experiences provided by digital games, topics that deserve special attention are those often considered taboo [2], such as war, death, and mortality, which have been labeled as an emerging category called empathy games [28]. These games seek to encourage the user to reflect about sensitive topics and often have sentimental content. In this context, it is crucial to analyze representations of death and human frailty in the narratives of digital empathy games. An important question therefore arises: which aspects are revealed from the user experience with empathy games?

The present study seeks to analyze user perception of this type of game, in order to identify relevant aspects of its design and assessment.

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For this reason, the authors first selected games that addressed issues related to death and resulting conflicts. Out of the few games analyzed during the bibliographic and netnographic research, Valiant Hearts: The Great War [3] was chosen as the object of study, due to manner it addresses death, which is a central aspect of its narrative, and also due to its autobiographical dimension, which heightens its ability to arouse empathy in the user. Furthermore, this game presents several technical features, such as visual elements, immersive stimulation, sound components, as well as relevant human factors, such as emotional and sentimental value, which are also analyzed in this experiment.

In the initial netnographic research, there were discussion forums in web platforms dedicated to Valiant Hearts: The Great War, where players relayed their experiences and wrote their reviews.

Therefore, the present study analyzed the comments of players in the internet discussion forum available in the digital distribution platform Steam, focusing on how technical issues and game quality issues, as well as topics of mortality and death, were addressed. Based on the analyzed data, this study categorizes the recurring content contained in comments by gamers in order to reveal aspects of their review of technical, emotional and general aspects of the digital game Valiant Hearts: The Great War.

Moreover, this research is part of the research project DAVI (Dados Além da Vida – Data Beyond Life)[1], which investigates post-mortem digital legacy from the perspective of technical, cultural, legal and affective principles, in order to propose design solutions for computational systems concerning the digital assets left by dead users.

The article is organized as follows. After this introduction, the theoretical reference will be presented, followed by the methodology, proposed classifications and, finally, the conclusion.

2 Theoretical Reference

Empathy refers to: "(1) the psychological identification with or vicarious experiencing of the feelings, thoughts, or attitudes of another; (2) the imaginative ascribing to an object, as a natural object or work of art, feelings or attitudes present in oneself." [4] According to these definitions, empathy is associated with the human ability to understand another person and place oneself in the other person's shoes. In games, this ability can be developed and associated with more sensitive topics such as death.

Death is usually present in games as a gaming strategy: to limit a session, in case the player has squandered his number of possible lives; or as an instructional mechanism, since, after dying and reinitiating many times, the player ends up learning the game; or even as a punishment, since, when dying, the player loses all his progress and has to start from scratch. However, topics such as mortality and human frailty are scarcely explored, whether due to lack of interest of the gaming industry and designers in working with such project or because consumers choose to play games with less contemplative appeal, as states Neto [5].

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1 http://lavi.ic.ufmt.br/davi/en.

For this reason, games that include death in their narratives, but not as central themes, arouse little or no debate about the relation between what is presented in the virtual realm and what occurs in real life regarding human mortality. Kingsepp [6], when analyzing the game *Medal of Honor: Frontline* and comparing it to films about World War II, states that, because the game does not depict a realistic dramatic experience suffered by a soldier in the midst of the war, it is labeled as superficial. Unlike this genre, one of the emerging categories that include games capable of generating reflection or emotional responsiveness are the "empathy games", as presented by Diogo [7].

Theresa Wiseman [8] defines four main attributes present in the state of empathy towards another person, starting with understanding another person's point of view, taking the perspective of a person through previous experience or recognizing her view as legitimate, being nonjudgmental and, finally, recognizing another person's feelings and communicating your understanding to her. Considering these attributes, Tiroli [9] states that inquiring about the reasons why a person acts a certain way leads the path to the root of the problem. This reflexive process, mediated by games, makes it possible to explore complex issues.

According to Goulart [10], "empathy games" have a different goal from those composing the "fun circuit", but they still maintain their central goal, which is to entertain the player. Belman and Flanagan [11] point out that "empathy games" should, necessarily, guide the player to objectively sympathize with the situations in which she is placed. For this to occur, four steps are required: it must create an open requisite for empathy; it must offer feedback about how the actions of the players influence the games; it must assure that empathy is both emotional and cognitive; and it must highlight the common aspects shared by the player's reality and the situation presented.

One of the empathy games includes *The Walking Dead: Season One*, which was analyzed by Toby and Stef [12]. The authors indicated the importance of using mechanisms and narratives that represent traumas, of providing immersion, and of triggering feelings of empathy and connection from the players while enticing game attitudes that contain high emotional impact. Firstly, there is interactivity and inter-reactivity, which is capable of containing interactivity supplied by the game and reactivity of players, molding their experience from the virtual project that is shown. Moreover, one must consider both dimensions of empathy: one that is cognitive, in which there is an intention of assuming another person's viewpoint, and one that is emotional, which consists in a more primitive and instinctive reaction to other people's feelings. Lastly, there is a sense of connection between the player and the events of the game, which derives from a mixture of the items mentioned above in order to provide the experience that the player is controlling and is responsible for the events occurring in the game.

Sellen [13] discusses the importance of emotional aspects for the Human-Computer Interaction (HCI) and states that words such as "magic", "enchanting", "pleasure", "surprise" and "emotion" started showing up when researchers and designers started discussing what technology meant to people.

According to Norman [14], the human mind, related to aspects of systems design, processes at three interconnected levels: visceral design, which refers to the appearance and the first impact generated by a product; behavioral design, which relates to use from an objective point of view and refers to the product's function, how effective it is at executing its functions, how user-friendly it is in terms of understandability and operability, and other aspects related to how the product "behaves" with the user; and reflective design, which considers the rationalization and intellectualization of a product, the emotional memory and the meanings ascribed to the products and their use. For Norman [14], the emotional dimension in designing projects may be more critical to the success of a product than the practical elements.

In turn, Xavier [15] defines feeling as one of the components of emotion, not representing the emotional state of an individual, but the verbal rendition that a person professes when faced with an emotional episode. Feeling is the conscious interpretation and verbal expression that the individual generates about what he is feeling at a given moment. This is the case when a person says they are feeling "happy" after purchasing a product online, or that they are "frustrated" because they are not able to connect to the internet [15].

Gerald et al. [16], when realizing there was a wide range of emotions involved, created the OCC (Ortone, Clore & Collins) Model. According to this model, emotions are categorized according to the feelings they generate, with the resulting acts and events of the involved actor. The model presents three classes, six groups and 22 types of emotions.

The technical aspects are naturally very important, considering issues related to the immersion, usability, sound quality, narrative, and other qualities of the game [17]. Aspects related to usability can be decisive in assuring the success of a game. Hartson and Pyla [17] highlight that the usability level can be influenced by two types of system complexity: (1) interaction complexity, related to the elaborateness of user actions, including cognitive load; and (2) technical development complexity (i.e. game development, game design). Systems with high interaction and high development complexity are more likely to have low usability.

In the gaming context, immersion generates emotion and movement to the narrative and can be explored by different computer resources and interaction strategies. According to Rogers et al. [18], the level of immersion that the game offers may, moreover, affect the perception of the player in relation to scene authenticity, cause nausea or dizziness, and influence the decision of the user to continue to play the game or to quit.

The technical sound quality, along with the narrative, may influence the level of player involvement and, consequently, in the realistic quality of graphics, as state Summers and Jesse [19]. Thus, it can be noticed that no technical aspect should be treated in isolated form, since it may positively or negatively influence another aspect. For instance, when the sound quality is inadequate, it may not cause immersion and, consequently, the scenes will not seem realistic.

3 Methodology

This research is descriptive, with a qualitative approach. For data collection, the netnographic method was used, i.e., a set of online ethnographic procedures using a manual process of interpretative comment analysis written by users of the digital game

Valiant Hearts: The Great War [3]. According to Leitão and Prates [20], "With the material at hand, the researcher classifies it into main categories of analysis grouped according to common meanings. Categorization is iterative, and the categories gradually gain a greater degree of abstraction in terms of assigned meanings. These categories will always be traceable, corresponding in descriptive terms to, for example, user testimonials in interviews or to excerpts of interaction during a session. At the end of the process, the different perspectives of users on the studied phenomenon are reflected in an articulated set of categories".

Bibliographic research was initially conducted on topics related to the object of study: games, death, empathy, feelings. Subsequently, games that dealt with war and death were pre-selected in order to provoke emotional reaction in the player. After a preliminary selection, the game *Valiant Hearts: The Great War* was selected for an in-depth study in this work, mainly due to its predominant focus on the issues being analyzed. It should be noted that, because the game was inspired by reports of soldiers who participated in World War I, it has a strong capacity to arouse empathy in the user by representing human emotions in the face of war and death, as well as the technical and human factors that can be analyzed. Additionally, there are several discussion forums about this game, which favors the collection of data for analysis.

The games that were discarded from the sample were not included in the corpus of this research because they presented mechanics and narratives that explored other themes. This group included the games *This War of Mine* [21], *Life is Strange* [22], *Brothers - A Tale of Two Sons* [23] and *The Walking Dead - A Telltale Game* [24].

Initially, in order to become familiar with the object of study, the game *Valiant Hearts: The Great War* was played for about four hours. Comments written in Portuguese and English were subsequently collected in the game's discussion forum (the latter being translated into Portuguese) from the software page on the Steam platform. From this sample, a new selection was made, separating the comments that presented the most articulate evaluations on the research object. Very short reviews or texts that did not present sufficient content for analysis were discarded. Examples of discarded publications include: "Great Game" and "Very Cute Game".

Therefore, 77 valid comments were considered, which were organized into a spreadsheet containing three columns: one with the name of the user, another with its comment, and the last with the content that was most notable from each comment. The user ratings were in Portuguese and English; however, only comments in Portuguese were used in this article. After that, these comments were subjected to a deeper analysis and, as analyzed, categories were created and, if necessary, thematic subcategories for the contents that were highlighted in the comments. Investigation was conducted by three researchers, two from the Technology field and one from the Linguistics field.

To ensure user anonymity, the following codification was used: the letter U, followed by a number. It is also worth mentioning that this study is part of the research project on the Pre-Management Systems of Post-Death Digital Legacy, which has been approved by the Research Ethics Committee of the Federal University of Mato Grosso.

The final part proposes categories of repeated content included in player comments, based on the analyzed data, in order to highlight aspects for the conception and evaluation of technical, emotional/sentimental and general elements of *Valiant Hearts:*

The Great War. The definitions of categories and subcategories are found in the results section of this article.

3.1 About the Game

Valiant Hearts: The Great War [3] is an adventure puzzle videogame developed by Ubisoft Montpellier and published by Ubisoft. The game is inspired in letters written during World War I and consists of four characters in the battlefield helping a young German soldier find his true love, in a story about survival, sacrifice and friendship. *Valiant Hearts* employs the UbiArt Framework, a 2.5D video game engine software developed by Ubisoft Montpellier. Its primary function is to organize 2D animated vector graphics into a playable videogame without extended codification. [25]. The game was released for Microsoft Windows, PlayStation 3, PlayStation 4, Xbox 360 and Xbox One in June 2014, followed by ports to Android and iOS [26].

The game includes four chapters. Most of the game involves solving puzzles. Other parts include: war battles, in which the player must survive under fire through intense shootings; furtive sections, in which the player must avoid detection by the enemy; and car chase scenes. Each character is able to interact with objects, engage in hand-to-hand combat and aim and shoot objects. There are also some traits and skills that are specific to each character, according to the narrative.

As for the plot, this is the story of four characters: Anna, a Belgian nurse; Freddie, an American soldier; Emile, a French farmer; and Karl, his German son-in-law. There is also a dog named Walt who helps the characters solve the puzzles. The story of *Valiant Hearts* follows the events of World War I chronologically, introducing a different approach to the theme by portraying the human side of war and its dire consequences in people's lives. Moreover, the game seeks to portray a dimension of war that is not commonly explored by video games, namely the human suffering involved and the fragility of life, issues of death and mortality, and the absurdity of war.

4 Results

This section presents the categories proposed during the analytical phase, as well as the quantitative and qualitative data of the analysis. It should be noted that this process was conducted in a reverse manner to that presented. First the qualitative data were analyzed, then the classifications were created and the comments were quantified by category. However, for the sake of clarity in the presentation of the research in this work, we organized the explanation of the quantitative data before the qualitative data.

4.1 Categories

Categories and their respective subcategories were as follows:

Technical Aspects

- Technical quality: comments belonging to this category mention the technical qualities of the game, whether related to graphics, sound, realistic features or immersion potential. Within the subcategories, there are comments that present issues related to sound, visual resources or level of realism.
- Design: comments in this category mention the design presented in the game.
- Art: comments in this category present opinions on the artistic qualities of the game.
- Usability: comments in this category mention issues related to usability, user perception during the gaming experience and their answers, according to ISO 9241-110:2010, evaluating the game's suitability and user learning.
- Narrative: comments in this category mention the plot or storyline of the game.

Emotional and Sentimental Aspects
Emotions and feelings: comments in this section present user reviews based on the feelings generated when playing the game. It is worth noting that the difference between both concepts is that emotion refers to emotional involvement that is not discriminated by a certain type of emotion, it is merely present or not. Feelings, on the other hand, are specific and easy to detect, such as anger, anguish and others.

General Aspects

- Positive recommendation: comments in this category present recommendations of the game to other users.
- Negative recommendation: comments in this category present user reviews that do not recommend the game to other users.
- Presentation of historical information: comments in this category present reviews in which users address historical factors related to the theme of the game.
- Mortality: comments in this category present reviews in which users mention death, or human frailty faced with that situation.

4.2 Qualitative Data

The data that led to the definition of each category are presented below.

Technical Quality. The comments in this section present reviews about the technical quality of the game, such as sound, graphics, scene harmony, as well as immersion and realistic features. In U44's opinion, the game has "good graphics in spite of the game's simplicity". Besides, the sound quality and soundtrack received many compliments from the players, as can be observed in Table 1, in which there are 25 comments. An example is a comment by U14: "the soundtrack aligns very well with the rhythm of the game. The melody manages to be delicate, but can also be intense if a more dramatic moment requires it". Furthermore, many users praised the game's realistic features and possibility of immersion, such as U25: "*Valiant Hearts* manages to show the horror of World War I in a simple manner and without 'gore'. Even though the artwork seems 'childlike', the game manages to be scary and exciting".

Design. The comments in this category mention the game's design. An example is a comment by U3, who states that "*Valiant Hearts* has an excellent design". A similar

Table 1. Number of comments mentioning technical aspects

Technical aspects	Total
Sound quality	25
Graphics quality	10
Realism/immersion quality	2
Design	3
Art	9
Usability	16
Narrative	33

comment was proffered by U42, who says that "*Valiant Hearts: The Great War* proves that simplicity is a powerful weapon".

Art. The comments in this category mention the game as an art form, such as the remark by U11: "it is a work of art". Additionally, there are players who elevate the game to the level of a masterpiece, such as U9: "I recommend this game to all who play this masterpiece".

Usability. The comments of this section refer to the game's usability. The game's usability is generally evaluated as good by most users. One of the comments, by U18, states that: "Usability is light and intuitive, which renders the game very accessible". Also, U46 claims that "playability is not difficult, as there are many puzzles and clues for players when they get stuck for too long in a part". However, there were criticisms deeming the game too easy for the player, since learning was too easy. In that respect, U49 states: "what I saw was a puzzle that was too easy and repetitive that it was almost annoying".

Narrative. Comments in this section mention the narrative of the game and, as seen in Table 1, most user reviews are positive, such as one by U2, who believes "the narrative [to be] incredibly captivating"; similarly, U11 considers it to be a "beautiful story (…) VERY charismatic characters". However, there were criticisms about the way the plot is addressed, as exemplified by the opinion of U48: "the game is boring; there is always sad music playing, everything is super dramatic, they overplay the dramatic part so much that when it gets to the end, you're not moved because you've been numbed throughout the whole game".

Feelings and Emotions. Comments in this section present reviews in which users mentioned their emotions and feelings generated when playing the game. As presented in Table 2, there are a significant number of comments mentioning feelings and emotions. One of the most common feelings among users was empathy with the presented scenes, as states U1: "right in the beginning you sympathize very quickly with the story and with the characters rooting for you to succeed". Moreover, U15 talks about the emotional involvement that the game provokes: "It is not enough to have spectacular graphics, the game has to involve the gamer. *Valiant Heart* goes beyond, and stirs your feelings". Furthermore, there were players who experienced an overwhelming emotional moment, such as U18, who says: "War isn't pretty, although the cartoonish style softens it, and I confess I cried at the end". U28 presented an analogous view: "At first, I read the criticisms, and I thought I wasn't going to cry like all the others… How wrong I was!".

Positive Recommendation. The comments in this section present user reviews regarding the game and recommend it to other players. Table 3 depicts the proportion of positive versus negative recommendations of the game, which demonstrates a high approval rate in the community. Among the many positive comments is one by U8, which says "I recommend this for almost all ages", or by U32, which states: "I strongly recommend this, especially for those who like puzzle games; this game undoubtedly deserves a rank in the list of best games of the year."

Negative Recommendation. The comments in this category present user reviews that do not recommend the game to other users. As presented in Table 3, there was only one negative comment about the game. The review by U49 stated: "I bought this game because of the large number of positive reviews. However, what I saw was a very easy puzzle and it was so repetitive that it was almost annoying. (…) If you want to play a decent puzzle game, try *The Cave*. If you like sad stories, I recommend *Brothers a Tale of Two Sons*. But not this game. This is not worth playing".

Presentation of Historical Information. The comments in this section present user reviews that address historical factors related to the theme of the game. It is possible to note, in Table 3, the large number of comments dedicated to this category, all of which praise the strong presence of historical content that provides deeper understanding about and immersion into the history presented in the game. According to the opinion of user U6: "The way in which the story is told gets kudos from me, because it talks about both side of WWI, it doesn't acclaim anyone as a hero, just describes the conflict itself, who was conquering or who as losing territory. It really highlights the situation of the soldiers in trenches, mentions the development of technology; in sum, there are many approaches". In turn, U13 considers the game "a very fun and exciting history class about the Great War. This game is an example of how games can be expression of art and how they can have didactic content and still remain fun". Additionally, many users evaluated the game as a history class, such as U25, who claims that "it is totally educational thanks to dozens of information about World War I, told through an interesting and comprehensible narrative".

Mortality. The comments in this section mention human mortality and frailty faced with the ravages of war, as the example of U1 who remarks: "In the course of the game, we have reports with incredible details (…) so we fully comprehend how war is dirty and cruel in its many facets (…) brave and honorable men have died to preserve our current way of life and, although their bodies have returned to dust, their sacrifices remain alive, and we must respect and be grateful for that!!" Another comment belongs to U39: "It tells the story of characters behind the trenches of World War I, (…) as well as the casualties that resulted from it."

Table 2. Number of comments mentioning emotional and sentimental aspects

Emotional and sentimental aspects	Total
Emotions and feelings	32

Table 3. Number of comments mentioning general aspects

General aspects	Total
Positive recommendation	25
Negative recommendation	1
Presentation of historical information	24
Mortality	8

4.3 Discussions

It should be noted that, during the classification of the posts, some comments could be assigned to more than one category, since a user can address several topics in the same post, as is the case of a sentence written by U2: "A simple game with good playability and puzzles, with an incredibly catchy plot and an excellent soundtrack." In the first sentence, there is a review mentioning the usability of the software; in the second, the user talks about the quality of narrative. Finally, he makes an observation regarding the technical sound quality.

Regarding the technical aspects presented during user reviews, the evaluations on the technical quality of graphics and sound are due to software engineering. Moreover, there is the question of the harmony between image and sound, which needs to be well aligned so that nothing is out of context. As far as art and design categories are concerned, they are obviously a combination of image quality, sound quality and usability aspects that, when well presented, provide to players the experience of watching and engaging in something unique and special.

Regarding the feelings and emotions presented in the user reviews, it is clear that one of the main goals of the developers was to present an involving story that was capable of eliciting feelings in the player. When compared to the amount of good reviews regarding feelings, there are 32 positive feedbacks versus 1 negative rating. Despite this evaluation, it is possible to conclude that the game has good acceptability regarding the presentation of an engaging storyline that is capable of eliciting feelings and emotions.

Other categories that are worth discussing are the positive and negative reviews. In a quantitative comparison, there are 25 positive recommendations against a single negative review. Perhaps something that can be evidenced in this is the presence of specific audiences that may or may not like the game, because in the case of the negative evaluation, the player appears to be more demanding in their expectations regarding the storyline and game difficulty, something that may have influenced their negative experience.

Finally, there is the category concerning the presentation of historical facts, which is important for contextualizing the player in the game's main theme, as well as providing additional knowledge. Within this category, there was the presence of didactic reference in the presentation of historical facts, and in some cases the users actually compared the game to a history class. This factor proves the ability that games have of transmitting, in a different and alternative way, important content that is usually taught in schools, while conveying this knowledge in a light and relaxed means, which is more attractive to the player.

When comparing these results with those obtained in studies with other empathy games [28], it is possible to notice similarities in some aspects approached, mainly the technical ones, like the graphics and sound that play an important role of creating immersion of the player in the virtual world. However, emotional aspects somewhat diverged, since the first analyzed game has a strong emotional appeal from being a personal story and may happen in daily activities. Still, aspects related to death, mortality and mourning were perceived more clearly in this research. In general, both have differentiated aspects, since they are games with distinct purposes and target audiences and thus allowed the emergence of new categories during the analysis.

5 Final Considerations

The central aim of this study was to analyze the perception of users regarding the aspects revealed from the experience of playing an empathy game. In general, the analysis conducted from the discussion forum presented the wealth of aspects involved in this type of game, allowing many possible reflections and studies.

One of the difficulties faced by employing the defined methodology was the diversity of results, since analyzing an empathy game requires interpreting the topic in light of the users' manifestations and classifying different aspects. Furthermore, because the game addresses issues associated with human frailty, such as death and mortality, players may experience different feelings and emotions, which many times can be misinterpreted due to double meanings in the sentences.

Additionally, the categorization of comments using the human eye takes time and can be inaccurate, even when handled by experts, since there are poorly written expressions, grammar and spelling mistakes, and slang. Exploring tools that automate this process and possibly compare it to this analysis is recommended. Moreover, there is a possibility of using a value-oriented approach in social software [27].

In future research, we will seek to investigate and propose a conceptual framework for the development, preproduction, production and evaluation of empathy games. Additionally, aspects related to feelings and emotions require deeper investigation, since they need to be classified. However, they are easily mistaken aspects, because the presence of double meanings, and the difficulty in knowing what the user really means to say can become a hindrance for the researcher. It is also possible to analyze these aspects in light of the User Experience (UX) theories and methods [29, 30] and, through techniques, capturing groups of emotions, since any media needs to create emotional involvement with the user in order to provide a positive experience.

It should be noted that, based on the analysis conducted in the discussion forums of the game which is the object of this study, there was a strong need to collaboratively align, with all the project stakeholders, the visual and sound aspects with the game narrative, so that they would seem coherent. In addition, in games that include a historical theme, such as the one in which World War I was explored, the context of the game and additional information being presented to the player while exploring the virtual environment can improve user immersion and involvement and, consequently, motivate interaction, besides providing the player with new knowledge.

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To the Mun: *Kerbal Space Program* as Playful, Educational Experience

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Abstract. This paper is a case study illustrating how a digital game that conforms to what James Paul Gee terms good game design is one which encourages a state of cognitive flow engages players as a playful experience. This case study will review how good game design, combining flow and specific elements associated with the play outlined in the playful experience framework can lead to learning outcomes. The paper will look at specific designed elements of the game *Kerbal Space Program*, such as open and directed play modes and the community of player-participants and content creators as they relate to principles of learning and elements of pleasure framework to illustrate how good educational game design is pleasurable game design and by linking pleasure, play and learning.

Keywords: Play · Flow · PLEX framework · Educational games · Game studies

1 Introduction

Kerbal Space Program [16], or *KSP*, is a digital game where the player must create and maintain a civilian space program akin to the National Aeronautics and Space Administration. *KSP* gives players the chance to explore elements of astrophysics, physics, rocket science and aerospace engineering by constructing rockets, airplanes, and probes in a robust simulation of modern and near future space travel. *KSP* also has elements of an optimal experience allowing players to enter into a state of cognitive flow, and as a designed game experience, it simultaneously embraces multiple elements of the PLEX framework [3]. *KSP* is a perfect example of a game that serves an educational goal while simultaneously designed to be an engaging, playful experience. *KSP* was formally released in 2015 and has evolved from a sandbox rocket construction game where the goals are entirely self-directed to include a far more enriching, heavily designed, goal-based game where a series of soft-directed goals are presented, and when complete, unlocking new paths of progression. At its heart, *KSP* is a game that takes complex engineering and scientific issues like interstellar probes, rocket science, and interplanetary robotic or manned missions and simplifies them enough to provide a broader entry point for the mass market without sacrificing sufficient fidelity to physics.

KSP is not just a game that is well crafted technically, but it is also an engaging game. An engaging game is a game which embraces the core elements of the

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psychological phenomena of flow [5]. While the identified qualities of flow cover everything from voluntary participation and temporal experiences, the qualities as they relate to games have been simplified down to four specific qualities [1]:

- Explicit Goals with Easy to Follow Rules
- Attainable Goals
- Clear and Usable feedback
- Minimize distraction from the experience

These same qualities are discussed by scholars and developers alike [4, 9, 10, 13, 16] when they talk about effective and engaging game design. The definitions offered, regardless of their origin, all address the above four points, weighting some points of greater importance than others. Regardless of their weighting, the above elements relate directly to the concept of flow, and in some cases, overlap. The qualities of flow [5] can be summarized as:

- Clear and immediate feedback
- Capacity for deep concentration
- Balance between skill and challenge
- User agency
- Effortlessness
- Altered perception of time
- Rewarding as activity and goal
- Complete intellectual investment

While *KSP* is a game designed to get its player into a state of flow, and thereby engaging, it is also an inherently educational game. While not explicitly educational, *KSP* does adhere to specific learning principles, per Gee [7], of games by creating or doing the following:

- A safe environment for learning and experimentation, where the player can make real choices and probe the boundaries of the simulation.
- Incrementally teach the player the skills and content to ensure mastery of the game rules and content and encourage self-determination.
- Allow for the creation of Affinity Groups, where players are more than just insiders to the game, but can become masters and share their information with others.

These elements have the potential to arise out of any well designed digital game, but are they vital to creating an engaging educational experience.

2 Digital Games, Flow and Playfulness

2.1 Digital Games and Flow

The concept of flow is directly related to games of all types. Often, players of sports like baseball or basketball talk about being in the zone. This idiom commonly describes being extremely so focused on the task at hand as part of the larger game that success seems to the outside viewer, as automatic. When players enter into a state of flow, they are in the zone, and are entering into the optimal state of play for that game.

The definition of a game varies and continues to serve as a point of contention amongst researchers and developers alike. Roger Caillois' [2] six qualities of a game remains relevant to everything from physical sport to digital games, as modern developers and theorists have sought to further quantify or take a more granular look at how digital game specifically fit into the greater ecology of games. Some developers couch it specifically in terms of an "active agent against whom you compete" [4], which is potentially subjective in its scope as it assumes that the active agent is either another player or a sufficiently challenging artificial intelligence. Others such as Juul [9] and Koster [10] have attempted to more generalize the definition of game to be retroactively inclusive, deriving a definition that encompasses everything from a first person shooter to puzzles and simulations. For the purposes of this analysis, a game consists of "a goal, rules, a feedback system, and voluntary participation" [13].

Csikzentmihalyai [5] defines flow as "a feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment". Built on that and in terms of games, Schell [16] defines flow as a "state of sustained focus, pleasure and enjoyment". A game can get a player into flow, or into the zone, if they successfully balance between an ever increasing challenge with ever increasing cumulative skill of the player. This relationship can best be thought of a sine wave (see Fig. 1), constantly moving toward anxiety and then back toward boredom and back again.

Therefore, as long as the design of the game keeps one from becoming too anxious or too bored, then the player has a greater chance of getting into a state of flow and becoming engaged by the game. *KSP* is most definitely a game: players are tasked with goals that are enforced by rules. These rules vary depending on the game type. The player then receives feedback as they work to achieve the goals to advance through the game. Most of all, people are playing the game voluntarily and creating a dedicated community of practice and online affinity spaces for players of all skill levels to utilize and learn from as they continue their attempts at exploration and play.

2.2 Flow, Playfulness, and Good Learning in Games

The pleasure framework, as proposed by Costello and Edmonds [3] outlines a framework by which developers and designers of interactive art can better quantify and subsequently design pleasurable experiences. Games of all sorts, digital and analog, can be considered interactive art, especially if we consider the definition as proposed above. In the case of what constitutes the game, interactivity is an assumed element of the definition, where players struggle to achieve a goal while working within and against the rules of the game. If one considers that player participants in games also, per Costello and Edmonds, "adopt an active role in order for this [interactive] experience to occur"[1] by struggling with and against the rules to achieve the defined goal. Therefore, the playful experience framework [3], or PLEX, is a suitable framework by which to

[1] See p. 1 of A Study in Play, Pleasure and Interaction Design.

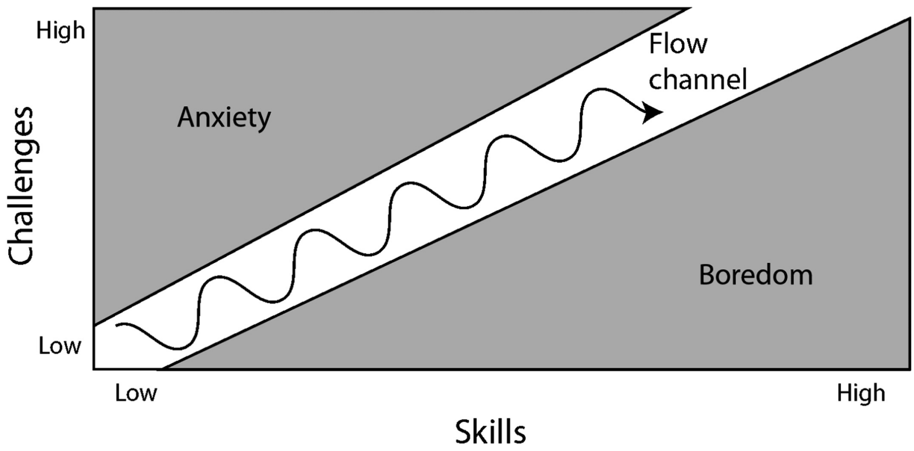

Fig. 1. Game Players within the Flow Channel [16]

judge the playfulness not just of interactive art, but of interactive digital and analog games.

PLEX is a series of categories that describe a broad range of activities through which interactive art can be evaluated. These activities range from the physical to the psychological and can easily be applied onto any sort of interactive art or technology specifically designed to encourage or foster audience or user interaction. These qualities are:

- Creation: The power to create something while interacting with the work.
- Exploration: The power of engaging with unknown situations.
- Discovery: Giving participants agency in solving a problem within the context of the work.
- Difficulty: Giving participants agency to learn a skill to overcome a challenge presented as part of the interactive experience.
- Competition: Giving participants agency to achieve a defined goal, either against the work itself or against other participants directly or indirectly.
- Danger: The work evoking a sense of fear or risk taking as part of the experience.
- Captivation: The feeling of being entranced or controlled by the interactive experience.
- Sensation: Haptic feedback as part of the interactive experience.
- Sympathy: Evoking emotion through the interactive experience.
- Simulation: The interactive experience is based on a real-life situation.
- Fantasy: Engaging with creatures or elements of fantasy or make-believe.
- Camaraderie: The interactive experience engenders positive social experiences with other participants.
- Subversion: The experience engenders pleasure from subverting the rules, whether that be cultural, social, or the interactive experience rules.

The qualities of playfulness outlined in the PLEX are cited as elements that overlay directly with the concepts outlined by Caillois but also Csikzentmihalyai, illustrating overlaps between the three structures.

For Caillois, per Fig. 2 below, overlap occurs across the four elements of games pairing with five elements of the framework. It is worth noting that Caillois was speaking of analog games and sports; his work predates the digital game by several decades.

For Csikzentmihalyai, per Fig. 3, qualities of flow theory span multiple elements of the framework. By combining the two lists, a set of qualities begin to isolate what could be considered good game design in general. Part of this analysis needs to account for Gee [7] and the learning qualities that he cites as being indicative of good game design that inspires good learning. These learning qualities draws directly from flow theory. While flow began to formulate around the time of the digital game boom, it was not conceived originally as something experienced by players of games. Only after the rise of digital games was flow theory applied to player experiences.

If we were to qualify qualities of good game design that facilitate learning per Gee and map it against the PLEX framework, the following links are made (Fig. 4):

The concepts of learning and identity, listed above in Fig. 3, outline the capacity for interactive games to not only create an alternate world that the participate experiences through the means of digital simulation, but to give the player agency to create their own identity. This identity may mirror their real world identity, or it may be something completely different, but it is through the creation of this identity that is both self-directed, projected and embodied that allows reflection of learned information. The semiotic principle is the ability to look across multiple semiotic systems as a complex whole, which involves the player engaging with and determining the affordances of the algorithmic systems presented as the digital game. Situated meaning and learning covers the process of using interactivity to discover new information through the course of play. Telling and doing covers a large amount of the PLEX, as the elements of the PLEX overlap with the core experiences of playing an interactive, digital game. Cultural models deal with establishing accurate content, agency, and semiotics of the game content and the ability for users to not just engage with it, but do so reflectively. Finally, the social mind brings the concept of learning in digital games back to learning being an inherently social activity[2].

The PLEX Framework overlaps with established frameworks, assumptions and definitions as to the constitution of good game design by both academics and professional developers. When we take all three frameworks together, we can see that there is some overlap, represented by the dotted line, with the elements of ‘problem solving’ and ‘risk and chance’ from Csikzentmihalyai, Situated Meaning and Learning and Telling and Doing from Gee and Discovery, Difficulty, Creation, Danger and Captivation from the PLEX framework. It is in these elements that, arguably, gameplay occurs in entertainment or educational focused games. *KSP* is a professionally developed digital game that provides a compelling learning experience, encouraging players to indulge in serious scientific and engineering principles. It accomplishes this through

[2] This is a simplified summary. For more see [7] in its entirety.

Caillois	PLEX Framework
Competition	Competition
Chance	Danger, Captivation
Vertigo	Sensation
Simulation	Simulation

Fig. 2. Caillois and the PLEX Framework [3]

Csikzentmihalyai	PLEX Framework
Problem Solving	Discovery, Difficulty
Competition	Competition
Risk & Chance	Danger, Captivation
Creative	Simulation, Fantasy
Friendship & Relaxation	Camaraderie

Fig. 3. Csikzentmihalyai and the PLEX Framework [3]

Gee	PLEX Framework
Learning and Identity	Competition
Semiotic Principle	Exploration
Situated Meaning and Learning	Discovery
Telling and Doing	Difficulty, Creation, Danger, Captivation
Cultural Models	Simulation
The Social Mind	Camaraderie

Fig. 4. Gee [6] and the PLEX Framework [3]

not just good game design, which evokes engagement and participation, but it also generates a playful experience that encourages participants to engage with several elements of the PLEX framework simultaneously.

3 Sandboxes and Self-Discovery

KSP is built around several different game modes. The sandbox game mode is a freeform mode giving players access to all of the content of the game. This mode was originally provided when the game launched, allowing players full access to the various components needed to build a variety of drones, robots, as well as manned and unmanned aircraft and spacecraft. The success or failure of missions is largely dependent on the survival of the craft, the skill of the player to pilot their created vehicle, and the capacity to achieve the self-directed goal established by the player for their own mission.

This sandbox mode is useful beyond utilizing the game as an electronic toy, such as *SimCity* [12], where goals are sufficiently broad to encourage a more pure form of play that is undirected and abides by more classical definitions of the term. Sandbox mode here provides a safe space to refine not just vehicle designs, but also to get a firm grasp on the complexities of piloting vehicles within a space where there is little to no penalty for failure. In this capacity, *KSP* is giving the player a chance to explore the game space on their own terms, embracing Gee's [7] discovery principle, which states that "Overt telling is kept to a well-thought-out minimum, allowing ample opportunity for the learner to experiment and make discoveries."[3], thereby allowing the player to "to experiment and make discoveries" at their own pace. Learning to pilot a simulated rocket that has enough power to achieve a stable orbit within the game is a challenge, particularly as one must navigate several different screens to plan the orbit and project that plan into the user interface while the rocket is in flight. The tools for doing this are provided to the player, but they require interaction to learn and any sort of instruction or tutorial is eliminated entirely and encourages player experimentation. The game mode encourages the player to test, through trial and error, new rocket designs while simultaneously pushing the boundaries of the game without punishment beyond the time sunk into the previous and current designs. This lack of penalty allows the player to explore optimal designs and mechanical configurations for their experimental vehicles and determine if they will meet their self-directed challenge. If the rocket does not, then the player is free to modify their vehicle until it can attain their goal, or they can destroy it entirely and start from scratch. The player can also revise their internal goal, and change the requirements to either suit the existing design or consider a new challenge to tackle with the existing rocket design.

In the sandbox mode gameplay variant, all goals provided to the player are intrinsic goals. This increases the chance that the player will enter into flow because the parameters of the goal are established by the player themselves and the act of play provides the award [14]. By placing the player in control of what they need to do, the goal can be modified, which "results in high-quality learning and creativity" [15]. This mode allows players to learn the interface without time or mission constraints, as the penalties for failure or modifying the mission is moot. This allows the players to understand the feedback as presented to the player within the context of the game. By allowing the players to self-direct and understand the interface, they can filter out unnecessary information not just as presented in the game that is moot to their goals, but can begin to assimilate the information presented and understand how to apply them during more difficult or directed scenarios and more easily get into a state of flow.

When we overlay the PLEX framework, the sandbox mode offers elements of nearly every aspect of the framework elements as listed in Fig. 5. All of this is contingent on the situation of play, of course, but by far the primary elements we see from PLEX are creation, exploration and discovery. While these elements assume a specific type of player, it is worth noting that the sandbox-style of game gives the ultimate amount of freedom to the player to do whatever they like within the constraints of the game systems. The sandbox mode provides open access to all game content without any sort of rule-based structure, allowing players to construct their own airplanes,

[3] For a full description of Gee's discovery principle, see Chap. 5 of *What Video Games have to Teach Us about Learning and Literacy.*

rockets, and other space vehicles, regardless of their efficacy. This mode allows players to do the following:

- discover how the various systems within the game work with little repercussion
- make modifications to the user interface to suit their attention
- learn how to understand the feedback provided by the game
- how to translate that into actions that will either positively or negatively impact their designs.

Sandbox mode also allows players to explore more than the mechanical systems presented by the game. Players have the agency to discover how these various systems, or semiotic domain, interact and practice developing and creating their own rockets in preparation for playing through the more limited, mission-driven aspects of the game. The exploration can also be literal, as players can explore the world of Kerbin, the Earth proxy within the game, or the entire solar system including the nearest astral body, the Mun, Kerbin's moon. If we take flow theory and the concept of a good game as described above, then captivation is entirely possible, as players generate intrinsic goals for their creations, from orbital insertion of a new satellite or landing a member of their astronaut corps on the distant Mun.

Because it is player driven, players in sandbox mode can engage with other elements listed in Fig. 5, like simulation, difficulty and camaraderie, but these are all highly contextual on where, when and how the player is engaging with the game software. When it comes to intrinsic motivation as part of the sandbox play experience, things like simulation and difficulty are not something explicit in the game mode. The sandbox is less concerned with extrinsic rules and motivations for the player, relying on self-motivated players to create their own meta-tasks within the game. The same with difficulty, where the difficulty is related more to intrinsically generated goals by the player. The challenge is self-imposed, and given the ease at which players can restart missions, difficulty becomes less about overcoming computer-imposed obstacles and more about player-defined challenges and obstacles.

Finally, the sandbox also offers the most flexible application in an educational environment by students in primary and secondary education. Teachers can provide the goals and missions that are not provided by the game, while providing a direction with the interface used in the planning and successful construction of rockets. Because the game lacks a specific tutorial, normally used to teach new players how to play the game, the sandbox mode gives the player and the instructor the tools needed to not just create a tutorial for a diverse number of age groups, but then hands these players a vast digital simulated scientific game where players can leverage information imparted by instructors and apply it within the game itself in a consequence-free environment. By doing this, *KSP* lays the ground work for an educational affinity space. In this affinity space, *KSP* creates the feeling of managing a space program, where the teacher and students can encourage and resource their own creativity and productivity [6]. If the players successfully apply the information generated within the affinity space, then their mission will be a success. If their mission is a failure, students join together in this affinity space to discover what went wrong and then retest their designs by resetting the game world and executing the mission again. The game provides a space in which students can explore, experiment and apply information that has been taught to them

Csikzentmihalyai	Gee	PLEX Framework
Competition	Learning and Identity	Competition
	Semiotic Principle	Exploration
Problem Solving	Situated Meaning and Learning	Discovery
Risk and Chance	Telling and Doing	Difficulty, Creation, Danger, Captivation
Creative	Cultural Models	Simulation
Friendship & Relaxation	The Social Mind	Camaraderie

Fig. 5. Gee [6], Csikzentmihalyai and the PLEX Framework [3]

without the necessity of grades or testing as the game is testing and retesting the students and completion of the goal illustrates a pass/fail state.

4 Achievement and Science

The second game mode for *KSP* is referred to as science mode. In this mode, the player is constrained as to what components are available to them based on the amount of research they perform on each mission. This mode places constraints on vehicle components by requiring players to pack their designs with a variety of unique scientific gear that generate points which can be spent unlocking new technologies. These new technologies then unlock new missions and new chances to generate more science points, creating an extrinsic motivation for the player. These awards illustrate compliance with the rules of the game and successful assimilation of game feedback, where the player can “obtain an externally imposed reward contingency” [15]. These rewards funnel the player into a series of challenges which tests their mission design, vehicle design and vehicle piloting capabilities. This is also a test of the basic application of physics upon which the game is designed. Science mode also serves to prevent information overload as players are introduced to vehicle components and capabilities in small chunks, allowing newer players to more gradually build their version of *KSP* by limiting not just their mission goals, but their vehicle capabilities to more manageable chunks.

This reduction of capabilities is useful for new players. By providing a subset of information, *KSP* is allowing players to learn the game and its mechanics slowly so that “by the time new players are aware of what basic skills in a given type of game…they have already mastered them” [7][4]. By reducing the number of components available to the player, the amount of information that needs to be processed in order to complete the provided missions is reduced. This allows the player to increase the amount of attention then can give to their goal rather than spending time sorting through a large

[4] For a full description, see pp. 135–136 in Chap. 5 of *What Video Games have to Teach Us about Learning and Literacy.*

variety of component types and capabilities which may far exceed the needs of the goals presented by the game. This ensures that the learning situation is based upon Gee's [7] incremental principle[5].

With PLEX, we see the invert the sandbox above. Instead of intrinsic self-directed motivation for the player, the qualities of PLEX become constrained by the gameplay systems. In this case, the simulation becomes highly restricted and bound by the rules of the game and beyond simply a representation of the physical world. While elements of creation are still leveraged, these are constrained by limitations to available parts, meaning players must do more with less until they achieve sufficient points in various categories to acquire new technologies and new rocket or vehicle parts. So follows, discovery and exploration are now directed toward achieving goals as determined by part research, gently directing the player extrinsically. Flow is still possible, but *KSP* becomes a different type of playful experience. Here the elements of competition, simulation, difficulty and danger come to the fore.

These elements are a mirror of most single player-focused digital games. Competition is indirect. Players do not play with each other, but they are competing against the challenges that have been intentionally designed and algorithmically enforced by the computer. That isn't to say that, in the right context, that competition cannot occur, but these are all external to the challenges presented by the game. Players may choose to race to the Mun if played in a computer lab or an internet café, but this does not change the challenges outside of science mode. Instead, players are competing against themselves and the game. They need to work within the constraints presented by the game challenges and their own capabilities, establishing a specific difficulty that constrains and challenges the player; a key elements of flow. The games challenges are explicitly designed to be difficult. Per flow, as illustrated in Fig. 1, the game provides a balance between challenge and skill. Initial parts provided allow players to create simple vehicles with limited capabilities. As they complete challenges, the new parts are unlocked and new capabilities allow for more complex vehicles. Danger also comes not to the player directly, but to the player avatar and representation in the game. In this case, losses of astronauts occurs, but equipment is replaced easily. Here, the game rewards engaging with danger as it relates to the flow channel. Performing risky designs that meet the challenges is a method of intrinsic motivation in response to the extrinsic motivation of the game.

Science mode is a different style of game than sandbox mode, but still an element that evokes a playful experience. The experience, in this case, is one geared toward flow, so it follows more faithfully with the elements and comparisons made above. That is not to say that the sandbox mode is not playful; they are both obviously playful. The type of playfulness that is fostered is different, based on either player-centered or game-centered challenges. Playfulness then becomes a choice between playing with the game systems or playing the game and within the constraints of a more limited experience. Both are certainly valid, and presents an interesting dichotomy in an educational context. Students and teachers alike can use the limitations of science mode to emphasize specific points about scientific inquiry and engineering, or they can use or

[5] See p. 137 in Chap. 5 of *What Video Games have to Teach Us about Learning and Literacy.*

use the sandbox to emphasize engaging with the simulation of astrophysics and aerospace engineering.

5 An Affinity for Rockets

KSP is a game intended to be played alone. It does not have an explicit networking component, so as players interact with the game, they are intended to do so solo. While this certainly fits with the classic idea of school work, experts who play this game and any game for enough time and with enough skill will become a member of the games semiotic domain. It is through this semiotic domain and the affinity groups that they generate that students are better to teach each other how to optimize their experience in the game.

A semiotic domain is defined as “an area or set of activities where people think, act, and value in certain ways” [7]. Most digital games like *KSP* qualify as individual semiotic domains. *KSP* possess a unique set of modalities (images, sounds, and information), which can be grouped together as a common set of signs that are used “to communicate distinctive types of meanings” [7]. Learning this information and being fully involved in the semiotic domain is how you learn to play the game as well as internalize the information presented.

KSP, by being a semiotic domain, also generates a community of players either locally or through the internet that has been termed an affinity group. Members of these groups are insiders who “recognize certain ways of thinking, acting, interacting, valuing, and believing as more or less” [7] the same. Every classroom where *KSP* is played has the potential to become a specific instance of an affinity space, joining other affinity spaces that already exist for the game, such as the *KSP* wiki [17]. The wiki provides another tool in the application of distributed cognition and knowledge accumulation [8] around playing the game, providing a central focus not just for individual players to seek out information on how to complete tasks in the game, but as a means to contribute their own information to the pool of knowledge around the game.

These affinity spaces, whether online or in the classroom, serve as means of bonding between the students toward their common endeavor of playing the game and the objectives contained within either by the game or by the instructor. In the vernacular of the PLEX, this is camaraderie. As defined in the PLEX, camaraderie is “the pleasure of developing a sense of friendship, fellowship or intimacy with someone” [3], and these affinity spaces serve as a means to meet and engage with, either in the classroom or mediated by the internet, allows the formation of a community practice by players and teachers alike. Here, teachers and students become both learners and producers. To play *KSP*, the student needs to not just learn the basics of physics to create their rockets, but they need apply what they have learned and produce rockets that achieve the goals either created by the game or intrinsically by the player themselves. It is through these affinity spaces that any information missing from the participants’ repertoire of knowledge can be supplemented and subsequently applied.

The extrinsic goals provided by the game also provide instructors and students alike a series of concrete goals to attain. This conforms to the expected role of the instructor and the game as a tool for instruction, as meeting the goals serves as a test to ensure proper instruction has not just taken place, but the information has been successfully applied. Extrinsic goals can undermine intrinsic motivation of the student [11] if unsuccessfully applies, particularly if the student loses a sense of psychological self-determination [14].

6 Conclusion

Games and education are at a crossroads. Digital games are becoming more powerful with increasingly complex and effective technology, with handheld phones like the iPhone coming with more memory and processing power than home computers and consoles that were modern a decade ago. As game content has become far more intertwined across multiple media, so has the player demand for more diverse and unique game experiences delivered with amount of polish and quality. Educational games will be compared against entertainment-focused games. If educational games do not measure up in terms of engagement and design principles that are used in creating digital games, they will be neglected and ignored by the students. The most obvious and well documented way to get students engaged with an educational game is to ensure that the game is well designed and therefore engaging. The PLEX framework provides a method by which all games can be analyzed. This is especially important in educational contexts, as stakeholders such as faculty, parents and administration view the value and use of explicitly entertainment focused titles in educational contexts skeptically. By providing for a set of criteria that elaborates on the value of the game as means of engagement in an educational context, it becomes easier to not only explain its learning goals and purposes. This data will allow designers and educators to better leverage these games in the classroom and meet students in familiar territory. By being inclusive of educational digital games like *KSP*, educators allow students to exceed and excel, rising over those “who never confront challenge and frustration, who never acquire new styles of learning, and who never face failure squarely” [6].

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Interaction Techniques in Three-Dimensional Virtual Environments Based on Games to Support Chronic Diseases Treatment: A Systematic Review

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Abstract. Games have quickly risen in culture, as well as serious games, which in addition to providing entertainment, also play the role of teaching resources. At the same time, the lack of information in children in relation to Diabetes has caused this disease to be treated with neglect. This paper presents the results of a Systematic Review on interaction and immersion strategies applied in Virtual Environments based on games or Virtual Reality proposed for children and adolescents in the context of the treatment of chronic diseases such as Diabetes. From the results obtained with the SR, it was possible to identify the main techniques that were applied to design the user-centered design project, including the experience of the stakeholders and their needs.

Keywords: Serious game · Diabetes · Chronic diseases · Virtual Reality

1 Introduction

Digital games have become popular in recent years and have become part of the popular culture, going beyond entertainment. Several areas of knowledge have applied digital games as an interaction strategy to aggregate knowledge and motivate training and teaching. The term "serious games" has been used to refer to games where entertainment is not the main objective [23]. Alvarez and Damien [1] define serious games as games aimed at combining serious aspects such as teaching, learning, communication or information with fun elements that are found in digital games.

Within the healthcare area, studies can be found that develop serious games with different purposes such as teaching and training [3], rehabilitation [3], physiotherapy [25], anxiety treatment [10, 20], as well as syndromes and phobias [10, 20]. In this

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context, we realized that the games area may contribute to the treatment of chronic diseases by means of involving, interactive and immersive Three-dimensional Virtual Environments (3D VE). Among the various chronic diseases that affect adults and children indiscriminately, Diabetes heads the list.

According to the International Diabetes Federation (IDF) [18], in 2017 approximately 425 million adults (20–79 y.o.) lived with Diabetes and by 2045 this number, representing world data, is likely to reach 629 million. In Brazil, estimates indicate that more than 12.5 million Brazilians live with the disease [2], which is responsible for the increase of blood glucose, and can cause complications such as visual impairment, renal failure and amputation of members.

Data from the IDF [19] also point out that about 1 million Brazilians suffering from diabetics develop ulcers and 200,000 will need to undergo amputations, out of which nearly 20% lead to death. Some of these patients, about 10%, may suffer lower limb amputations, such as feet due to the destruction of their tissues. One of the disease's microvascular complications is nerve damage, which can lead to loss of feeling and worsen existing wounds in the feet, kidneys and eyes, as the disease can progress to kidney failure and blindness. Therefore, it is important to make the population aware of the adequate treatment of the disease, using different means of communication and interaction.

It should be noted that the greatest challenge lies in the lack of an early diagnosis and an adequate diet. The lack of information on best practices in the treatment of Diabetes, especially children and adolescents, has contributed to the progression of the disease.

In this context, this paper presents the results of a Systematic Review (SR), aiming to answer the following research question, "which interaction and immersion in 3D VE techniques based on Games and Virtual Reality (VR) are applied in contexts of chronic disease treatment, especially Diabetes?".

2 Methodology

The investigation methodology applied in this study started from a Systematic Review of the literature that followed the PRISMA model (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [11]. Three phases were followed: planning, conducting and results extraction.

In the planning phase, the SR protocol was established by guidelines that were followed throughout the review. In the conducting phase, primary studies from the last five years (2012–2017) were sought to find new approaches that could answer the research question of this study *"Which interaction and immersion in 3D VE techniques based on Games and Virtual Reality (VR) are applied in contexts of chronic disease treatment, especially Diabetes?"*. The search for studies was based on the combination of search strings applied in the IEEE and ACM databases.

The SR conducting phase considers two important steps: (i) preliminary selection, which consists of the analysis of the titles and summaries of each work and (ii) final selection, which consists of the analysis of the full texts of the articles included in the preliminary selection stage. The selection of the works of interest was performed according to the inclusion and exclusion criteria defined in the protocol.

In this study, we considered as **inclusion criteria** the papers that present:

- applications that address the treatment of Diabetes through 3D or 2D Virtual Environments, based on Games and Virtual Reality;
- applications that address the treatment of chronic diseases through 3D or 2D Virtual Environments, based on Games and Virtual Reality;
- interaction and immersion techniques in 3D VEs, specially aimed at children and adolescents.

Regarding the **criteria for the exclusion** of papers, those studies whose focus did not correspond to the research question raised or that did not meet the established inclusion criteria were excluded from the SR.

In the results extraction phase, the answers to the research question were included in the SR final selection and the results were summarized. Figure 1 shows a distribution of the included and excluded works of the SR, as well as the search strings adopted in the research.

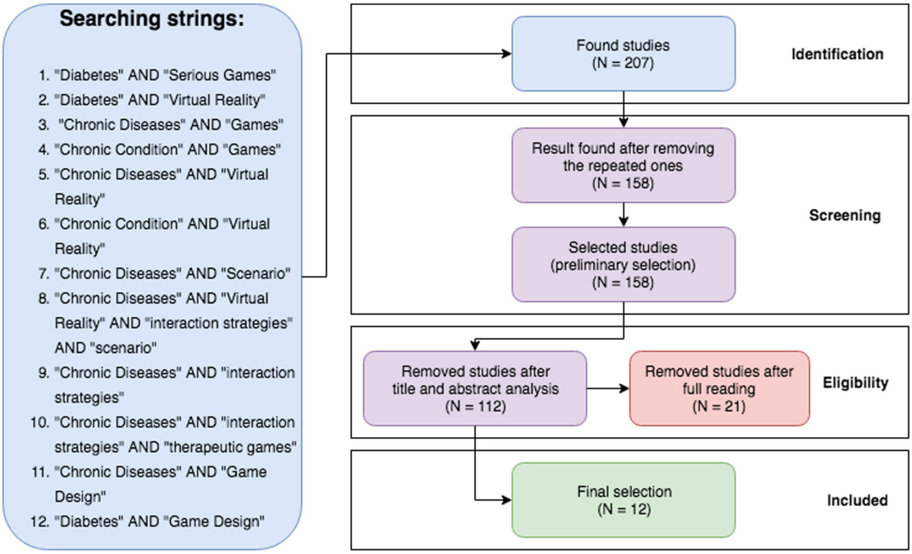

Fig. 1. Number of articles included and excluded in the RS steps

A total of 207 studies were found during the SR phase, 34 studies selected in the preliminary selection and 12 articles included in the final selection phase, which present answers to the research question.

From the SR results, some relevant aspects were identified, such as: the type of Virtual Environment (VE) in which the work (2D or 3D) was developed; the interaction strategies applied; the VE study context; Participatory Design (PD) techniques applied; the challenges explored in the VE scenarios; the available computational interaction and/or immersion devices; whether or not experiments were carried out and the target audience of the works. SR results are presented in Sect. 3.

In sequence, the results of the SR were used to support a 3D serious game project to aid Diabetes Treatment, especially for children and adolescents. The serious game project is presented in Sect. 4.

3 Systematic Review Results

This section presents the SR results, showing studies that use Virtual Environments in the context of Diabetes and also those related to other Chronic Diseases. Table 1 summarizes the main aspects observed in the studies in the SR, and then presents a synopsis of each work, aiming at a better understanding of the contributions from this bibliographic survey to the larger objective of the research project, which is the design of a 3D VE to support the treatment of Diabetes.

3.1 Works Related to Diabetes

The work of Fernandez et al. [12] presents a design proposal containing illustrative images for the design of a game, which uses VR techniques to simulate a supermarket and a person shopping. The game's goal is to present an attractive environment of food products for the player to interact with, and through the interactions during the exploration in the VE, to verify the behavior of people suffering from Diabetes, in order to guide them on how to overcome the food consumption challenges and adopt healthy eating habits. It is an educational tool, the objects of which were modeled using Maya[1] and 3D Studio Max[2] softwares to recreate the scenario in a 3D environment. In addition, Eye Tracking (EG) and Electroencephalography (EEG) techniques were applied to compare measurements such as the gaze pattern and cognitive load. The results are incipient, since the tool is still being designed and has not been tested with potential users.

Borsboom [6] presents a "proof of concept" study which demonstrates the feasibility of creating a serious game for the purpose of teaching people how to manage Diabetes symptoms. The game prototype was developed on the Unity 3D game engine and features a set of gaming techniques that can be applied to represent different symptoms of Type 1 Diabetes through a video game. The research methodology included the selection of participants from different age and gender groups suffering from Type 1 Diabetes in order to play the video game for a short period of time. Data were collected on how much participants knew about managing Diabetes symptoms before and after playing the video game. Data collection was related to the content depicted in the video game, specifically about glycemic control, calorie count, meal portions, and types/levels of physical exercises. Different instruments were used in the data collection, such as checking participants' hemoglobin level, questionnaires and interviews. Results showed that it is possible to adapt the Minecraft game or The Elder Scrolls: Skyrim to train people on the best way to manage of Type 1 Diabetes, and this is part of future research of Borsboom's study.

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1 https://www.autodesk.com.br/products/maya/overview.

2 https://www.autodesk.com.br/products/3ds-max/overview.

Table 1. Main aspects of the studies selected in the SR

Font	Environment	Interaction Strategy	Approach	Participatory Design	Challenges	Interaction Devices	Experiments	Target Audience
Hatzigiannakoglou. [15]	2D VE	Game, Avatar, First person shooting (FPS), Explanatory Audios	Down Syndrome	Uninformed	Choice	Mouse and Wii-Remote	✓	Children, Teen and Parents
Stach and Schlindwein [26]	2D VE	Game Based Learning, Avatar, Google Maps	Diabetes	Interviews	Defense	Touch screen		Children with Diabetes
Oikonomou and Day [27]	3D VE	Breath Exercise, Game, Avatar	Cystic Fibrosis	Usablity feedback	Breath	Positive Expiratory Pressure (PEP) connected by USB	✓	Children and Parents
Fernandez et al. [12]	3D VE	Game, First person shooting (FPS), hands-on food choice training	Diabetes	Uninformed	Exploratory learning	HMD VR Wrap 1200VR, joystick		Patients Uninformed Age
Orji, Vassileva and Mandryk [28]	2D, cross platform application	Game Based Learning, slow-casual game	Health Care, Diabetes	Profile Questionnaire	Nutrition knowledge	Touch screen	✓	General

(*continued*)

Table 1. *(continued)*

Font	Environment	Interaction Strategy	Approach	Participatory Design	Challenges	Interaction Devices	Experiments	Target Audience
Borsboom [6]	3D VE	Game, First person shooting (FPS), Avatar	Diabetes	Uninformed	Management of Diabetes	Touch screen	✓	Patients with Diabetes Tipo 1
Bomark [4]	2D VE	Social learning Game, Virtual community, Avatar	Diabetes	Feedback Questionnaire	Mini-Games with several challenges, missions, competition	Touch screen	✓	Children and Parents
Brox et al. [7]	2D VE	Social learning Game, Virtual community, Avatar	Diabetes	Feedback Questionnaire	Mini-Games with several challenges, missions, competition	Touch screen	✓	Children and Parents
Bomfim and Wallace [5]	2D VE	Game Based Learning, Creating of Character	Health Care	Uninformed	Nutrition knowledge	Touch screen		Young Adults
Chen et al. [9]	2D VE	Game Based Learning, Avatar	Diabetes	Feedback Questionnaire	Best choices	Touch screen	✓	Adults

(continued)

Table 1. *(continued)*

Font	Environment	Interaction Strategy	Approach	Participatory Design	Challenges	Interaction Devices	Experiments	Target Audience
Harris, Duresi and Tuceryan [14]	2D VE	Game Based Learning, Gamification	Diabetes, Obesity	Uninformed	Mini-Games with Several Challenges	Touch screen, accelerometers, camera and voice recognition		Children and Teen
Kyfonidis and Lennon [21]	2D VE	Game Based Learning, Interface Tangível with multiple feedback channels	Diabetes	Uninformed	Exploratory learning	Touch screen		Children and Parents

The works of Brox et al. [7] and Bomark et al. [4] discuss the design process of a game based on the concept of social learning games, which are both engaging and fun for diabetic children. The methodology applied in the research included, in addition to a bibliographical research, search in discussion forums related to Diabetes chronic disease, interviews with Diabetic children (aged 8 – 12), their families and health professionals. The authors found several educational games related to Diabetes, especially dealing with nutritional aspects and healthy eating habits, but no social games were found. Thus, the authors proposed a game that explores most of the social aspects through a social learning platform, in which avatars, leader boards, achievements and communication, among other issues, are part of the game. This allows strategies, such the use of sections of pre-recorded games by opponents, to be contested by other players, making an asynchronous game seem to be synchronous, or strategies that require players to ask their friends for help in some tasks. Another feature is the ability to “push” missions onto players by asking them to help on behalf of one of their friends or by challenging them to overcome a high score set by one of their friends. In addition, rewards encourage participants to continue playing and to try other minigames on the platform. The authors realized that offering several minigames introduces variety and helps integrate learning tasks.

To test the concept, Brox et al. [7] developed the Glucose Race minigame, in which the player uses different types of transport (airplane, car, motorcycle, walking). The minigame challenges players by using their own knowledge about insulin (fuel is food, oil/air is insulin, and speed is level of exercise). Once the player realizes that the game's strategies match the mechanisms of insulin and blood sugar, they can use their knowledge to perform better. The player must plan the race before starting; speed, fuel and oil must be balanced. The competition takes place with races pre-recorded by friends, giving the impression of live interaction. Friends' help can be provided by pre-recorded comments and tips from previous game sessions. The game also explores aspects of persuasive games, as it seeks to persuade users to modify their behavior.

The authors concluded that it is not easy to get feedback from children about issues they are unfamiliar with. It should be noted that the children who participated in the experiments were not familiar with intrinsic learning games, social games and persuasive games, which may have somehow hampered the performance of the players [4, 7].

Another study on Diabetes, with an educational purpose, is presented by Chen et al. [9]. The game design was applied to an existing open source 2D game (Mario Brothers). The study led to the identification of three strategies to enable education through games: (1) Structure Enhancement (SE); (2) Feedback Enhancement (FE); (3) Challenge Enhancement (CE). Driven by the three design strategies, the authors implemented game modifications to incorporate educational resources. The main character in the game, named Mario, has Type 1 Diabetes. Health-related choices, which must be faced by Mario, become the challenges of the game.

Examples of challenges are managing Mario's health, especially about blood sugar; making choices about food intake or insulin injection when Mario's blood sugar level diverges from the appropriate level; keeping adequate blood sugar levels as they increase when children progress through the different phases of the game. The final goal is to save a princess who is locked in a castle and beat the guards of evil. To achieve this goal, Mario needs to manage his Diabetes and keep himself healthy. What is expected is that as Mario advances through the phases of the game, he will gradually learn the skills to remain well by making appropriate food choices; taking regular exercise and injecting adequate amounts of insulin when needed.

A pilot study on usability issues was conducted using a version of the Mario Brothers game adapted to the purpose of the research. Forty-six people participated (25 women, 21 men, 18+) playing for 20 min and answering a feedback questionnaire at the end of the game. The results of this pilot study showed that participants enjoyed playing the game and found it valuable for educating diabetic patients [9].

Harris et al. [14] present a 2D VE conception that seeks to motivate children and adolescents, prone to or diagnosed with chronic diseases such as Diabetes and Obesity, to use technology to develop healthy habits for the purpose of prevention and treatment. The system is based on gamification techniques, mobile platforms and cloud computing. In smartphones, the accelerometer, camera and voice recognition are used to capture lifestyle data such as eating habits and exercise. The cloud is responsible for processing the data collected by the smartphone, since its battery and processing power are limited. Gamification is represented by trophies (achievements) or penalties (failures).

The project developed the Architecture of the Integrated and Personalized Diabetes Coach for Children, based on the lifestyle intervention proposed by one of the authors' Medical Clinic, including the following five themes: (1) think about your drink – choose water, leave out sweet beverages; (2) make your plate colorful – include more fruit and vegetables; (3) snack attack – choose healthy snacks; (4) pay attention to portions – portion control; (5) eat at home – eating out trouble shooting [14].

The VE is based on minigames to encourage children's participation. All minigames follow a 2D interface, with play mechanics similar to "Angry Birds", "Pokemon" and "Bubble Pop." Each minigame is meant to teach about a specific topic. No experiments were conducted with the project's target audience, but the authors are confident that the VE will have a great impact on the treatment of Diabetes in children [14].

The work of Kyfonidis and Lennon [21] proposes a tangible interface game for the learning of concepts on Type 1 Diabetes for 3–8-year-old children. The design and evaluation phases include multi-stakeholder collaboration (diabetes advisors, nurses, parents and children). Based on requirements elicited by an initial qualitative research and literature review, the game will promote exploration, collaborative learning, learning through reflection and will follow the concepts the constructivism theory of developmental psychology. The creation of a tangible interface game for interactive learning with multiple feedback channels will, potentially, empower children with Diabetes, providing a more effective, engaging, fun and age appropriate education. This work resulted in the conception of a more accessible game design for 3–8-year-old children with Type 1 Diabetes, within a clinical setting.

Stach and Schlindwein [26] present web-based health game for children suffering from Diabetes to help them check their blood sugar level (BSL). The game design proposes that the player build bases in different locations using the Google Maps locator and the data of his glucose meter. Google Maps is used to locate the player through the user's login to their Google account. When the player starts the game, he can see his location on the map. The game attaches the player's diabetes data to real life locations. Players build their castle with a protective wall around it by entering the value of a BSL measurement for the first time. From then on, the location of each measurement will become a tower point to give more scoring points and more protection against mysterious Dark Forces. The game's objective is to protect the castle and earn points. Thereby, the player is forced to walk around and measure the BSL regularly. The measuring and the BSL data transfer need to be done manually, as there is no glucose meter which can be connected to the smartphone – thus, especially young children are tempted to cheat in order to reach good values and game scores.

3.2 Works Related to Other Chronic Diseases or Health Care

Hatzigiannakoglou [15] proposes a 2D serious game of First-Person Shooting (FPS) aiming to help children and adolescents with Down Syndrome to understand healthy eating and change their habits when necessary. The game uses explanatory audios throughout the story, in order to make children's understanding and engagement easier. The game uses a mouse or Wii Remote as interaction devices. The article does not provide details on the game development methods and techniques. The results of the study highlight that it was possible to develop the game design, which consists of four minigames (Breakfast, Snack, Lunch, Beverages), from the interviews conducted with the children's parents and/or caregivers. Initially, the VE presents a story that addresses the healthy food and beverage groups in contrast to the unhealthy groups.

Oikonomou and Day [27] present a breath-controlled serious game that encourages the user to engage more frequently, and effectively, in the cleansing physiotherapy of the vital mucus. They present a game that uses software that controls the heart rate and an air pressure sensor connected to the computer via a USB port. Four minigames were developed (Cave Flight Game, Flower Garden Game, Pirates Game, Whirlpool) based on existing physiotherapy guidelines for Cystic Fibrosis patients. The game was tested by a young patient along two weeks. Preliminary results showed that minigames need to be improved in some aspects of usability, which were pointed out by the experiment participant and their parents. No hardware errors were reported.

Orji et al. [28] present a slow-casual style game (slow, simple, easy to learn, easy to play) that addresses the need for intervention in order to teach patients (with Diabetes or potential risk of Diabetes) how to make healthy choices while eating out. This approach includes patients with different health goals in order to promote learning and reflection. LunchTime is a cross-platform application, based on a client-server system implemented using Java Enterprise technology. Participants played the game for a period of 10 days. The evaluation consisted of pre (baseline) and post (exit) surveys, used to identify behavioral changes before and after playing LunchTime for a period of time. The pre and post surveys included the same questions on nutritional knowledge (attitude towards healthy eating and health concern), but some other (different) questions were added to the post survey. The results of the evaluation showed that the LunchTime game made learning easier by increasing participants' nutritional knowledge and led the authors to a reflection both during the exploration in the game and then out of the VE. Thus, LunchTime met the goals, which were to teach people about healthy eating according to their health goals. A positive attitude change regarding healthy eating was noticed in the research participants group. As future work, the authors intend to evaluate LunchTime with a diverse audience and for a longer period of time in order to identify the positive and/or negative impacts on patients' lives.

Bomfim and Wallace [5] propose a game design that uses the Self-Determination Theory (SDT) to build up players' competence, autonomy and relatedness as consumers, encouraging them to develop an understanding of the nutritional benefits of healthy food. The game's reward is achieving balanced sugar, sodium, fats and fibers in their purchases. The design of the game is based on the Food Literacy (FL) approach which combines knowledge, skills, and behavior required to plan, select, manage, prepare, and consume foods that meet nutritional recommendations. FL is also associated with confidence, autonomy and empowerment towards food. The game's Artwork (design) was downloaded from icons8, vecteezy, pixabay, and clipart. The game was developed using Android Studio, which is compatible with Android 4.0 or higher versions. This study addresses an important gap in the literature that focused primarily on weight loss and calorie control to improve health conditions. The proposed game is an important step in understanding how game design can be used to develop FL skills. The proposal has not yet been validated by potential users, since the authors point out that experiments to validate the proposal will be conducted, in the future, with university students.

3.3 Discussion on the SR Results

Considering the SR results and the research question (which interaction and 3D VE immersion techniques based on Games and Virtual Reality are applied in contexts of chronic disease treatment, especially Diabetes?), we identified that the main strategy of interaction applied in VEs developed in the context of chronic diseases is Game Based Learning, combined with other interaction strategies, such as: First Person Shooting, use of avatar, hands-on food choice training, social learning game, virtual community, slow-casual game, explanatory audios, google maps and tangible interface with multiple feedback channels.

It is important to note that 25% of the selected studies propose 3D VEs, while 75% present 2D VE proposals. The main interaction device implemented in VEs is still the touchscreen feature, which may be justified by the ease of interaction and the fact that it is available on smartphones and tablets making the VE more reachable for users who do not have access to web devices, knowing that approximately 65% of the world's population have access to some kind of mobile device, according to the GSMA [29].

Other interaction devices were found in the studies, such as the use of HMD in the work of Fernandez et al. [12] in addition to features available on the smartphones themselves that were found in the work of Harris, Durresi and Tuceryan [14], such as accelerometer, camera and voice recognition. Therefore, in relation to the immersion techniques raised in the research question, we only found these two studies that make use of immersive virtual environments.

Considering chronic diseases, it is important to highlight that most studies (75%) were developed to support the treatment of Diabetes in order to seek the balance of blood glucose level through healthy eating habits, learn to make the best choices and improve nutritional knowledge on foods.

Regarding VE design supported by Participatory Design techniques, we did not find this approach in the selected studies. We noticed that approximately 50% of the works included users' participation through the application of Profile and/or Feedback Questionnaires and interviews. However, we did not identify the application of a PD methodology, seeking to guarantee the "willingness and capability" of potential users of the proposed technologies. When we do not use the PD techniques, we do not feel confident enough of the public acceptance considering the different user groups, and if, in fact, the VE attends the citizens' need, who in this case, are people with some chronic illness, their caregivers/parents and health professionals who accompany them.

Given these results, we noticed that there is a gap in the literature regarding the design of 3D VEs available in mobile devices and designed with the co-participation of users from the beginning of the development cycle.

Taking this into consideration, Sect. 4 presents the ABCDiabetes serious game proposal designed with the users' co-participation and including some of the interaction techniques identified in the SR.

4 The Serious Game "ABCDiabetes"

The ABCDiabetes game was designed in partnership with Júlio Muller University Hospital - Federal University of Mato Grosso, Brazil. The first phase of the game aims to raise awareness among Diabetic children and adolescents for them to make the best food choice.

The results of the Systematic Review were used to support the serious game project considering some of the successful strategies found in the SR. Considering that the works selected in the SR did not address PD techniques in the conception and evaluation of VEs, this study proposes a serious game constructed in a collaborative way, with the participation of stakeholders and potential users of the system, in order to offer a product that meets the real needs and desires of end users. Thus, the Contextual Inquiry and Mockups techniques were adopted.

4.1 Participatory Design Sessions

In the first stage of the PD sessions, the Contextual Inquiry technique [16] was applied involving the multidisciplinary team (nurses, pediatricians, psychologists, nutritionists, developers, children, adolescents and caregivers). In the second stage, we presented the Mockups [7] to potential users and their caregivers in order to conduct experiments to evaluate the user experience. The stages are described below:

Stage 1. Contextual Inquiry

The Contextual Inquiry technique consists of field interviews and brainstorming meetings with HUJM health professionals, four children with Diabetes and their parents or caregivers (indicated by the physician in charge of the Pediatric ward of the Hospital), as well as the project development team [14].

Initially, a meeting was held at the Julio Müller University Hospital, where the pediatrician and the multidisciplinary team nutritionist explained, by means of a therapeutic toy (Fig. 2), what Diabetes is, how the disease acts on the body, and how to

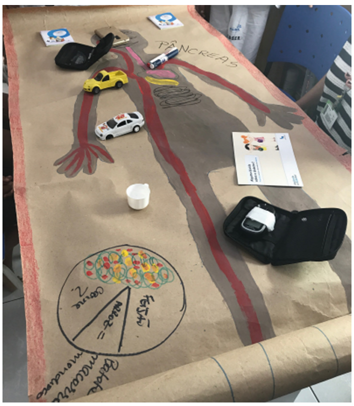

Fig. 2. Therapeutic toy used by the HUJM team (teaching about Diabetes).

choose good food items by making healthy food replacements. The Contextual Inquiry technique also included the application of questionnaires with the users, to specify the system requirements. According to Kumar et al. [12], the adoption of this type of technique makes the collected information more reliable. From the results of the meetings and aspects identified in the SR, we defined that the first phase would address the choice of food for a healthy meal. Thus, we determined the game scenario, the narrative, 3D objects, virtual characters and strategies of interaction and gameplay.

Stage 2. Mockups

The Mockups technique basically consists of creating prototypes of the object to be developed, in order to obtain samples of its artifacts, as well as to test and evaluate with potential users [22]. Generally, the prototype presents all the components that will be part of the final product, in a clear and objective way, seeking to avoid double interpretations. The Mockups technique is the result of the application of the Contextual Inquiry technique, considering that the final product must meet the needs of the end users.

From the results of the PD sessions with the multidisciplinary team in the first design stage, it was possible to plan the ABCDiabetes game interfaces, starting with the "Food Choice" phase. This phase was defined by the multidisciplinary team, considering that the meals directly influence the glucose level of the patients, being a complex stage, especially for school children.

After the meetings held at the hospital, the prototype was built and PD sessions were conducted with health professionals and some children selected by the Pediatric team in order to validate the game's proposal.

4.2 Serious Game Interface Project

The game is divided into phases, the first phase being "Food Choice", which aims to educate the player in the choice of the best food for diabetic people. When starting the serious game, the player can select his avatar and explore the "Joy Square" virtual scene. In the square, the player finds nutritional information about the food available in the environment.

When the player gets near the non-playable character, represented by the nutritionist (Fig. 3), she interacts with the player offering three daily meals (breakfast, lunch/dinner and snack) for the player to assemble. The player then chooses which meal he wants and starts the "Food Choices" phase. It should be noted that the player must consider the nutritional information while choosing food items.

Thus, it is recommended that before the player chooses the food he will include in his meal, he should navigate through Joy Square exploring the food stalls and observing the nutritional information of each food, as shown in Fig. 4. Food stalls are separated by types: Fruit, starchy foods and Bread, Beans and Peas (legumes) and Meat.

Soon after the player chooses the meal (breakfast, lunch/dinner, snack), the avatar is taken to Joy Square where healthy and unhealthy foods from the upper part of the scene (Fig. 5) begin to fall, randomly, and the player chooses the food to assemble the meal according to the nutritional information of each food, previously presented in the stalls.

Fig. 3. ABCDiabetes "Food Choice" - Interaction with the Nutritionist to select the meal

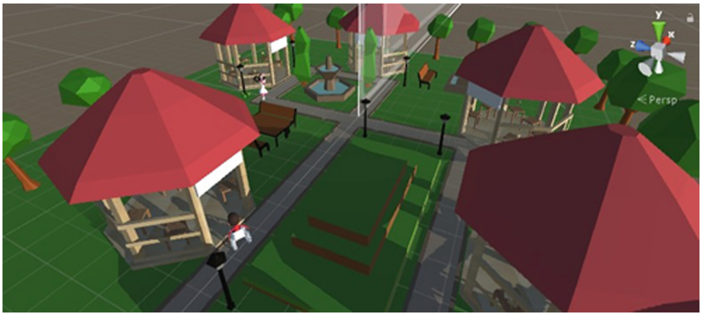

Fig. 4. Joy Square interface with food stalls

It should be emphasized that the navigation system allows movements in three dimensions (3D). As for the interaction techniques, these were implemented by virtual control - touchscreen, Bluetooth VR control, accelerometer/gyro sensor and Playstation 2 (PS2) control model [17].

The first-phase interface includes a glucose meter bar, which indicates the amount of glucose ingested from the food collected and displays the player's score. The player should pay attention to the glucose level displayed on the meter as he is advised to keep the meter bar on the green level. If the player collects more foods with a high glucose content, the bar turn red, indicating a high level of glucose in the blood. However, if the player stops collecting food, the bar will also turn red indicating low blood glucose.

Fig. 5. First phase interface - “Food Choice”

4.3 Used Technologies

The ABCDiabetes game was implemented using the Unity 3D[3] game engine, which has a good rendering graphics engine, easily portable to other platforms and it allows the developer to use C# and JavaScript programming languages.

For the development of the 3D virtual world scenario and the virtual characters, the Blender[4] tool was adopted, which is a free and open source 3D modeling tool. The scenario was assembled also using some 3D models acquired in the Unity Assets store, in addition to models developed in the LAVI[5] research group.

For the animation of the virtual characters and 3D objects, the Mixamo[6] tool was used. In addition, other animation features available in Unity itself and even the implementation of specific animation algorithms that are under development in the LAVI research group were adopted.

Each scene in the game has a 3D audio soundtrack. In the square scene, where the game begins, the sounds of birds singing are distributed near the trees of the VE, and the sound intensifies according to the proximity of the avatar that represents the player in the scene.

5 Conclusions

Based on the results obtained from the SR, interaction strategies and game challenges were satisfactorily identified and applied in the ABCDiabetes proposal.

[3] https://unity3d.com/pt.
[4] https://www.blender.org/.
[5] http://lavi.ic.ufmt.br/.
[6] https://www.mixamo.com/.

The design and evaluation phases of ABCDiabetes were conducted in a collaborative way, with the participation of the multidisciplinary team and end users. We emphasize the importance of Participatory Design techniques in the success of this construction. The 3D VE was developed following the game-based learning strategy, using avatar, virtual characters, 3D virtual objects, challenges the player will have to face and hands-on food choice training, in order to control the level of blood glucose through a healthy diet. The technologies used in the implementation of the project were satisfactory.

Future work will consist of using the ABCDiabetes game with diabetic children and adolescents to verify the game's contribution towards the treatment of Diabetes, and consequently, its contribution to the Healthcare area. It is still necessary to improve the serious game in relation to aspects of movement and interaction with the virtual objects.

Finally, this study represents a relevant social contribution to the areas of Health and Education that use 3D VE for different issues. For the Computing area, this study represents a reflection on the best practices in designing 3D VE interfaces, as well as the need to propose methodologies based on PD approaches for the design and evaluation of 3D VEs based on games.

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Developing Entrepreneurship Skills with a Serious Game

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Abstract. Rural areas in Europe still lack the ability to create high-quality and sustainable jobs. This situation can change if there is a clear promotion of the use of electronic commerce and digital entrepreneurship in those areas. As part of that effort, this article presents an initiative that intends to provide aspiring young entrepreneurs in the rural areas with the necessary tools to understand and to develop e-commerce to boost the economy in those places.

This initiative is supported by a serious game which allows players to learn while motivating them to become digital entrepreneurs. Players are transported to an online collaborative/competitive and dynamic environment where they must find the best strategies to negotiate with their opponents and push their business to a successful finish.

The game was tested with an initial group of students and the results allowed to conclude that it fulfills its purpose, showing that it can be used as a tool to support and encourage youngsters towards digital entrepreneurship.

Keywords: Serious games · Entrepreneurship · Competences

1 Introduction

More than 91% of the territory of the European Union (EU) can be classified as "rural" and these areas are home to about 56% of the EU's population [1]. And even if Europe's rural areas are diverse in terms of population, demography, economic structures and labor markets they face a common challenge: the ability to create high-quality and sustainable jobs [2]. Therefore, rural area development measures should be committed towards employment growth and job creation so that they match the numbers in urban areas. In that sense, the current "counter-urbanization" flow out of urban areas into accessible rural areas, made possible by new transport and technology infrastructures, should be exploited: electronic commerce and digital entrepreneurship, in particular, open the opportunity for very new and original businesses that can be an opportunity for the development of rural areas.

Transform@ is a European initiative, based on a serious game approach, that aims to provide the tools to foster entrepreneurship and online commerce skills to young

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people from rural areas [3]. More specifically, the initiative pursues the following main objectives:

– To enhance digital and e-commerce/e-business related skills;
– To develop an entrepreneurial spirit with an international dimension;
– To facilitate young people's transition from training/education to the work market;
– To increase employability and entrepreneurship in rural areas.

Supporting the initiative through a serious game allows users not only to learn but to apply their acquired knowledge by collaborating/competing in a motivating virtual environment with other players, thus transporting them to a dynamic environment where they have to find the best strategies to negotiate with their opponents.

The design of the game considered the need to strengthen a set of skills and competences identified as relevant for the young entrepreneurs [4–6], namely: Managing people; Developing people skills; Mobilizing others; Selling ideas, products or services to customers, investors or employees; Decisiveness and assertiveness; Self-efficacy; Initiative; Spotting and acting on opportunities; Resilience; Innovation and creativeness; Learning through experience and learning by doing; Self-reflection; Ability to prioritize; Tactical and strategical thinking; Coping with uncertainty, ambiguity and risk; Financial and economic literacy; Ethical and sustainable thinking.

The game has already been tested and evaluated by a large number of users in different European countries. A complete evaluation methodology supported by specific data collection tools allowed to identify the users' perception on the different aspects of the game, namely on its usability, gameplay and skill development. This article presents the game concept and design and the results from the evaluation methodology.

2 Transform@ as a Serious Game

Videogames are virtual entertainment environments which transport the player to new situations giving them the opportunity to develop skills, experience stories, make decisions, outline strategies, etc. Wattanasoontorn et al. present four elements that games must have [7]:

1. Gameplay and rules, that define how the game is structured, its mechanics, objectives, plot, etc.;
2. Challenges, that define the difficulty and rewards that the player can achieve by reaching a goal;
3. Interactivity, that represents how the player interacts with the game;
4. Purpose of the game.

Serious games were defined by Clark Abt as games with an educational purpose that do not have entertainment as the main goal [8]. They are thus developed with the objective of passing a serious message to the player, be it educationally focused, advertising, awareness raising, etc. Therefore, a serious game has explicit and implicit objectives where the explicit purpose is fun/entertainment and the implicit objective is related to skill, knowledge or experience development, that is, it has a personal development component. This follows the definition given by Mike Zyda, who states that "…serious games are more than history, art and software, they have a pedagogical component that educates or instructs the user and that consequently increases knowledge and/or skills" [9].

The interest of using serious games therefore relates to the possibility of providing the user with an environment that will motivate him/her whence we know that motivation is a paramount factor in any learning or skill development process [10]. Serious games can be particularly effective with younger target groups as they are very close to their interests and habits [11].

According to Marc Prensky, motivation is directly related to the experienced fun and relaxation [12]. Relaxation allows the apprentice to complete goals more easily, because they strive naturally without feeling forced. People play games because they like to feel challenged in a relaxed environment. This motivation leads to the state of flow presented by Csikszentmihalyi [13]. A player is in a state of flow when he/she is completely immersed in the challenges because there is a balance between their difficulty and the player's ability to complete them. On the contrary, if a novice player finds himself in an environment where challenges are too difficult he/she will enter into a state of anxiety, interrupting the flow state and cutting the motivation. Likewise, if the difficulty is too small for the player's abilities, the player will feel bored as he/she can complete the challenges without any difficulty, causing him/her to lose his motivation. In serious games this component is very important because, as mentioned before, motivation is one of the essential factors in learning processes. If the state of flow is broken the player will have difficulties in withholding information and will lose interest in the game and in the skill development process.

The possibilities of application of serious games are widely varied. In 2008, Sawyer and Smith tried to classify these possibilities by creating a taxonomy that related the purpose of the games with their area of application in a 7×7 matrix with 49 different potential serious games use [14]. Later, in 2010, Breuer and Bente created a new classification, dividing serious games according to different aspects like the supporting platform, the subject matter, the learning goals, the learning principles, the target audience, the interaction mode, the application area, the controls and interfaces and common gaming labels [15]. Again what was demonstrated was the large gamma of potential application of serious games. Unfortunately, there are only a few serious games aimed at the development of entrepreneurship skills. On the other side, there are several games, primarily developed and distributed as an entertainment product, that use some form of business management as gameplay. These games, although meant to be used for fun purposes, can be repurposed for a serious objective, in a process that Djaouti et al. denominate as "serious gaming" [16]. A few examples are presented next:

- Monopoly: Monopoly is one of the most popular board games and one of the best-selling ones. The objective of this game is to be the richest player by owning the most properties. The game has now been converted to digital platforms as Monopoly Plus, developed by Ubisoft and released in 2015 for Xbox 360 and PS3 and relaunched in 2017 for PC, Xbox One, PS4 and Nintendo Switch. The game works in a 3D environment and the goal is the same as the physical game, where players move around a board trying to buy as many properties as they can. Throughout the game players buy, rent and sell properties, negotiate, pay fees, borrow money and even get arrested. All players who are in bankruptcy are eliminated. The digital version also allows multiplayer matches, where the player can draw his/her own board, give names to the houses and choose their preferred symbols [17].

- Catan: Catan is a board game that transports players to a time of discovery. Players assume the role of settlers who have the goal of developing and building colonies, roads and cities, and collecting and obtaining the necessary raw materials. Each player earns points as their colonies grow and the goal of the game is to be the first to achieve 10 points. Trading is an important aspect of the game that, being ignored, will make winning more difficult. Players can also exchange resources to obtain the materials they need. Each of the elements requires different resources for their construction that can be obtained by negotiating with other players or through harvesting the lands that the players possess. Catan forces players to interact with the others, to learn how to negotiate to achieve their goals, as well as to have a sense of how to manage their resources, which will also influence how they spend and negotiate. Catan was released as a digital product in 2007 for Xbox 360. However, this version was discontinued and only ten years later a new version was released for various platforms, called Catan Universe. In this version players have the opportunity to play against others in the online mode, or they can enjoy the single-player mode where matches are made against AI [18].
- The Game of Life: The Game of Life is a board game where the player moves through the various stages of life until his retirement. Initially, each player has to choose whether to start through an academic career or to start immediately a professional life. The first option implies that the player will have to play more turns before he receives a salary, but then he/she will have more professional options. In the second case, a profession is randomly assigned to the player who starts immediately to receive a salary (that will be the same throughout the entire game). In addition, the player who selects the academic option will be burdened with a student loan that will have to be settled later on. Throughout the game, players will be exposed to different challenges and dilemmas related to real life, like buying properties, paying fees, loans … The goal is to reach retirement with the best quality of life. This game was released in 2015 by Marmalade Game Studio Ltd for PC [19].
- Biz Builder Delux: Biz Builder Delux is a simulation game produced by Kairosoft for mobile devices where the player tries to be the best and most successful entrepreneur in the city. The player starts a new business and must manage it to make it profitable, so that it can expand it and become a successful entrepreneur. The player has to choose what type of business he/she wants to start and then hire employees, train them, deal with their occupation and their productivity. The player has to outline a strategy, analyze the market and maintain the interest of its customers, as well as research and develop new products, compete with the rivals in order to evolve and expand the business [20].
- Capitalism II: Capitalism II is a business simulation game released developed by Enlight Software Limited. In this video game the player has the CEO role and is responsible for the creation, development and growth of his/her company. Throughout the game the player will come across various challenges similar to the

ones in a real business world. As he/she develops the company, the player decisions (in production, purchase, import, marketing, etc. …) will influence the results obtained, forcing him/her eventually to outline a new strategy [21].

- Rise of Industry: Rise of Industry is a business simulator game developed by Dapper Penguin Studios and released in February 2018. The player is an entrepreneur responsible for building an industrial empire so he/she has to create industries, transport lines, produce raw material resources, exchange of resources with other cities, etc. During the game the player has to manage his/her resources and products, being also attentive to his competitors. There are two game modes, career mode and sandbox. In the first mode the player will have to choose one of four specialties (gathering, farming, industry and logistic) which will provide more research and development points. As for the Sandbox mode, everything is unlocked and accessible and the player can build his empire without financial or research limitations [22].
- Factory Manager: Factory Manager is a strategy and business simulation game developed by StainlessHeart and released for PC in August 2018. Here the player has to develop a business, starting with a small financing. He/she has to hire employees and buy the materials and resources needed to build products. The commitment of the player will be reflected on the workers' productivity, taking advantage of their efficiency to get the best of them. The player must be prepared for unexpected events such as breakdowns or declines in sales and must take risks to be able to prevail in the industry and grow the business [23].

All these games, even if not considered as serious games, allow captivating players to perform certain entrepreneurship and management related actions and provide extremely interesting and enriching content for the player, leading him/her to perceive and learn some aspects related to business, product and resource management.

As for Transform@, the serious game was designed as a tool to learn and apply knowledge related to e-commerce and digital entrepreneurship. It includes mechanics similar to some of the games that have been presented here, implemented in such a way to make the game playful, but more important, educational. Transform@ falls into the genre of games like Monopoly and Catan as a board game with the exchange, purchase and sale of resources. However, it is intended that this application goes further and the theme gets closer to the one in Capitalism II or Factory Manager, where the player has a more active role in the company's activities.

Transform@ was finally designed as a turn-based board game with single and multiplayer modes. In the single player mode, the game manages Artificial Intelligence (AI) players that can adopt different strategical approaches, from a more easy-going attitude to an aggressive stance. It is up to the human player to identify who he/she is dealing with and adopt the right counter-measures. Transform@ can also be played in an online multiplayer mode against other (2–4) players.

The game is played by moving a pin along the board spots in order to gather the required resources (funds, staff and clients) to setup a company. Because the board has multiple paths it is up to the player to decide which approach to take. Some board spots correspond to quiz spots that expose the player to different challenges: their knowledge and skills can be tested and correct answers lead to rewards as wrong answers lead to penalties. Other board spots provide casual events that can randomly provide a boost to the player or introduce difficulties in the path to create the company. Direct competition between players can arise if they fall in the same spot. In each turn, the player can also negotiate with the other players or external entities (banks, suppliers, business angels, etc.). Resources can be swapped or common business ventures established. Players can also take more aggressive measures against other players and try to take resources from them or simply buy them out. As already mentioned, the goal of the game is to reach the end point with the necessary resources to open a new business (currently a wine shop or a biological farm). Should a player reach the end without the necessary resources, he/she must continue to traverse the board until he obtains the minimum resources to win the match (Fig. 1).

Fig. 1. Transform@ board to setup a biological farm

Each turn consists of a set of steps that must be followed in this order:

1. Throw dice
2. Choose path to follow (and spot to land on)
3. Resolve spot (quiz or luck)
4. Negotiation with other players or external entities
5. Payments

At the beginning of each turn, players roll the dice to know how far they can move. Players then can choose which path to follow according to their strategy (some paths are shorter others are longer but provide more rewards at the expense of higher risk). When a player lands in a quiz spot, he/she must choose the difficulty level of the question. If the player answers correctly the question he receives the prize value associated with the difficulty level, if he/she fails, the player loses half of that amount. In each question the player has the opportunity to pass the challenge to another player, who is then required to answer the question. When a player lands in a luck spot he/she receives a card that can have a positive or a negative effect on his/her progress in the game (Fig. 2).

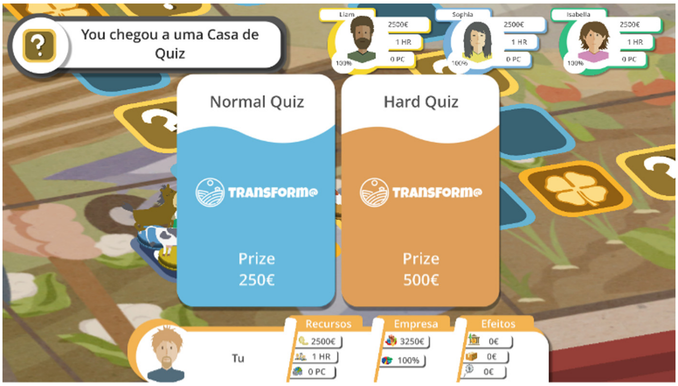

Fig. 2. Quiz spot option

Players can also collect resources through negotiation. After moving to a spot, the player will have a list of negotiation options (some options depend on the amount of resources that the player has) like negotiating with other players, entering job fairs, creating new products, searching for new niche markets, etc. Some of the options have a delayed effect, i.e. the player will have to wait a certain number of turns until he can select them again (Fig. 3).

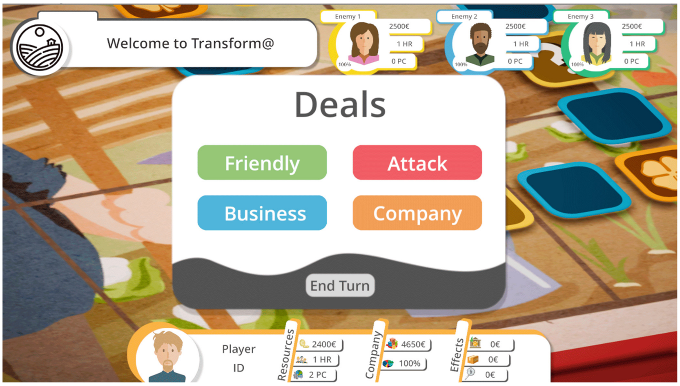

Fig. 3. Negotiations screen

There is an option in the negotiations that allows the merging of companies. Here, the player launches a proposal to one of the players present and if he/she accepts both companies merge and their resources become the sum of the resources of both players, forming a new company.

In the single player mode, Artificial Intelligence players can have three types:

1. Easy Going
2. Entrepreneur
3. Tycoon

These three levels of difficulty are distinguished by their behavior in the game. For example, a “relaxed” (easy going) AI player will not have the same knowledge as a “tycoon” and therefore will make more mistakes in his actions, he will not be so rigid in negotiations and in the way he manages his resources. In contrast, an “entrepreneur” will be more thoughtful and wise in his choices, committing risks where he can get results. He/she will also be more keen to negotiate with other players while a “tycoon” will have a more aggressive stance (Fig. 4).

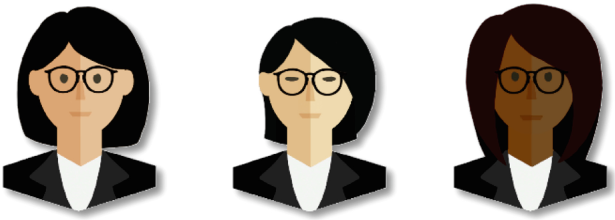

Fig. 4. Female avatars for tycoon level

3 Evaluation Results

The evaluation of the Transform@ initiative and serious game was done with a group of 53 students from rural areas. Students were gathered in a game presentation session where they were shown the game and introduced to its mechanics (Fig. 5).

Fig. 5. Transform@ game testing – presentation session

They were then able to play the game on their own for a month, either as single player or as multiplayer. In the end, they completed a questionnaire (25 questions) where aspects related to the Usability, Gameplay and Cognitive Development were assessed, following the proposal by Olsen et al. [24] and the one from Wiberg and Jegers [25]. One open question was provided to gather qualitative comments. Closed questions used a Likert scale from 1 to 5 where 1 was the lowest score and 5 was the highest score. The set of closed questions used was the following:

Usability

1.1 Is the game intuitive?
1.2 Is the interface intuitive?
1.3 Is the design of the application consistent?
1.4 Is the interface simple and fast?
1.5 Are all the options easy to access?
1.6 Did you had any problem starting a game?
1.7 Does the game has many bugs?
1.8 Could you find other players for the multiplayer mode?
1.9 Would you recommend this application to another person?

Gameplay

2.1 Is the game fun?
2.2 Is the game frustrating?
2.3 Do you think interesting to allow the game to be customizable?
2.4 Was the meaning of each resource perceptible?
2.5 How do you rate the difficulty of the quizzes?
2.6 Did you notice how the negotiations work?
2.7 Do you consider the negotiations important?
2.8 Was the multiplayer mode interesting?
2.9 Would you use this game regularly?

Cognitive Development
Number of Questions Answers

3.1 Is the theme found in this game interesting?
3.2 Does the game encourage learning?
3.3 Do you find it useful to have access to the correct answer of the quizzes after being answered?
3.4 Do you agree that having feedback after one question is a positive point for learning?
3.5 Using this game increased your knowledge and skills?
3.6 The content of the game influenced my understanding of the problems related to e-commerce and entrepreneurship?

In relation to the game usability 39% of the testers considers that it was intuitive. However, 35% had difficulty understanding how the game was played and 26% felt that the game was more or less intuitive. These values made us realize that there is a need to create a tutorial level so that player are introduced to the game features. Regarding the interface, most considered it intuitive, with 52% making a positive evaluation and 13% considering that there were some flaws. The remaining 35% consider it to be more or less intuitive. Most of the players also agreed that the interface was consistent, simple, fluid and facilitated a quick access. Regarding the bugs found in the application, students reported that although they found some during use, they were

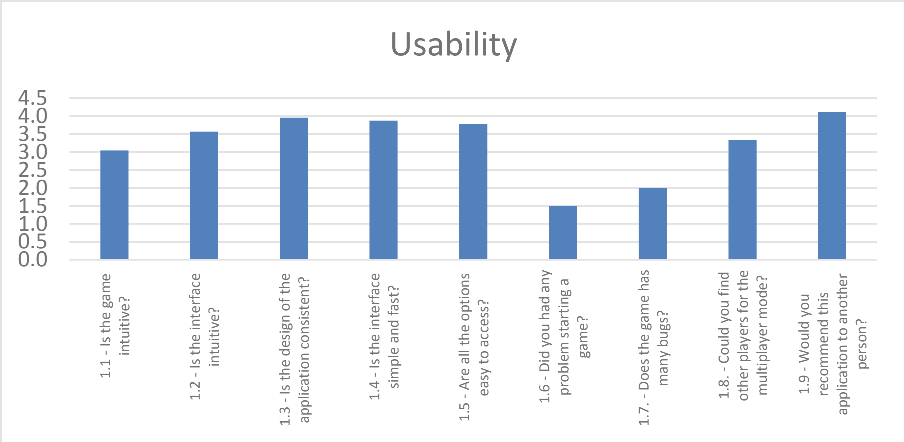

Fig. 6. Usability evaluation (average scores)

minimal things, like a flaw in the menus, or specific situations that happened when the connection failed when trying to connect to a game room.

17% of the testers said that they would probably use this game regularly and 65% were undecided. When asked if they would recommend Transform@ to other people, 43% said they would probably do so and only 9% responded negatively (Fig. 6).

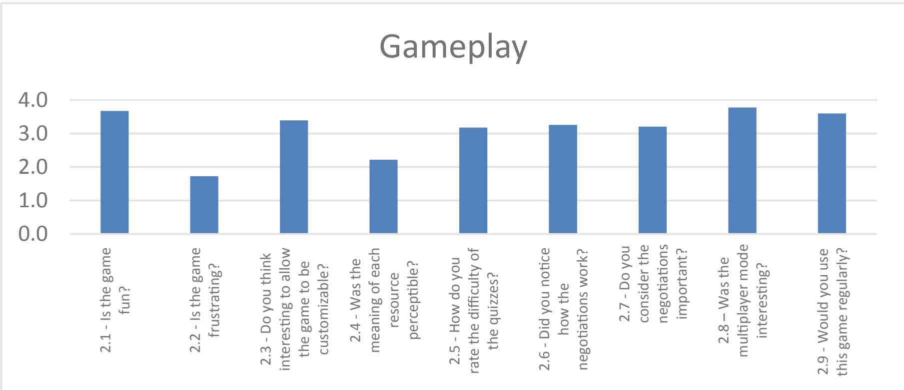

Fig. 7. Gameplay evaluation (average scores)

In terms of gameplay, the majority of the students found the game to be fun rather than frustrating (40% responded that they considered the game fun, 35% felt it was more or less fun, and only 13% responded that the game turned out to be frustrating). In any case, there are some aspects that need to be improved to lessen this level of frustration, like making artificial intelligence decisions more balanced. Another factor that can cause frustration is the content of the quizzes which can repeat quickly.

All the testers considered that customization would be useful (17%) or very useful (57%). Only 26% of people had difficulties in perceiving the meaning of each game feature in the interface. However, 44% of the players had difficulties in understanding how the negotiations worked during the game.

Transform @ has two game modes, a single player mode and a multiplayer mode. These two modes were present in the distributed build to the students who ran the application tests. They were free to choose which way they wanted to test. The multiplayer mode was evaluated very positively, considering that this mode is challenging. 80% had almost no difficulty in creating a room and 60% had no difficulty joining a match (Fig. 7).

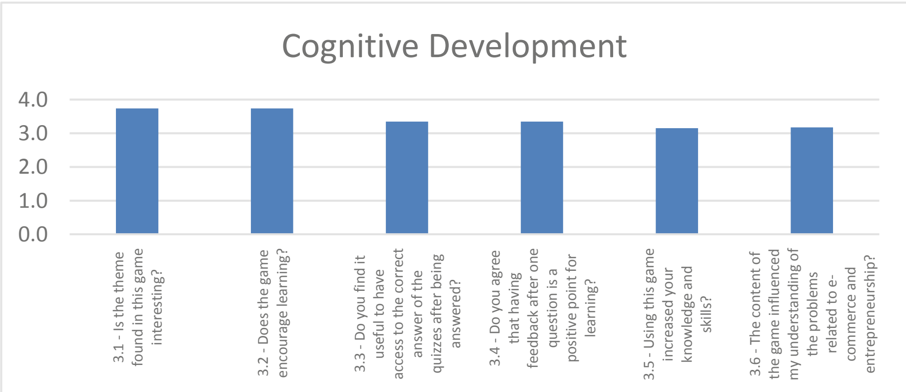

Fig. 8. Cognitive Development evaluation (average scores)

In terms of cognitive development, 57% of the testers considered that the theme of this game is interesting and 52% consider that this game encourages learning (Fig. 8). 26% of the testers agree that the game has helped in a way to increase their knowledge on the subject and 43% say they agree more or less and the remaining 31% believe that playing Transform @ did not deepen their knowledge. As for the content present in the game, this allowed 31% to better understand the theme, while 14% stated the opposite. The remaining 52% agreed that it had no major impact. As the purpose of this serious game was to provide tools that help users to acquire or add knowledge about the area of entrepreneurship and online commerce, this information was transmitted also through the quizzes. In the questionnaire there were three questions about the difficulty of the presented quizzes. The vast majority, 74%, considered that the difficulty is balanced. The testers considered that it was very useful to have access to the correct answers (57%), but also consider it very positive to have access to the explanation of the answer (61%).

In terms of qualitative evaluation, testers mentioned some technical issues and suggestions to improve the application, for example to develop more animations, sounds and to insert elements of humor. Another interesting suggestion was to ask for the movement of the player's pin to be autonomous and only need the intervention of the player when and only it is in a bifurcation, in order to make the matches faster and more fluid.

It has also been reported that the game can be more fun if played with friends in multiplayer mode.

4 Conclusions

Digital games are now very present in our lives. They are able to make the users stay focused and engaged in the gameplay for a long time. This immersion is very relevant for serious games, games that are not produced exclusively for the purpose of entertaining, but rather to pass an important message to the user.

In the case of the Transform@ initiative the objective was to create a product that could motivate and sensitize users to the theme of entrepreneurship and digital commerce in rural areas to foster the creation of new forms of business in those areas. In the scope of this work, a set of relevant products was analyzed and it was possible to verify that there is still a gap in this area, with very few serious games with a similar purpose. The most relevant cases ended up being video-games where business management was the gameplay focus. It is here that the Transform@ serious game distinguishes itself by representing some real business-related situations at the same time as the player is challenged with educational content.

An evaluation of the game was conducted with a group of students from rural areas and the usability, gameplay and cognitive development was assessed. The results were quite positive and participants were very helpful and gave constructive feedback. In conclusion, it was possible to validate that Transform@ can fulfill the purpose for which it was created, giving players a fun and stimulating experience with their educational content. Some of the collected suggestions are pertinent and will be taken into account in order to improve the game and make it more interesting. For instance, the lack of a tutorial level was the factor that most felt missing.

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Research on the Design to Alleviate University Students' Oppressive Emotions Through the Use of Serious Games

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Abstract. Depression has become one of the most serious problems among university students. The purpose of this study was to help mentally sub-healthy university students to alleviate negative emotions through art therapy based on serious games. This study measured physical records and MMPI records of subjects during the experiment to find out whether the inclusion of art therapy theory and medical treatment frameworks in serious games can achieve the goal of slowing down negative emotions of mentally sub-healthy university students. According to the data analysis, after intervention, the skin electrical value the MMPI records are obviously declining, which proves that the intervention is effective, that is, the serious game with art therapy as the core has relieved the effect of depression. After the experiment, negative thoughts of more than half of the university students had improved to be better, and they had found interesting developments. The above situation proves that long-term use of art intervention can alleviate the symptoms of university students with depression.

Keywords: Serious game · Art theory · Alleviate oppressive emotions

1 Introduction

In recent years, due to the rapid progress of technology, people have invested a lot of energy to keep up with the pace of society, which has exerted increased psychological pressure on university students who are about to enter society. According to statistics, 42.3% of university students have mild or moderate depression, accompanied by other mental illnesses such as bipolar disorder and schizophrenia [1]. However, due to lack of awareness of the disease or fear of facing their own psychological problems, the psychological sub-health problems of university students are often not treated in time. Furthermore, if the patient is not diagnosed with a mental illness, the doctor will not choose to intervene with medication. Although there are many treatments to alleviate depression, such as behavioral cognitive treatment, they need to be completed under the guidance of professionals. Therefore, art therapy, combined with medical treatment,

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has become an effective method to improve university students' mental health, by addressing their psychological problems, increase contact with society, and improve their biological clock through serious gameplay without the intervention of others [2].

2 Literature Review

The essence of "art therapy" is "analysis" and "motivation". The specific method is to freely paint the patient, and then freely associate the picture. (Naumburg 1930) Art therapy is an auxiliary psychotherapy that allows patients to reasonably vent their subconscious content without disturbing their defenses. (EdithKramer 1930) Because in creative behavior (art creation), conflicts are re-experienced, resolved, and integrated, (Rubin 1984) it also facilitates emotional development, intellectual development, and creative expression. (Miralevvik 1983). Creativity is important to human development. (Winnicott 1991) Writing journals, including quick sketches or graffiti, are art treatments that benefit the patient's expression of the inner world. (Pennebaker, Mayne, and Francis 1997) Using artistic creation to distract attention can trigger positive emotions. (Dalebroux, Goldstein and Winner 2008) Art therapy interventions most effectively alleviate negative emotional states when art therapy interventions require structured tasks that lead to specific outcomes or target states (Kimport and Robbins 2012)

Serious games provide a rich learning environment where users can choose their own choices to enhance their motivation (Morris et al. 2013). The richness of serious games also provides an opportunity to explore, because more powerful and long-term exploration of stimuli can be described as complex (Berlyne 1966). Another advantage of serious games is that they can be viewed as continuous assessments, giving players the opportunity to demonstrate what they have learned (Morris et al. 2013). Serious games enhance learning motivation, effort and participation, thus improving learning outcomes (Garneli, Giannakos and Chorianopoulos 2017; Guillén-Nieto and Aleson-Carbonell 2012; Wrzesien and Raya 2010). The same is true in the medical field (Boeker, Andel, Vach and Frankenschmidt 2013; Diehl et al. 2013; Hannig, Özman, Jonas and Spreckelsen 2012; Lagro et al. 2014; Sliney and Murphy 2008; Stanley and Latimer 2011).

Art therapy is considered to be an effective means of relieving depression and has been used by many clinicians in clinical treatment [3]. Although there are many existing studies on how to treat depression in an artistic way, this study is based on serious game and art therapy mitigation methods for groups of university students with tendencies for depression, and their mental state usually does not be considered that doctoral and drug interventions are needed, so many times the condition deteriorates when it cannot be alleviated. Serious games tend to have an impact on people's subconscious, therefore games are increasingly used in medicine and education, [3] especially in disease intervention programs, to become a tool to solve social and health problems. This study integrates art therapy into serious games, explores how to combine games with art, makes the target group more acceptable and allows university students to perform step-by-step psychotherapy.

3 Method

The purpose of this study was to help mentally sub-healthy university students to alleviate negative emotions through art therapy based on serious games. This study uses theoretical and analytical physiological data to explore the inclusion of art therapy theory and medical treatment frameworks in serious games to achieve the goal of slowing down negative emotions of mentally sub-healthy university students. (as shown in Fig. 1). This study focused on the combination of art therapy and serious games for the relief of negative emotions in mentally sub-health students. This study took a quantitative approach. In view of the vast space for development in this field, more quantitative indicators will be studied in the future to determine the research results, which will give more straightforward conclusions for future research.

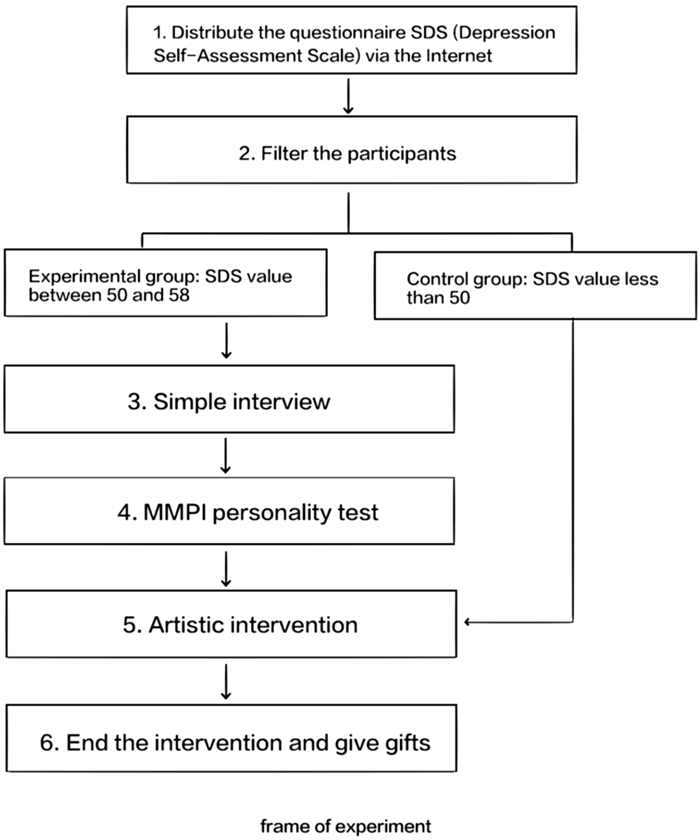

Fig. 1. Frame of the experiment

3.1 Settings

The subjects of this study are university students' in Shanghai. The authors first used the SDS (Depression Self-Assessment Scale) to screen out suitable subjects (score between 50 and 58, 50 or less for mild or no depression, 59 and upper for major depression). After a brief interview, the participants selected the appropriate subjects based on criteria that included the recent state of life and repression, the status of playing games or using electronic products, and whether they had a certain interest in art. After that, the classification test of depression tendency was conducted again. Accompanied by a professional psychiatrist, the experiment used the self-rating scale of the university student MMPI to conduct further suppression state analysis, test the mental health degree in the near future, and conduct experimental intervention for the population in the high D (depression) category. The plan consisted of two steps: (1) The art materials were prepared experimentally, and the multi-channel physiological instrument and skin sensor were worn and opened during the game experiment by filling the color with a certain visual comfort or painting the relevant theme. The duration of the treatment was 60–90 min, and the physiological indicators of the patients during the intervention were collected. (2) After two weeks of experimental intervention, after a period of experiment, the subjects were asked to fill in the MMPI scale again, and the number of the scale was observed to determine the psychological state after the intervention.

Since the SDS is a very basic measure of the mental state, it can only judge a basic depression tendency and cannot provide a clear classification of the disease, such as whether the patient is depressed or schizophrenic. Therefore, in order to ensure the final effect, the MMPI scale was used to ensure that the effect of the intervention was based on the numerical fluctuation of D (depression), which excluded the experiment from interfering with other types of mental illness.

The serious game in this experiment is divided into three stages. (as shown in Fig. 2). In the first stage, the experimenter will give the proposition of "self-portrait" [4], allowing the patient to have a clear understanding of the existence of the self, and admit themselves. In the second stage, the experiment was based on the illustrations in the famous illustration book "Secret Garden" [5] to match the visual comfort of the illustrations for the patient to paint, while the experimenter provides a pleasant color. In the third stage, the

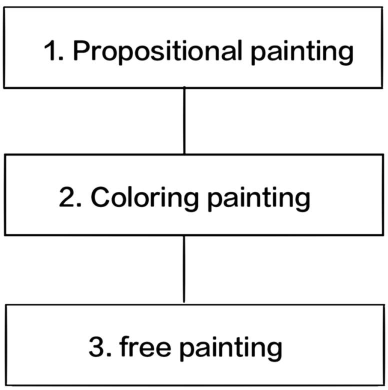

Fig. 2. Three stages of serious game

experiment will give the participants the opportunity to self-paint, create their own inner real thoughts, and make themselves more intuitive to face and build life [6, 7].

This study will produce a “change theory”: a serious game centered on art therapy that can help mentally sub-healthy university students alleviate negative emotions and improve their motivation in the face of depression. This “change theory” can be widely used by schools and society to help university students: (1) acquire artistic creation skills, (2) improve physical and mental health, and (3) improve self-awareness.

3.2 Recruitment

In the experiment, SDS (Depression Self-Assessment Scale) was published on the Internet. A total of 466 university students’ depression status data were collected. A total of 65 students with a depression score of 50–58 were selected, and emails were contacted one by one. It was finalized that 33 university students conducted the study (regardless of attendance). During the course of the experiment, all undergraduates were told in advance that they would wear a multi-channel physiology instrument, a skin sensor, and they all emphasized their willingness to participate voluntarily and to keep the process of the experiment confidential. This experiment ensures that data acquisition is non-mandatory, available, and respects the preferences expressed by university students. If a withdrawal occurs in the middle of the course, the willingness of the participants will be respected. During the experiment, all participants were allowed to record. After the end of the experiment, the author immediately recommended mental health consultation and exquisite gifts to the participants to express their gratitude. The data was collected from June to December 2018. Table 1 is the information of participants.

Table 1. Information of participants

information of participants

	classification	percentage
age	17–19	13.89%
	19–21	19.40%
	21–23	47.22%
	>23	19.50%
gender	male	55.56%
	female	44.44%
Medical history	have turned better	8.33%
	none	91.67%
Accompanying other tendencies (converted to standard score >60)	none	41.66%
	1–2	13.88%
	3–4	11.11%
	beyond 4	5.55%

3.3 Measures

Screening out the target subjects through the SDS, first semi-structured interviews, the interview content: (1) What has made you feel depressed recently? (2) Have you been interested in artistic creation, especially painting? Have you been exposed to painting before? Describe the feelings of painting and the feelings after completing a piece of work. You can also describe the content of the painting. (3) Do you like to play games? What type of games do you usually play? (4) Are you willing to participate in the experiment? Then, participants were told to wear and turn on the multi-channel physiological instrument and skin sensor during the game experiment. The experiment process was recorded, and the experimental results and dialogue were kept strictly confidential.

After the experiment, a brief semi-structured interview was conducted again. The interview contents were: (1) Self-thinking in the process of artistic creation, (2) Suggestions for improvement of this serious game. (3) A brief discussion of the depression of university student conditions and ways of self-remission, and (4) Participants were asked if they would continue to play games related to this kind of art therapy.

The semi-structured interviews before and after the experiment added a basis for theoretical derivation, and more powerful analysis of the effect of art therapy based on serious games, in relieving university students' depressed emotions, as well as its advantages and disadvantages.

At the same time, during the experiment, the experimenter provided painting tools and proposition and non-propositional painting game titles, and obtained quantitative intervention results through the physiological values of the subjects during the test. Finally, by analyzing the physiological index fluctuations of all the subjects and the MMPI scale records after the end of all experiments, the quantitative analysis of the experiments was carried out, and the rational experimental conclusions were obtained.

3.4 Data Collection and Analysis

There were 33 participants in this trial, 3 of whom were absent from the second MMPI test, and 2 were considered invalid data as the L (lie) value was too high. Therefore, a total of 28 ($n = 28$) valid records were collected for comparison.

Skin Electrical Value (SC\GSR). The experiment uses the method of comparing the coefficient of variation (CV). CV has no dimension, so that objective comparisons can be made. CV represents the degree of dispersion of the values during the intervention and can directly reflect the effects of the intervention. After that, the T test was used to compare the coefficient of variation between the experimental group and the control group during the intervention period.

The null hypothesis: in the art therapy intervention based on serious games, the experimental group's skin electrical value will not change more than the control group.

Alternative hypothesis: in the art therapy intervention based on serious games, the skin electrical value of the experimental group will be higher than that of the control group.

Table 2. T-test result of SC\GSR

Part of participant when testing SC\GSR

SC\GSR	Depressive group (A)						Control group (B)					
	Min	Max	Mean	Var	StdDev	Coeff.V	Min	Max	Mean	Var	StdDev	Coeff.V
1	2.5	3.75	3.03	0.07	0.27	0.09	3.36	4.56	3.82	0.05	0.22	0.06
2	1.66	2.77	1.91	0.07	0.27	0.14	3.15	3.69	3.48	0.02	0.15	0.04
3	2.04	3.91	2.82	0.2	0.45	0.16	1.62	1.66	1.64	0.00	0.01	0.02

unit:KΩ

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	cg	.1511	28	.03047	.00576
	eg	.0404	28	.01644	.00311

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	cg & eg	28	.088	.656

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	cg - eg	.11071	.03333	.00630	.09779	.12364	17.580	27	.000

As shown in Table 2, by performing the T-test, the intervention period, the t value = 17.58, $p < 0.001$, df = 27, and in the case of the Sig. of 0.05, the null hypothesis was rejected. That is, in terms of skin electrical value, there was a significant difference between the experimental group (M = 0.1511) and the control group (M = 0.0404), which showed that the coefficient of variation of the skin electrical value of the experimental group was greater than that of the control group.

Blood Pressure Variability (BPV). The null hypothesis: in the art therapy intervention based on serious games, the blood pressure variability of the experimental group will not be greater than that of the control group.

Alternative hypothesis: In the art therapy intervention based on serious games, the blood pressure variability of the experimental group will be higher than that of the control group.

Table 3. T-test result of BPV

Part of participant when testing BPV

BPV	Depressive group (A)						Control group (B)					
	Min	Max	Mean	Var	StdDev	Coeff.V	Min	Max	Mean	Var	StdDev	Coeff.V
1	−83.58	22.1	−50.3	319.84	17.88	−0.36	−35.54	4.12	−25.58	53.15	7.29	−0.28
2	−54.73	22.33	−37.53	302.74	17.4	−0.46	−59.33	72.73	−18.58	617.92	24.86	−1.34
3	−67.06	−11.54	−48.24	90.8	9.53	−0.2	−90.8	−59.6	−76.76	17.15	4.14	−0.05

unit: HZ

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	cg	−.1950	28	.38640	.07302
	eg	−.2136	28	.68411	.12928

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	cg & eg	28	.008	.969

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	cg − eg	.01857	.78306	.14799	−.28507	.32221	.125	27	.901

As shown in Table 3, by performing the T-test, t value = 0.125, p > 0.05 (p = 0.901) is obtained, and in the case of degree of freedom 27, and significance greater than 0.05, the null hypothesis is supported. That is to say, under the art therapy intervention based on serious games, the blood pressure variability of the experimental group is not greater than that of the control group, which is demonstrated by the fact that there is no significant difference in blood pressure variability between the two interventions.

Heart Rate. The null hypothesis: in the art therapy intervention based on serious games, the heart rate of the experimental group is not greater than that of the control group.

Alternative hypothesis: in the art therapy intervention based on serious games, the heart rate of the experimental group will be higher than that of the control group.

As shown in Table 4, by performing T-test, t value = −0.716, p > 0.05 (p = 0.480), and in the case of degree of freedom 28 and significance greater than 0.05, the null hypothesis is supported. That is to say, under the art therapy intervention based on serious games, the heart rate of the experimental group is not greater than that of the control group, and the specific rate is that there is no significant difference in the central rate of the intervention process.

Table 4. T-test result of HR

Part of participant when testing HR

HR	Depressive group (A)						Control group (B)					
	Min	Max	Mean	Var	StdDev	Coeff.V	Min	Max	Mean	Var	StdDev	Coeff.V
1	74.56	84.4	77.88	2.27	1.51	0.02	72.45	93.66	81.11	12.58	3.55	0.04
2	66.21	80.85	72.89	10.39	3.22	0.04	70	96.37	94.32	36.32	6.03	0.06
3	61.94	86.34	72.65	17.89	4.23	0.06	58.18	89.31	72.92	38.53	6.21	0.09

unit: time\minute

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	cg	.0426245	28	.014805393	.0027492
	eg	.04500	28	.011180	.002076

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	cg & eg	28	.076	.697

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 1	cg – eg	−.0023754	.017866160	.003317663	−.00917140	.004420445	−.716	28	.480

MMPI Personality Test. At the end of the experiment, one month later, the subjects conducted another MMPI personality test. The results showed that 65% of the subjects with depression tendency had a significant decrease in D (depression) value, and only 5.56% of the participants D (depression) values rose and were not willing to disclose the reason. Subjects with a significant decrease in D (depression) values also showed a slight decrease in other concomitant mental illness values, and there was no significant increase in any values.

The null hypothesis: in art therapy intervention based on serious games, the MMPI difference before and after the intervention of the experimental group will not be greater than that of the control group.

Alternative hypothesis: in the art therapy intervention based on serious games, the MMPI difference of the experimental group will be higher than that of the control group.

Table 5. T-test result of MMPI

Statistical group

		N	Mean	Std. Deviation	Std. Error Mean
V1	1	28	3.96	2.009	.380
	2	28	.25	1.175	.222

Independent sample test

	Levin's variance equivalence test		Mean equivalence t-test						
								95% Confidence Interval of the difference	
	F	Sig.	t	df	Sig. (2-tailed)	Std. Deviation	Std. Error Mean	Lower	Upper
Assumed variance	1.620	.209	8.446	54	.000	3.714	.440	2.833	4.596
Non Assumed variance			8.446	43.529	.000	3.714	.440	2.828	4.601

As shown in Table 5, the change of value difference of the MMPI scale D (depression) between the experimental group and the control group before and after the experiment. By performing the T-test, t value = 8.446, $p < 0.001$, df = 54, in the degree of sig. >0.05, the null hypothesis is rejected. That is, there is a significant difference between the control group and the experimental group before and after the MMPI intervention. The specific performance is that the D (depression) value of the MMPI had a greater decrease than that of the control group after the intervention in the experimental group.

4 Found

According to the data analysis in the above table, the university students with repression tend to have a higher pre-skin value; upon intervention, the skin electrical value is obviously declining, which proves that the intervention is effective, that is, the serious game with art therapy as the core has relieved the effect of depression. However, for depression-prone university students, the heartbeat before and during the intervention did not show significant differences from the control group. Because university students with repression are more likely to be immersed in their own fantasy world, they can keep their sympathetic nerves in good balance during the period of artistic intervention, so that their breathing slows down and muscles relax. The skin resistance increased and the final skin electrical value showed a downward trend [8]. However, for the heart rate, depression differs from anxiety. It shows that the heartbeat is not much different from ordinary people. After the test, it is concluded that it is impossible to judge whether the intervention is effective through heart rhythm changes.

In the re-interview after the trial, more than half of the university students said that their moods had improved to some extent, and they had found interesting developments, and their negative thoughts had subsided. The above situation proves that long-term use of art intervention can alleviate the symptoms of university students with depression.

5 Discussion

According to experiments and interviews, many university students use art or art-related hobbies as a tool to cope with psychological challenges, and can alleviate depression when performing art or related hobbies. According to interviews with some university students with regards to art, we found that art can give hints to people's psychology and produce certain self-protection functions.

5.1 Advantages of Art Therapy

In the experiment of artistic intervention, the subjects used their own familiarity with the color of security to create a graphic with visual compressibility in a quiet environment [9–11]. In this process, the subject's vision will gradually relax and the mood will be more comfortable. It is particularly noteworthy that one of the interviewees mentioned that after the completion of the artistic creation, people will have gained a sense of satisfaction and accomplishment. For him, art is a positive righteous thought. In the world of creation, you can give yourself a role in what you can't do in life. Many of the participants said that they experienced different degrees of harm during their childhood and growth, leading to their current repressive mood. For example, one participant described his emotions as unstable after he lost his father at the age of 15. After that, he used painting to portray the family and his father, allowing his father to be reborn in his fantasy world, after which his depressive symptoms improved [12].

In the subsequent two weeks of experiments, the experiment was conducted to allow the subjects to freely play and engage in artistic creation. In the process, participants immersed themselves in their own world in an unconscious situation [13], and record their thoughts and expectations of their hearts. When they are alone, talk to this mysterious character and play games. In the face of setbacks, they can also gain strength from mysterious characters in fictional places [14]. For example, Carl Jung's psychological friend is a dwarf. This dwarf satisfies his safety needs and spiritual support to a certain extent, and is the god in his heart [15].

5.2 Advantages of Serious Games

The aim of this experiment was to combine serious games and art therapy. Under the care of professional psychiatrists, university students may encounter (1) inability to persist for a long time to relieve self-depression, and (2) problems such as incorrect methods that lead to unsatisfactory treatment results. Therefore, the study used practical and serious games to aid university students to understand how to conduct art therapy step by step. First, the mechanism of serious gameplay in this study was designed [16]. The experiment used a graphic with visual compressibility to allow subjects to test. People divided the graphics into easy-to-compress graphics and not-easy-to-compress graphics. For people who are upset, it is easy to be more annoyed if they are in an environment that is not easy to visually compress graphics. According to the characteristics of this kind of graphics, the experiment also paid special attention to the compressibility of the graphics. Compressible graphics layout rules, that is, less things, positional rules and less content that the brain needs to deal with. Predictability is also a factor. The predictability of the movement of things will make people feel a sense of control and reduce their psychological burden. Finally, graphical objects are more common, that is, easy to find matching models and provide a little more sense of security and familiarity that can make people relax. Images that are easy to compress exert less pressure on the information processing part of the brain, and the image that is not easy to compress has the opposite effect, which will create processing pressure and make people feel depressed and potentially panic [17–20].

Secondly, the serious game in this study allows patients to receive treatment with interest regularly. Conducting interesting experiments and explorations, can enhancing insight, improving self-image, and broadening perspectives [21]. In the first week, the content of the treatment was a "self-portrait" task, which did not require a high level of painting, and was used to mainly give the subjects a deeper understanding of themselves. People in a depressed state are more likely to despise themselves and are not confident in themselves. At the same time as the painting, the patient can be self-affirmed: even if there is a defect, there is always a merit worthy of pride. The second stage of coloring is to cultivate the color perception of the patient. If they don't have the ability to paint their own appearance, coloring is also a viable art creation, and patients can choose interesting black and white lines to increase their interest. The third stage is the stage of self-creation. During the process, the artistic level of university students will be improved. Self-creation allows patients to draw a psychological world, create their own safe space, and build confidence, which can lead to more confidence in future treatment.

6 Limitations of Future Research Prospects

As an abstract treatment, art therapy is now becoming an important intervention in addition to medical treatment. Through the combination of art therapy and serious experiments, this experiment can make appropriate interventions for university students with higher depression tendency, and can be used and re-created in the future game industry and the medical electronics field [22]. However, although the experiment selected different university students to do a lot of data testing to draw conclusions, there were some limitations. First of all, this experiment was not a long-term follow-up type. It is impossible to estimate whether there are other events in the daily life of participants that alleviate the depressed symptoms of the subjects. Second, this study is not applicable to all mentally sub-healthy university students. Only those students who have some interest in art can effectively influence the intervention of the experiment and help this experiment study the meaning and effect of artistic creation on this group of people. For those who have no artistic interest, the experiment cannot guarantee the effect of their intervention. Third, a small number of subjects have a tendency to other mental illnesses other than depression, and cannot prove their role in the intervention process.

It is worth noting that although this experiment uses painting to represent artistic creation, in future practice, sculpture, crafts, music, cooking and other artistic methods can be used to influence people with different interests.

In future research, a more subdivided approach should be considered for comparative analysis of subjects with different levels of depression and subjects with other mental illness tendencies. Studying the courage of artistic creation for different marginalized groups will lay a more solid foundation for future clinical medicine and serious game research.

7 Summary

This study shows that art therapy based on serious games has a certain relief effect on university students with depression. The study also emphasizes the need for art to be more self-protective and to promote mental health. When performing artistic creation, university students can build their own psychological space, relieve visual stress and gain self-affirmation, as well as gaining a sense of accomplishment in artistic creation in the discovery. Although people with depression tendency cannot be attributed to depression, their mental state is also worthy of research and attention, hoping to self-resolve before the deterioration. Therefore, in future research, more in-depth interventions and research are required to make the serious game mechanism more effective in alleviating the depressive state of university students.

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Gamification

Gamification Framework: The Contribution of User Centered Design, Social Media Applications, Gaming and Psychology Concepts and Frameworks

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Abstract. This paper reviews the literature on gamification in different context. As a result of reviewing 200 peer-reviewed studies a 39 paper was cited to cover most frameworks and context in the field of gamification. Based on our review, we discussed the use of user-centered design, game design elements, HCI, social media application, and psychology concepts in gamification development. We provided some examples from the literature to illustrate the application of gamification in different context.

Keywords: Gamification · Game design elements · HCI · Gamified education · Social media application

1 Introduction

Gamification refers to the use of game design elements to non-game activities and has been applied to many fields and different contexts including education [1]. Many Gamification frameworks built on game design elements to increase users engagement, interactions, and the application outcomes [2]. Most of Gamification frameworks focus on motivational, psychological, and behavioral outcomes [2]. Most of these studies of gamification focused on the general concept and factors of gamification. Also, they develop Gamification frameworks based on selected game design elements such as points, badges, leaderboards, and storyline and selected game design elements frameworks [3, 4].

Searching for peer reviewed articles in the field of gamification, edutainment, and game design elements to investigate gamification related frameworks in different libraries including ScienceDirect, EBSCOHost, ACM Digital library, Web of Science, Proquest, and Scopus would show results of more than 10000 studies. Using Google scholar would be more effective in the case of using keywords such as gamification and edutainment frameworks to investigate the most relevant top cited papers. Since the recent studies would have lower number of citation in Google scholar, we reviewed the most relevant 100 papers to gamification frameworks in the last three years.

Looking at the potential of gamification in many fields we are interested to review frameworks and game design elements that have been used as a base for Gamification

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frameworks. Hence, in this paper, we review the literature on gamification and report our synthesis of the findings from the literature.

2 Method

The literature review conducted by searching multiple libraries including ScienceDirect, EBSCOHost, ACM Digital library, Web of Science, Proquest, and Scopus. The search included topics such as gaming Skills, game Simplifying process, increase effectiveness and motivation through computer games, engagement in video games, educational games, edutainment, e-learning and video games, social effect of video games, gaming and play in educational setup, games/simulations and classroom instruction, game elements and educational needs, learn from games to support educational environments, gamification, serious game, using video games to change behavior and learning future, potentials of gaming design elements in education, game effect on student skills and motivation, game strategies to engage learners, use games as educational tools, educational games vs. simulation, educational VR games effect and acceptance, video games and learning outcomes, serious games opportunity and design factors, healthcare and video games, online games, and virtual reality and interactive learning environments. This process produced more than 10000 papers. Thus, we used Google scholar and selected the most relevant papers to gamification and edutainment. The top 100 cited papers using keywords such as gamification and edutainment frameworks and the most relevant 100 papers to gamification frameworks in the last three years were reviewed. All books or book chapters, and duplicates with other articles were excluded. Papers with more than 60 citations and from 1980 to 2018 were reviewed.

3 Review of Literature

We carried out a review of the literature on gamification studies and game design elements frameworks. Many game design elements, user centered design, and HCI concepts for gamification are discussed in these papers along with their impact on the field.

3.1 Gamification Studies

Gamification has been a hot topic of investigation since 2010. Most researchers define gamification as merging game design elements in non-gaming contexts [1]. Enjoyable systems and interfaces have been studied intensively since the early 1980s. Several studies discussed challenge, fantasy, and curiosity as video game design elements to influence user enjoyment and UX on other systems [5]. For example, Malone [5] analyzed that challenges, clear goals, feedback, fantasy, emotions, and curiosity are the key elements to designing enjoyable systems. Thus, a gamified layer on non-gaming systems adopts elements involving enjoyable factors, while providing options for decision making, creating additional feelings that transfer from the digital to the real world, uncertain connections to external values, and work by rules [6]. Some of these gaming elements - such as clearly defined goals, better scorekeeping and scorecards, more frequent feedback, a higher degree of personal choice of methods, and consistent coaching - came from understanding the role of enjoyment in improving performance throughout many gaming and non-gaming environments [7].

Changing of information and work environments, knowing how to play online games, the high-use of social networks, and an increase in customer-driven business, lead to the development of more effective gamification environments. In the field of education, Mitchell, Danino [8] have recently analyzed the importance of student involvement in the development of an effective learning experience by motivating them through self-learning tools. They reviewed an additional study conducted in 2007 by Presky, in which the author examined why humans engage in games. They report: “He suggests that the key structures of games can be classified into six key categories: rules, goals and objectives, outcomes and feedback, competition, interaction, and representation.” In addition, they evaluated an additional study conducted in 2010 by Corcoran, in which the game provided “instantaneous feedback, egging on the competition, and rewarding even tiny steps of progress”. Gamification assumes that the player isn’t especially motivated and then provides barrels of incentives to ramp up that motivation.” Mitchell, Danino [8] also argued that connecting the gamification process to the user’s real world would motivate the user even further. For instance, “one student commented that seeing his team move up and down the leader-board was like seeing his grade go up and down each day, and this made him increase the effort he put in.”

Similarly in the field of advertising, Terlutter and Capella [9] discussed that there are out-of-system factors that could affect the gamification application. First, individual factors include: level of maturity, cognitive capabilities and capacities, advertising literacy, media literacy, recognition of commercial intent, game familiarity, gaming experience, brand familiarity, attitudes toward advertising, involvement with game, involvement with brand, flow and its antecedents, and entertainment. Second, social factors include whether the game is single- player versus multiplayer, whether there is any social interaction during game play, peer communication, peer group influence, family influence, opinion leadership, and culture.

In addition, most gamification developers focus on customers and ignore employees. This is in spite of the fact that employee satisfaction builds customer satisfaction, and employee dissatisfaction could destroy the organization and customer loyalty [10]. Moise [10] reported that one can have pleased customers for a short period of time; however, an inattentive organization will have to face economic downturns, and even their customers will no longer be loyal if the organization does not also take care of their employees in the long term.

Aparicio, Vela [11] identified several tasks involved in creating an effective gamification environment. First, producers must identify the main goal of the function they want to gamify. Second, they must identify objectives that are interesting to people. Third, they must select game mechanics that match the objectives and support the needs of human motivation. Finally, they should test the effectiveness of the gamification application based on fun, quality indicators and satisfaction, and service quality. Another use of gamification lies in combining games with social media networks, which leads to changes in the lifestyles of consumers. Berkovsky, Freyne [12] stated that gamification's enjoyable properties of playing elements can change the nature of the activity, and induce participants to participate in bursts of physical activity.

In other words, gamified systems borrow elements from video games, SMA design elements, and HCI theories and concepts to make other "non-game" services and products more enjoyable and engaging [1]. Some studies identified gamified systems according to gaming and playing concepts [1]. According to these studies, any system can be gamified if one gaming element is used in part of that system. Also, gamification application uses game design elements rather than being a fully-developed game, video game, or serious game [1, 13]. Gamification "has the game structure, but not the game surface" [14].

While the objectives of both gamification and serious games applications are not entertaining, serious games are more related to simulated game solutions. These developed for the purposes of training, investigating, and advertising [1, 13]. Serious games feature a full-fledged game design [1]. On the other hand, gamification is more suitable under partial game designs [1]. However, some research suggested that gamified systems should be defined as the continuous process of improving users' system interaction, with opportunities for gameful experiences to fulfill stakeholder needs and values using game design elements [15]. Therefore, connecting user-centered design concept of game design elements to gamification would make it more effective [16]. Nicholson [16] in fact suggested that a meaningful gamification system would include user-centered game design elements into non-game contexts.

Furthermore, gamification structure, as previously mentioned, influences the system output by changing user behavior. But, how do gaming elements work to motivate people? Flatla, Gutwin [17] discussed this particular question, and argue that collaboration is an essential part of interactive systems to ensure that input and output are ideally configured. Thus, gamification structure would motivate users to participate, thereby improving the performance and accuracy of human-computer interactions [17]. Also, Mekler, Brühlmann [18] added that meaningful frame elements motivate participants to generate more interactions and inspired them to do better at tasks within the game, thereby creating a high quality experience.

Gamified applications take the advantage of using powerful game design elements, and apply this advantage to solving problems in different fields [19]. The use of gamification concepts has the ability to affect engagement and loyalty, improve motivation, change behavior, encourage contribution, increase involvement, and contribute to efficiency [19, 20]. For example, a company could use gamification for brand awareness, improving marketing strategies and effectiveness, and increasing user retention and participation [1, 13]. For instance, in personal and business use, gamification could affect work completion time positively and improve the quality and the quantity of work [20]. In addition, it would reduce errors and mistakes with faster feedback, in order to improve visibility of progress and recovery from errors [20].

Gamification adopted concepts from the video game industry, psychology, computer science and marketing to deliver more effective results [21, 22]. In gamification, psychology and HCI studies and concepts play the role of understanding human behavior and needs [23]. Thus, it drives user behavior toward specific targeted values [13]. Furthermore, motivating contribution on a system using gamification can affect user behavior [21]. Moreover, social psychology theories contribute to our understanding of gamification, particularly with regards to understanding the motive behind human social interactions and participation in gamified systems [20, 21].

3.2 Gamification Theories and Frameworks

Many developed gamification systems' design based on theories and frameworks from HCI, gaming, and psychology fields. For example, a "User-Centered Theoretical Framework for Meaningful Gamification" has been used to define users as the center of designing meaningful gamified system [16]. Also, many studies considered gamification investigations under persuasive technology field [24]. Fogg [25] provided eight steps in the process of designing persuasive technology (Fig. 1). These steps are used as milestone for effective design in gamification.

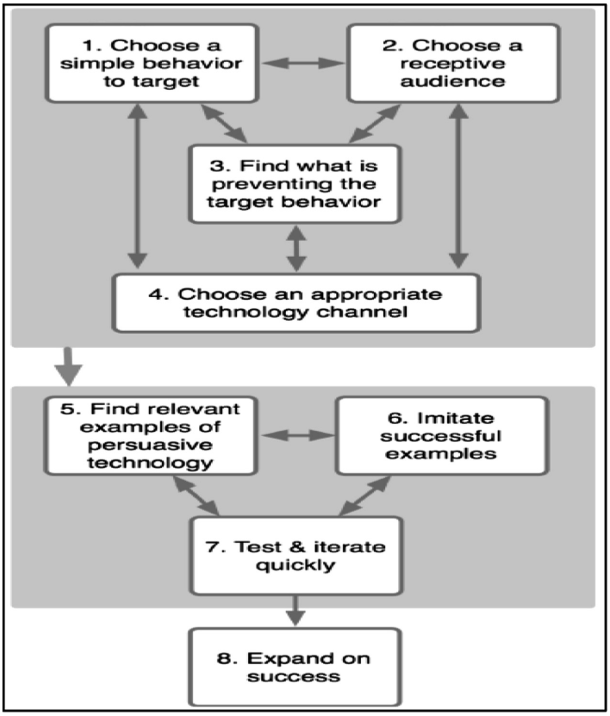

Fig. 1. Fogg's eight step model of persuade technology [25].

Since gamified system in utility applications required users integration, understanding people behavior is an essential factor in designing an effective gamification system. "Self-determination Theory" (SDT) [26, 27] helped understanding users behavior. SDT predict goal-oriented behavior through user needs and motivation [28]. Three fundamental needs (Competence – Relatedness – Autonomy) were defined to enhance personal growth [26]. Two motivation categories (intrinsic and extrinsic) were defined from SDT needs [26, 28]. Four types of intrinsic rewards (Satisfying work - Experience of being successful - Social connection – Meaning) were developed using SDT theory [29].

Gamification applications use combination of both extrinsic and intrinsic motivations to engage the users [30, 31]. As well as “Four –Drive” model helps to understand the reasons of users acting in a certain way [32]. The model categorizes motives to change user behavior to four categories[32]. Thus it would satisfy our biological need for curiosity. These categories include [32]:

- Acquire: The felling of obtaining physical and emotional things.
- Bond: The relationships and communication between individual.
- Defend: Protection from physical and emotional threats.
- Learn: Gaining new knowledge and skills.

In addition, “Fogg’s Behaviour” model proposed three elements to change use behavior (Motivation – Ability – Trigger) [13, 22, 33].

- Motivation: The desire level of engagement in an activity.
- Ability: The level of skills to performer a task.
- Trigger: The level of encouragement to do a task.

Furthermore, “Persuasion Profiling” model provide several principles to enhance users’ behavior towered specific manner [22]. These principle include:

- Reciprocation: The obligated feeling to return a favor.
- Scarcity: People value rare things more.
- Authority: The power of legitimate authority request (people will follow/believe the request).
- Commitment and Consistency: People do as they said they would.
- Consensus: People do as other people do.
- Liking: We say yes to people we like

From game design field, the “Four Elements that Defined a Game” theory [34] has been used on gamification. This theory provides four elements to define games, which it could be useful for designing gamified systems [34]. These elements include goal and outcome, rules, feedback, and voluntarily participation [34]. McGonigal’s Four Game Experiences model [34] supports using game design elements to develop an effective gamification system. This model suggests four types of experiences in gamification influenced by game design elements [34].

- “Urgent optimism”: enjoying overcoming obstacles to engage with the system and others by searching for the solutions.
- “Blissful Productivity”: the motivation of continues efforts to face challenges.
- “Social Fabric”: The feel of belonging.
- “Sense of Epic Meaning”: enjoying selfless objective achievements.

In addition, using “Dignan’s Behavioral game” model in designing gamified systems would enhance any activities and tasks to be more engaging and learnable by employing game elements to user interactions in everyday experiences [35, 36] (Fig. 2).

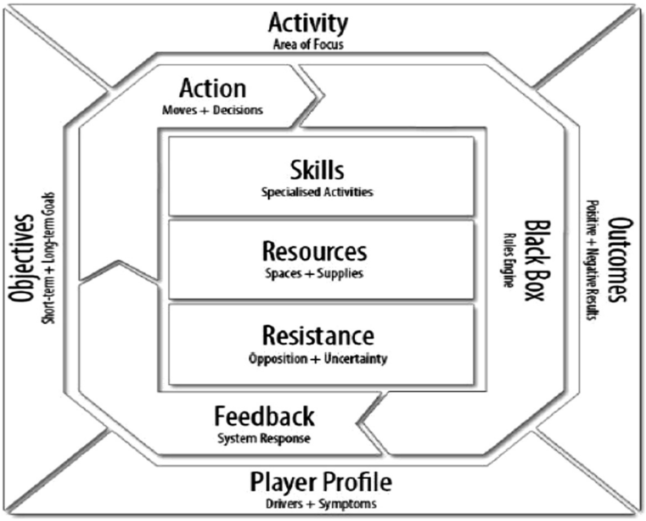

Fig. 2. Dignan's Behavioral game model [35].

Moreover, Flow Theory [37] is widely used in gamification. Flow is defined as the state where users are deeply involved in an activity, forget about the time and nothing around matter [37]. This concept would affect changing behavior; witch is one of the objectives of gamifying applications and activities [22]. In term of players personality "Bartle's Four Player Personality Types" model would help to develop an effective gamified strategy by understanding the users behavior and play experience patterns [38]. It suggests four types of players [38].

- Explorers: This type drives by the enjoyment of finding, understanding and exploring everything.
- Killers: This type drives by the enjoyment from causing anxiety.
- Socialisers: This type drives by the communication and relationship between players.
- Achievers: This type drives by the enjoyment of getting to the goal/objective.

Finally, "Five Stages Behavior Change Lifecycle" model provides insight into the type of games that will modify users' behaviors [24]. First stage focuses on the improvements of the users' behavior. In this stage behavior-instrumentation games are used to measure real-world behavior and investigate best practices [24]. It helps to view users' behavior and connect that to the real-world behavior. Thus, it would enhance the recognition of improvement opportunities [24]. The main challenge of this stage is when we don't know if the users are doing something wrong in the real-world behavior [24]. Second stage is the committing to the change effort. In this stage cause and effect-simulation games are used to illustrate the benefits and build a structure to measure sub-goals [24]. The main challenge in this stage is the ignorance or not fully understands the value and the cost of the change [24]. Third stage is to understand the principles and the major mechanisms of the target behaviors. In this stage dynamic-system games provide a way to understand the target behaviors and patters that develop specific processes and mechanisms. The main challenge is not having enough background knowledge to understand the target behavior and the principles involved in the target behavior [24]. Fourth is adopting a new behavior. In this stage skill-building games helps users to practice and exercise specific behavior in controlled environment [24]. The main challenge is the lack of experience to of specific mechanisms and not having the comfort level to perform specific patterns of target behavior [24]. Final stage is mastering and maintaining the new behavior. In this stage behavior-instrumentation games are used to measure real-world behavior. It does help to maintain real-world behavior and refine the target behavior over time through controlled environment [24]. The main challenge of this stage is the continues need for practice and reinforcement of the target behavior [24].

4 Conclusions

In short, the research in this field show that systems having some game design elements and gameful experience can produce some quality results in contexts other than games. In addition to using game design elements and providing gameful experience, most of the gamified systems are using social media application elements to enhance specific users' behavior toward the system values. Therefore, the combination of psychology, video games, business, computer science, and HCI theories and concepts comprise the power of gamification to deliver more effective results. Gamification uses these powerful elements and applies it to solve different issues relate to different fields (help organizations teach, persuade, motivate, and develop meaningful brand relationships, and enhance the user experience) [22, 39].

However, most of these studies of gamification focused on the general concept and factors of gamification. In addition, they propose high cost implementation to different existing system such as enterprise systems.

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Small Business Owners Handle Website Design Effectively Using Gamification

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Abstract. Regardless of how big or small the business, technological advancements, such as building an efficient website, should be of great concern for business owners due to the technological dominance in the current society. Web design describes the process of creating a website, and embodies many different aspects such as webpage layout, content production, and graphic design. However, there are many obstacles that small business owners face when developing their websites, such as not having enough time, lacking technical skills, or difficulties with the content itself. This study tries to apply gamification design in the website education area to support and help small business owners in business web development. Additionally, Gamification describes the process of using game elements in non-game settings to engage the audience. Thus, a website development guideline is proposed in a game style model. The benefit of using the Gamification Theory in business is that it will help keep the audience engaged, and will make the process of development feasible, engaging, and less time consuming. This study will support business owners both short term as well as long term.

Keywords: Website design · Small business websites · Gamification in business · Theory of Gamification

1 Introduction

1.1 Web Design and Creating an Effective Website

In today's day and age, no matter the size of the business, a website is an essential component of a company's business. In fact, according to Rakhmawati et al. (2017), technology had made websites function as the heart of nearly every institution. Web design describes the process of creating a website, and embodies many different aspects such as webpage layout, content production, and graphic design ("Web Design" 2019). Thus, web design is a subset of web development. A good website is similar to a greatly designed business card. This is because a well-defined website is the first impression to potential clients. Also, a good website can help the business grow, and can also increase visibility. Additionally, a website will help give the business credibility, and will make the organization look bigger, professional, and more efficient. Thus, the more professional the business appears, the greater its competitive advantage. Websites are usually created using HTML, a markup language, and webpages use

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HTML tags, and the element of the webpage are defined using cascading style sheets, which are also known as CSS ("Web Design" 2019).

There are many steps to consider when building a successful website. Some of these steps include, the visitor must come first, starting with a clear navigation, using conventional English and avoiding industry jargon, providing relevant information, leaving out the hype, making your homepage a to-the-point summary, creating unique landing pages for the specific topics, letting pictures tell the story, including trust – building content, keeping the website up to date, using a straightforward layout, making it easy for visitors to contact you, keeping forms simple, including a call to action on every page, and making it as perfect as possible (Greene 2018).

The most important part of creating a website is to write with the customer in mind. This is due to the fact that the customer will be the main one to access the website for information. As a result, if the website does not make sense to the user, it is useless and not effective. Thus, customer-centric websites are the best websites in business. Additionally, it is critical to organize the pages into logically-named categories with standard terms (Greene 2018). This will prevent visitors from having to guess and get frustrated about where to go. Additionally, it is important to remember to write as if you are speaking directly to the visitor without having to worry about not using contractions. Thus, an informational tone is preferred by the users over a corporate tone. Also, it is important to avoid industry jargon that customers might not be familiar with. In addition, it is very critical to be very detailed and to include as much information as possible. This is due to the fact that if customers do not find the answers that they are looking for in a website, they may very easily go on to the next site. Also, it is very important to leave out the excessive hype due to the fact that customers expect honesty and transparency, and then will make decisions accordingly. In fact, having too much extra marketing on the site will make the website seem unreliable and will influence individuals to ignore the page all together (Greene 2018). It will slow down the website, which will lead to upset customers. According to research, speed is crucial when it relates to customer satisfaction. Research conducted by Hernández et al. (2009), demonstrates the positive correlation between website loading time and user satisfaction. Thus, it revels the fact that rapid loading is critical for online transactions to be settled.

Moreover, since the homepage is the first page that customers will come into contact with, it should provide a summary of how customers will benefit from the content, products, or services. Also, the unique landing page for specific topics should be on specific pages, and not on the homepage. This will allow the unique landing pages to be detailed without affecting the homepage at all. Additionally, real photos are the best in terms of helping customers visualize actual products or services and help convey the story more meaningfully. Similarly, it is important to include trust-building content that will help exemplify the uniqueness of the company and help build trust. The website should be updated on a regular basis to remain credible, and the content that is no longer available should be deleted. Additionally, a simple, organized layout works best, and will prevent clutter. Thus, it will make it more intuitive for visitors to find what they need without wasting time. Also, contact information should be made easy to locate, in order for the customers to contact the website's owner, if they need. Moreover, if forms are a part of the website, it is crucial to keep the forms simple with as few questions as possible, in order for customers to provide feedback (Greene 2018). Otherwise, customers will totally ignore the forms. A call to action should be included on every page by telling the customers what they should do next. For example, lead the customer through the path of making a purchase. Lastly, it is very beneficial to make the website as perfect as possible. Thus, spelling, grammar, and keeping the website accurate with the most up-to-date information is critical and will give the audience an impression of professionalism.

1.2 Small Business's Owners

A small business owner can be defined as the owner of a privately-owned corporation that has few employees and relatively less revenue than other regular-sized businesses. In the current society, the importance and number of small businesses is on the rise. To further elaborate, according to a peer-reviewed article from Kozan et al. (2012), small business growth and entrepreneurship has been a foundation of the liberalization process in the world economy. Thus, business owners have a great impact in the economy.

Furthermore, business owners have many characteristics such as being risk takers and exhibiting openness to change. Thus, these variables explain the small businesses growth and many degrees of success. In addition, in order to fulfill their characteristic and make the business successful, small business owners make a variety of personal, financial, and relational sacrifices. For example, when business owners and entrepreneurs are considering business growth, often times they have to work extended hours, and give up a lot of free time. To further illustrate, business owners sacrifice losses of financial assets and property, family conditions such as marriage due to time, and also sacrifice resources such as time and knowledge (Kozan et al. 2012). Thus, due to the resource sacrifices that business owners have to make, it can be very challenging to find time and resources to create an effective business website.

In addition, one of the main dilemmas that business owners are facing is time and budget constraints. Although small business owners may want to produce an extremely successful website, the budget and time limits may not allow this to be feasible. Therefore, we have developed a study to help small business owners support websites development with reasonable resources and reasonable costs. This study adopts Gamification as a tool for engagement to help business owners develop effective websites easily themselves. This is the first academic research using Gamification in small business owners website development education.

2 Literature Review

2.1 Forbes Six Components of a Successful Website

Creating a business from scratch can be an exciting as well as a terrifying journey. According to Womack (2008), almost everyone with an interest in business has dreamt of starting their own company, and with the proper information, reality is possible. Once the business idea is laid out, the business concept put to work, and the product or service created, the next step is building a website in order to make the brand or service known. However, building a successful business website for a start – up company that is just beginning to take off can be a challenge. As a result, Forbes has come up with six of the most important components of a successful business website in order to help small business owners. According to Forbes, the six components that every business website must have in order to be successful include good design, a clear call to action, a story page, organic search ranking, social proof, and mobile responsiveness (Lubinsky 2018).

To further elaborate, good design, regarding how easily the visitors are able to navigate through the business website is a key component of good design and a major factor that converts to the respect of the business. Additionally, the layout should be user-friendly and intuitive with a focus on the end goal and customers (Lubinsky 2018). Additionally, appropriate colors, and fonts should be used to relate to the business and make the website professional. For example, for a security app, it would be appropriate to use darker shades and a bolder font. Thus, this will portray the security image of the app, and will tie in the service provided through the app with the business website.

Moreover, a clear call to action is very significant when considering the success of the website. The visitor's attention should be captured by using language such as "Click here", "Shop now", or "Watch our story". Words and tactics such as theses sway people into clicking and further continuing to be involved with the website. Thus, it is crucial to be very direct with the call to action, and keep people engaged with the website.

Furthermore, having a story page in the website, that connects the brand or service to customers is a great way to establish a strong connection. Thus, a pronounced way to accomplish this task is through telling the brands story and how it began. It is important to share information about the founders, why the company was started, as well as the mission and vision statement. This will allow customers to visualize the business's goals. Additionally, it may help to have individuals tell their stories about the products and services. By having real people's stories on the website, it may help to make the brand more credible, and this leads to customer loyalty. This allows customers to connect to the brand/business and creates trust and familiarity with the product or service (Lubinsky 2018).

To further elaborate, taking the time to set up correct page titles and product descriptions leads to increasing the organic search ranking of the website. In addition, one other important thing to do is to have third-party websites linked to your website in order to increase the organic search ranking. Also, another great way is to create a blog for your business. The blog will allow founders to write articles that will surround the specific business product or service, and will allow for key terms to rank on search engines. Thus, leading to the popularity of the website and business product or service.

In today's day and age, with social media being such a significant part of our life, considering the importance of social proof is crucial when building a successful business website. Thus, integrating social media into the homepage of the website helps strengthen brand identity and trust. Especially since individuals like to keep up with current trends that their friends are involved with. Also, it is a great idea to display positive reviews from customers on the home page of the website.

Lastly, and one of the most essential components of a successful business website, is ensuring that the website is mobile responsive. For example, in sales businesses, the website is suppose to act as the "silent salesperson" (Lubinsky 2018). Thus, due to the fact that phones are very convenient, the majority of the customers rely on mobile devices to access websites and make purchases. This is further supported by the fact that the majority of website traffic is driven by over 60% mobile traffic. Thus, it is important to drive the customers to be happy with the presentation of the product and service, and allows the customer to access the website at their convenience, and through the device of their choice.

2.2 A Small Businesses Guide to the Steps of Building a Successful Business Website

Customers visit the internet for everything from searching products to searching a businesses locations and hours. Thus, having a simple, well-designed, website can easily expand the new business. A step–by–step guide to creating a successful business website for small businesses includes determining the primary purpose of the website, deciding the domain name, choosing a web host, building your pages, setting up a payment system if applicable, testing and publishing your website, marketing your website on social media and search engines, and maintaining an updated site (Fabian 2017).

Determining the primary purpose of the website is crucial because a website provides information about the company, or even a direct platform for e-commerce. The most important thing is to say, in simple plain terms, what the company does, on the homepage. This way, the users do not have to waste time searching around to discover what the company does. According to Fabian (2017), no matter what the main goal of your website is, users should be able to reinforce the goal through navigation of the website. Additionally, if the website will process transactions, additional external services are required during the set up.

Next, determining the domain name is one of the most essential features because it is the URL that you will be sharing with your current and potential clients. Also, this is the URL that will be used to share the website on social media sites. Thus, it should be made as descriptive as possible to relate to the company's purpose; however, should be kept as short as possible so that customers can remember it easily (Fabian 2017). Likewise, acronyms, abbreviations, and numbers should be avoided in order to avoid customer confusion. The next step after determining the domain name, is to determine the top-level domain. The top-level domain is the suffix at the end of the domain name. For example, .com, or .net. The next step is confirming the sites availability and purchasing it through a domain name registrar such as Wix or Web.com, or Squarespace (Fabian 2017). It is crucial to check copyrights to ensure that other individuals rights are not infringed. If the URL is taken, it can be bought only with permission from the company that currently owns it.

Choosing a web host is the next phase of the process. Every website is required to have a host, which is a server that stores all of the data and allows the public to access the data at anytime. Also, depending on the budget, it is more beneficial for small businesses to select an external host due to the fact that the expenses are too large.

Thus, there are two options available to pick from. The least expensive options is a shared web host, that allows sharing a server with other sites. On the other hand, dedicated hosting is more expensive, but it allows the owner to have a private server and will not have to compete with other websites for speed (Fabian 2017).

Building pages is the next step in the process of a successful small business website. Multiple pages should be created and devoted to different aspects of the business, such as a detailed catalog of the products or services, or a blog section for recent updates (Fabian 2017). For the website in general, it is crucial to ensure that the page supports the primary goal of the website, has a clear purpose, and a clear call to action such as signing up and purchasing. Also, it is significant to have a contact page that includes information such as phone numbers, e-mail address, and physical location. Moreover, an about page will help customers put names to faces and know all about the people that created the company and brand. Additionally, a few tips to help produce efficient, content-rich pages for the website include being clear about what the business does, placing strategic calls to action, automating speed improvements, and avoiding stock photos (Fabian 2017). Furthermore, if applicable, setting up your payment system is the next phase in the website building process. The easiest and cheapest way to do this is through a third-party payment processor such as PayPal. Thus, this allows there to be less involvement with the website itself.

Next, testing and publishing the website before announcing the site live on the web is very important. For example, it is crucial to ensure that the website works on all major browsers such as Internet Explorer, FireFox, Safari, Chrome, and Microsoft Edge (Fabian 2017). Also, it is a good idea to go through each page one-by-one and ensure that all links are correct and that all images and options show up. In addition, setting up an analytics program right from the beginning of the website can be very helpful due to the fact that the page can monitor the successful and unsuccessful pages (Fabian 2017).

Moreover, marketing the website on social media and search engines is vital. This is because this is what will increase the audience's reach through social media sites such as Facebook, Twitter, LinkedIn, Instagram, or Pinterest. Likewise, submitting the website to major search engines such as Google will help direct leads to the website (Fabian 2017). According to an article written by Fabina (2017), in order to create traffic early, it is crucial to construct relevant keywords into the content of the website from the very first phases, and have a strong focus on SEO from website launch. Thus, this leads to a greater audience and, thus, more business and revenue all together.

To conclude, keeping the website up to date and relevant is super important in order to keep the customers informed with the latest information, newest products, and current industry events. Also, it is crucial to check at least monthly that all the software and add-ons are up to date. Thus, according to Fabian (2017), creating a website for the business is a low-cost investment that will help immensely in the future by establishing credibility and reaching a wider customer base audience.

2.3 Difficulties of Designing a Good Website for Business

Although most consider the actual building of the website to be the challenge, in reality, the most difficult part of a web design project is the actual content itself.

For business owners, the main reasons why it is difficult to design an effective website is due to the fact that it is difficult to get clarity around what the practice will be incorporating, estimating the amount of content that is needed, content is too abundant, and organizing the content is a challenge (Love 2016).

Furthermore, the challenge of designing an effective website is increased exponentially due to the fact that it is significantly difficult to get clarity around what the business will entail, especially in the early stages of business development. Thus, as a small business owner, it is essential to have the business plan fully laid out when designing your businesses website. Additionally, in order to empathetically reach the audience, it is fundamental to keep the target audience in mind at all times in order to help guide the content of the website.

Moreover, estimating the amount of content needed in the website can be very tough. For example, a website contains much more than the businesses' home page and logo. It contains detailed sheets such as a FAQ page, Contact page, CTA's for every page, Blog posts, Privacy Policy, and the Terms of Service page. Also, estimating the right amount of content to include in each page is a task on its own. This is due to the fact that if content is too abundant, users will ignore that page all-together due to time constraints. However, the right amount of information should be included on the pages in order to get the information across to the public.

Furthermore, organizing the website's content is a rigorous process. This is because information and design need to be combined at the correct momentum. For example, some questions that come up include: should the resources and worksheets be put onto a separate page, or should they be included in the blog post, where should the videos be placed, or should videos even be used at all, what questions should be included in the FAQ page, and how about events and workshops? (Love 2016).

For Business Owners, it is hard to control the content, and if the audience will approve of it. Similar to how custom-made clothing has to fit a person's physique perfectly, the website has to suit the strategy and the content of the web design client.

2.4 Gamification

Gamification is a term that is currently gaining popularity and drawing the attention of business professionals in the current technology driven world. According to Swacha (2018), Gamification describes the use of game-design in non-game settings in order to engage the target audience. Additionally, Gamification motivates users to act in a certain way. Thus, Gamification is more than just games and applications. It is used in the educational environment as well as in the business environment to enhance user engagement. According to a peer-reviewed article from García et al. (2017), by incorporating game techniques, Gamification pursues to improve the user's engagement, motivation, and performance when carrying out certain tasks. To further illustrate, it describes the process of taking something that already exists such as a website, and incorporating game elements into it to motivate users and increase user engagement ("What is Gamification?" 2018). This means that Gamification results in learning from game design, and includes listening to what the game can teach us, learning from the game design, and appreciating the fun (Sari 2014).

Moreover, gamifying is a very important concept due to the fact that it provides individuals with choices, and prevents them from unnecessary actions such as shopping, teaches progression mainly through the different levels, since level 1 and 100 are nowhere near being the same, and it instills socialization through collaboration. Additionally, Gamification is altering business models positively by creating new ways to develop longer-term engagement and leads to user trustworthiness ("What is Gamification?" 2018). Therefore, by combining Gamification with big data that is generated by users, Gamification allows businesses to create loyalty.

Gaming developers are experts at finding techniques that engage the audience in order to keep them attached. Moreover, gamification has seen rapid adoption in business, management, marketing, and ecological initiatives (Dicheva et al. 2015). After realizing the impact that the Gamification Theory brings, educators have decided to implement it in the classroom setting. Currently, Gamification teaching strategies are being used to engage student's learning. According to Alhammad and Moreno (2018), Gamification has been considered one of the key emergent and extensively adopted teaching technologies in current education. This is mainly because learning is like a game and contains rules, levels, and even rewards (Cox 2019). Therefore, student's need to obey the rules in order to move up the latter and into the next level, and in the end there is most likely a reward. Thus, by integrating gamelike components into the classroom, students will engage by 'unlocking' the next level of their assignment, or challenging other students (Cox 2019). In order to make teaching more like a game and engage students, educators can incorporate user levels, create challenges, give a second chance, allow students to make choices, and give rewards and badges. In academia, gamification is based on the idea that it supports and motivates students, and as a result, can enhance learning outcomes, (Alhammad and Moreno 2018).

Furthermore, when students play a game, they have to complete levels in order prior to beginning the next one, for example, level one has to be completed before level two. There is usually a progress bar that continues to fill up that provides players with an idea of their completion. Similarly, in the educational setting, when students have an assignment to complete, they start with 0%, and have to work their way to getting 100% completion. The grade acts as the "progress bar" and is the incentive to earn a good grade. In addition, creating a challenge is a hook that gaming experts incorporate in order to keep players attached. Correspondingly, using the challenge incorporation element in lessons can motivate students to challenge themselves and will allow them to add more to their assignments (Cox 2019). Moreover, in the school setting, when student's fails an assignment, there is usually no second chance given. However, in the game setting environment, when a player fails, there is always a second chance given to keep the users engaged, and for them to learn from their mistakes. Thus, by implementing the Gaming Theory into the classroom, students can be given a second and a third chance, and this will give students the opportunity to learn from their mistakes and will push them to move forward. In addition, through repeated attempts, students will learn to eliminate the pressure of failure (Cox 2019). Finally, rewards and badges are a major component of games. In the game setting, badges and rewards are used to inform the user that they have achieved a level, and are an incentive to keep players moving forward towards the finish line. Correspondingly, by using the Gamification Theory in the classroom, rewards can be used as an incentive for students to continue to expand their efforts and will be very beneficial in the end. Therefore, Gamification is used to enhance education. The theory has been recently growing in popularity in order to help keep students engaged in the classroom and teaches students practical life skills. Overall, making learning fun keeps students of all ages engaged.

2.5 Web Development and Gamification

Based on the literature review, the main goal of websites is to create an appealing existence that meets the goals and objectives of their business (Beachboard 2017). Additionally, this research is working towards a solution for small business owners to adopt the Theory of Gamification in order to quickly develop a website efficiently. Based on an article from Hsu et al. (2013), Gamification basically functions as entertainment, thus, website users enjoy actively participating and engaging with other individuals. In addition, Gamification pursues to improve user engagement, motivation, and performance when carrying out a certain task through integrating game mechanics and components, thus, making the task more appealing to users (García et al. 2017).

Moreover, according to research from Mitchell et al. (2018), Gamification greatly impacts motivation of workers, and the most common reason for using the gamification application in the work setting were to improve productivity by 32%, followed by tracking task completion/compliance by 19%, and education/training by 16%. Thus, these applications gamify task completion through the role of playing games. If this theory is implemented and gamification is used to help business owners, by the time that they have completed the interactive game, the goal is for there to be a fully-functional website developed for business owners.

Furthermore, game design contains many frameworks that help individuals understand the strengths and weaknesses of game design. One of these frameworks, known as the MDA framework analyzes design by breaking it into many different components that includes mechanics, dynamics, and aesthetics (Kusuma et al. 2018). The mechanics component is related to the components and control, in this case, it would be considering the components of the business owners' website as well as basic actions and algorithms. In addition, dynamics is concerned with the context, constraints, choices, chances, consequences, and cooperation. It relates to how mechanics run in the game according to the inputs that the player, or in this case, the business owner chooses to use. Moreover, aesthetics is concerned mainly with the organization, creativity, and compliance (Kusuma et al. 2018).

Elemental Tetrad is another framework of game design that is used. It breaks down the process into four aspects that are known as mechanics, story, aesthetics, and technology. Mechanics and aesthetics focus on the same elements as the theory of MDA covers. However, story is related to the chain of events that happened in a game that players need to follow. Thus, in this case, it will be the steps that the small business owners take in order to build their website through the process of gaming (Kusuma et al. 2018). On the other hand, technology is concerned with the objects that make the game available such as physical media or digital media, in the search for website building.

According to Hernández et al. (2009), the design of a dominating website, as part of e-business strategy, has become a key component for success in the online market.

In addition, accessibility, speed, navigability, and content are the main areas of concern that need to be considered for a successful business website. Thus, these components need to be reflected upon during the building of the game design that will help business owners complete their websites. Moreover, accessibility relates to the quality of the website regarding its ease of use, speed is concerned with having a very fast response time in order for customers to remain satisfied, and navigability is related to the ease of use that the company offers in the website (Hernández et al. 2009).

Additionally, responsive web design is another component that needs to be implemented in the game design strategy that business owners will be using. According to Baturay and Birtane (2013), there is a need to switch to Responsive Web Design in order for the capability of reshaping itself depending on various screen size and resolutions. This is due to the fact that the use of smart phones and other mobile devices has sky rocketed in recent times. Furthermore, the main key features of a responsive website include media queries and screen resolution, fluid grid layouts, and flexible images and media that automatically changes the page layout and resizes images proportionally to suit the specific mobile device. Thus, HTML 5 and CSS are great tools that need to be considered in the instance of mobile devices as new standards will continue to evolve and change the world of technology.

3 Research Method

According to the literature review, we designed a group of games to help small business owners, who have no programming experiences in web design, develop their own business websites.

Within a game map named My Home Page Land, there are 8 games spread in the map:

1. Art & Design game: asks users to draw desired page design and identify mistakes they made to give them a good idea of website design;
2. Fighting game: includes 20 levels of tasks for each website design language and database language, such as HTML, Javascript, Python, CSS, Ruby, PHP, C++, and SQL. Each level teach users how to program several certain web design functions/commands. After users pass all the levels, they will understand how to program a website;
3. Puzzle game: helps users understand navigations of a website;
4. Story development games: help users to create brands stories, missions and vision statement;
5. Simulation of establishing social networks: guides users to build linkages between a website to popular social networks.
6. Simulation of effects on mobile devices: lets users compare the effects of a website on both PCs and mobile devices, and understand mobile responsiveness of the website;
7. Simulation of translating website to a mobile application: asks user to build a mobile application from a website design.

8. Error correcting games: asks users to test different website designs based on organic search ranking, and other characteristics of a website, such as spelling, grammar, and keeping up-to-date information accurately.

Research Method Implementation (Fig. 1).

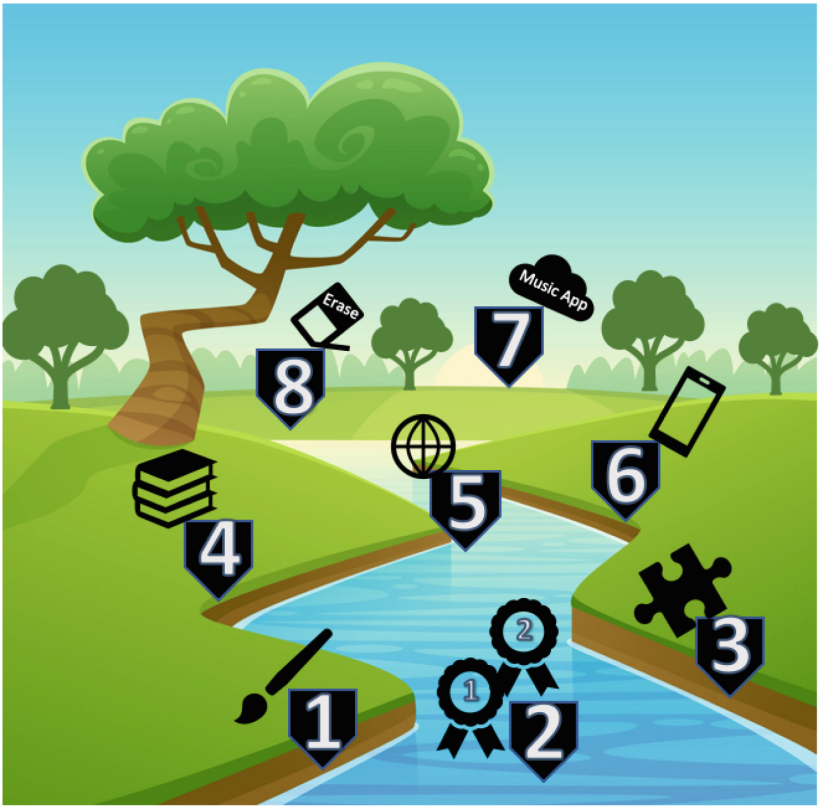

Fig. 1. Research method implementation following steps 1–8. (Background source: Summer Cartoon Landscape Vector Image VectorStock)

4 Discussions and Conclusions

To conclude, the next step will be the actual game design to have the game developed and to test the game to have the results showing. Future work will include further research and experimentation with the Theory of Gamification, to prove its benefits to small business owners. No other previous research in the area was found to guide small business owners to develop their own websites. Thus, this is the very first study in the zone that developed a research model regarding Gamification in order to help business owners effectively develop their own business websites. The research method implementation that is pictured above can be used to help describe the steps that business owners will be involved in throughout the game. Therefore, Gamification is widely adopted today in order to help improve the business and education industries.

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Gamification in Mobile Application Development Education

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Abstract. Compared to traditional lecture education pedagogy, gamification is positioned to offer several advantages for motivating and engaging students. In this paper, we aimed to assess previous studies of gamification applications in education to identify key factors and challenges influencing the effectiveness of gamification. We reviewed both success cases and failure cases with gamification applications in education. To improve the usefulness of gamification in education, we recommend the alignment of gamified functions and non-game context in gamification design. A gamification model was proposed to improve students' learning outcomes in a mobile application class.

Keywords: Mobile application · Education · Gamification

1 Introduction

The development of mobile services has become so strikingly rapid in the last decade. It has been driven by three main factors: the excitement regarding mobile technology; the continuing growth of e-commerce, and the high penetration level of wireless devices worldwide [1]. With the increasing rise in smartphone ownership, the smartphone applications provide valuable and various useful features in our daily lives. According to statista.com [2], there were about 6 million applications in different app stores by the 3rd quarter of 2018. After "angry birds" became the largest mobile app success story, more and more individuals are trying to come up with new ideas and develop their own mobile apps. Therefore, in colleges and universities, Mobile application development class becomes one of the hot courses in Computer Science or Information Systems. However, there are many real challenges in mobile app development, such as dealing with multiple mobile platforms, and analyzing and testing mobile applications [3]. Students in the Mobile Application Development class not only need to learn the computer language, but also have to face to and overcome these challenges. Wilson and Shrock [4] identified 12 factors contributing to the success of learning a computer science program: math background, attribution for success/failure (luck, effort, difficulty of task, and ability), domain specific self-efficacy, encouragement, comfort level in the course, work style preference, previous programming experience, previous non-programming computer experience, and gender. These factors are considered from students' learning perspectives. From a teaching perspective,

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failure in an App design and development could be a lack of alignment by teachers of pedagogical models with students' learning outcomes [5].

New technologies always bring new teaching methods in classes [5]. In education, gamification, the adoption of game elements in non-game contexts [6], becomes a new method to help students learn new knowledge in a game environment. Gamification transforms a "serious" and "boring" knowledge learning process to a gamified flow by entertaining students with enjoyment and fun as to educate, train or change their behaviors. In mobile application development education, gamification can be helpful toward students who have different learning styles and learning difficulties. The purpose of this study is to address the usefulness of gamification in mobile application development education and propose a gamification model to improve students' learning outcomes.

2 Literature Review

2.1 Mobile Application Development

IBM software team [7] categorized three types of mobile applications: native, web, and hybrid. A native application runs on a certain mobile Operating Systems (IOS, Android, etc.) and can be downloaded from an App store. Therefore, the same native application will have different version for different Operating Systems (OS) in different App stores. Web based applications runs on a browser and does not require different versions for different OS. Hybrid applications combines both native and web applications utilizing native development and web technology. Native applications are getting more popular now for they can easily adopt mobile devices' native functions or features, such as camera, calendar, and so on. Additionally, in mobile application development courses, we always teach native application development. Therefore, native applications represents the mobile applications in this paper.

Through a case study, Falloon [5] explored advantages of mobile applications in education:

a. communicating learning objectives in ways young students can access and understand;
b. providing smooth and distraction-free pathways towards achieving goals;
c. including accessible and understandable instructions and teaching elements;
d. incorporating formative, corrective feedback;
e. combining an appropriate blend of game, practice and learning components;
f. providing interaction parameters matched to the learning characteristics of the target student group.

However, the quality of a mobile application significantly impacts users' adoption [8]. From the mobile development perspective, Joorabchi et al. [3] argues that there are four general challenges in mobile application development: Mobile application platforms, application monitoring, analysis and testing, intensive data handling, and updating applications. From mobile application success perspective, Inukollu et al. [8] identified four crucial factors that cause mobile apps to fail: negligence by the

Table 1. Challenges of mobile application development.

Critical factors	Sub-factors and description
Mobile development	-multiple platforms require different source code and settings -developers' capability of coding -understanding users' needs -standard of development process/approach -simple registration process for users
Technical issues	-application testing -capability of intensive data handling in application -application updating -changes by source code language updating -clear hardware/platform requirements of the applications
Marketing efforts	-enough budget for marketing -trust between users and the applications -marketing strategy
User prospects/adoption	-understanding reasons to cause user adoption -spending enough time with the applications from users' perspectives

developers, technical issues, inadequate marketing efforts, and high prospects of the users/consumers. Table 1 summarizes the combination of the findings from both studies.

2.2 Gamification

The purpose of gamification is to increase users' engagement with an application and to improve their adoption and retention by removing obstacles preventing behaviors with enjoyment experiences [9]. Original coined in 2008, gamification borrowed theories from game design and applied into variety of areas, such as education, online communities and social networks, health and wellness, crowdsourcing, sustainability, orientation, computer science and engineering, research, marketing, computer-supported cooperative work and other applied research areas [10].

A widely acknowledged game design framework is the Elemental Tetrad Model [11]. There are four constructs in the proposed model: Story, Mechanics, Aesthetics, and Technology. The story element provides a platform with a meaningful context to offer players a cognitive system to understand, explore, and consume. The mechanics element regulate the basic rules and structural aspects of the game, such as a gravity effect from real world. Additionally, mechanics defines the success of tasks of each level in the game and rewards to the players. It is a protocol or contract between the game and players to limit players' in-game behaviors, control and enable players' desired achievement. In an open world game with artificial intelligence, the mechanics provide a dynamic, flexible, and open-end environment for players to create unique and customized experiences. The aesthetics element refers to players' feelings of a game from graphical design and human-computer Interface (HCI) perspectives. It interrelates with story element closely offering game players an immersive experience in virtual world. The last element, technology, provides hardware support for the game to guarantee game players enjoying the game without technical issues. It also expand game players' experiences with certain technologies. For instance, the Internet connection will enable multiple players to play the same game at the same time on a server, which gives players social network experiences.

In Schell's framework [11], all four elements have to align with players' engagement. Therefore, game players' characteristics should be considered as a key aspect in a gamification design. Adopting Bartle's [12] two dimensional model with player orientation and player competitiveness, Robson et al. [13] defined four types of players in gamification: strivers, slayers, scholars, and socialites. Strivers are the players with high competitiveness and self-orientation. These players always try to reach the best personal score or gain highest self-performance. Slayers, with high player competitiveness and more social personality, are more interested in comparing with other players in game achievement. Scholars are players with low competitiveness and more self-orientation. Understanding and learning experience is more important for scholars in the game. Lastly, with low player competitiveness and high socialization, socialites prefer to build social relationships in the game.

Gamification is an integration of game elements and gamified activities with no-game context. Deterding et al. [14] identified five levels of game design elements, which should align with gamified no-game context in gamification (see Table 2).

Table 2. Levels of game design elements.

Level	Description	Example
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leaderboard, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	MDA Model: Mechanics, Dynamics and Aesthetics; challenge, fantasy, curiosity; game design atoms; Core elements of the gaming experience
Game design methods	Game design-specific practices and processes	Play-testing, play-centric design, value conscious game design

Kiryakova et al. [15] list key features/elements in gamification: users, challenges/tasks, points, levels, badges, and ranking of users. As a combination and integration of a game and no-game context, gamification is a complex process with multiple challenges. According to multiple case study results, Robson et al. [13] identified five lessons for gamification design:

- Understand players before finalizing the game mechanics;
- Find right time to reward players in the game;
- Expand the game with levels, tasks, or players as needed;
- Gamified experience needs to be monitored;
- Use gamification mechanics to keep track of players' scores.

Additionally, Morschheuser et al. [16] argued that a gamified software has two critical requirements as to smoothly integrating both gamified and no-game context: well-designed functions of no-game context and gapless engagement with gamified elements.

2.3 Gamification in Education

The educational application has seen a rapid ascent of the adoption of gamification in last decade. Cases were implemented to assess the usefulness of gamification in education. Li et al. [17] tested gamification features in a gamified AutoCAD tutorial system and found that 20–76% completion speed increase for four tasks. This tutorial system also increased engagement, enjoyment and performance among novice users. A badge system was developed to increase interaction in online education [18]. Half of the students were motivated when a friend achieve badges. However, in Denny's study [19] in an online course, badges was distributed unevenly across students suggesting that students were motivated by other factors in this online learning. In some other cases, students did not enjoy the gamified design [20] or most of the students did not consider the software being a game [21]. To ensure the quality of gamification design and deal with the complexity on the design of engagement challenges, a design principle was recommended by Morschheuser et al. [16]:

- DP1. Understand the user needs, motivation and behavior, as well as the characteristics of the context
- DP2. Identify project objectives and define them clearly;
- DP 3. Test gamification design ideas as early as possible;
- DP 4. Follow an iterative design process;
- DP 5. Profound knowledge in game-design and human psychology
- DP 6. Assess if gamification is the right choice to achieve the objectives
- DP 7. Stakeholders and organizations must understand and support gamification
- DP 8. Focus on user needs during the ideation phase
- DP 9. Define and use metrics for the evaluation and monitoring of the success, as well as the psychological and behavioral effects of a gamification approach
- DP 10. Control for cheating/gaming-the-system
- DP 11. Manage and monitor to continuously optimize the gamification design
- DP 12. Consider legal and ethical constraints in the design phase
- DP 13. Involve users in the ideation and design phase

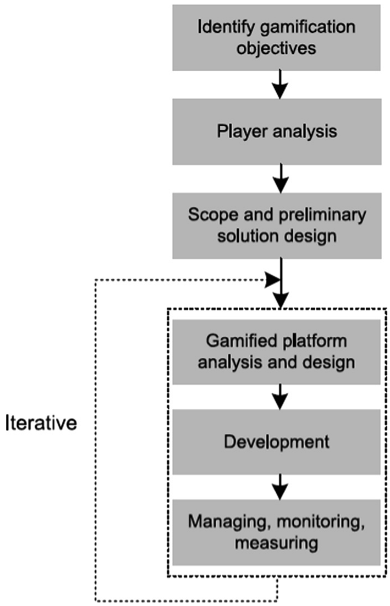

Fig. 1. GOAL framework

Additionally, Garcia et al. [22] proposed a gamification focused on application lifecycle management (GOAL) framework to improve the quality of gamification (Fig. 1). The lifecycle model and the iterative monitoring design achieves a quality solution for gamification.

After testing a proposed model including gamification, learning motivation, cognitive load, learning anxiety, and academic performance (Fig. 2), Su [23] argued that a well-designed gamification learning system would affect student learning motivation

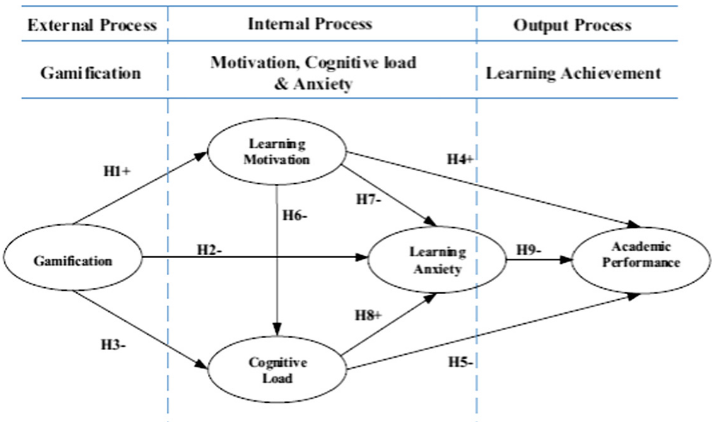

Fig. 2. Gamification research model

and academic performance. Furthermore, Urh et al. [24] demonstrates that with proper integration of gamification in e-learning, some positive achievements, such as higher satisfaction, motivation, and greater engagement of students, can be accomplished. A gamification model was proposed in this study (Fig. 3).

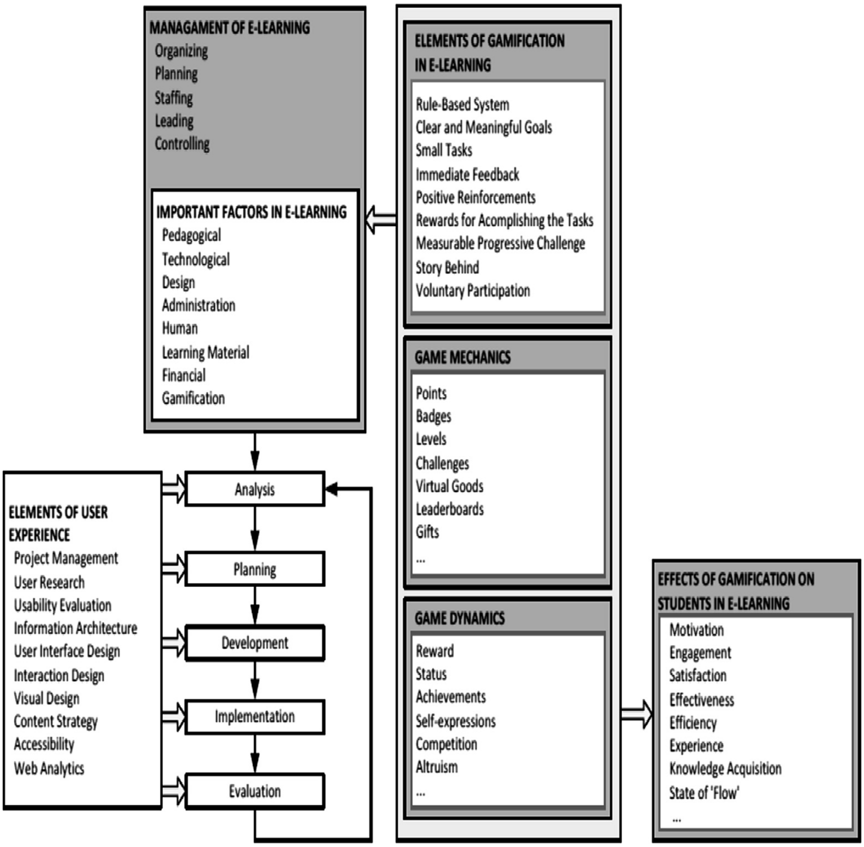

Fig. 3. The model for introduction of gamification into the field of e-learning

3 Proposed Framework

From the literature review, we identified key challenges in mobile application development, such as user needs, programming, multiple platform issues, data handling, interface design, simple registration, testing, and user adoption. We applied these factors in the Elemental Tetrad Model [11], and we expect several learning effectiveness achievements from students in a mobile application development class using gamification, such as learning outcomes, motivation, engagement, and students' learning experiences. We propose this research model (Fig. 3) in our mobile application development education to improve students' learning outcomes. An example would be assigning a team project to develop a small App as a challenge between teams in the class using rewards for the best App created within the time allotted during one class session without any advanced warning of the assignment. It is a great method for team building and providing a fun way to learn (Fig. 4).

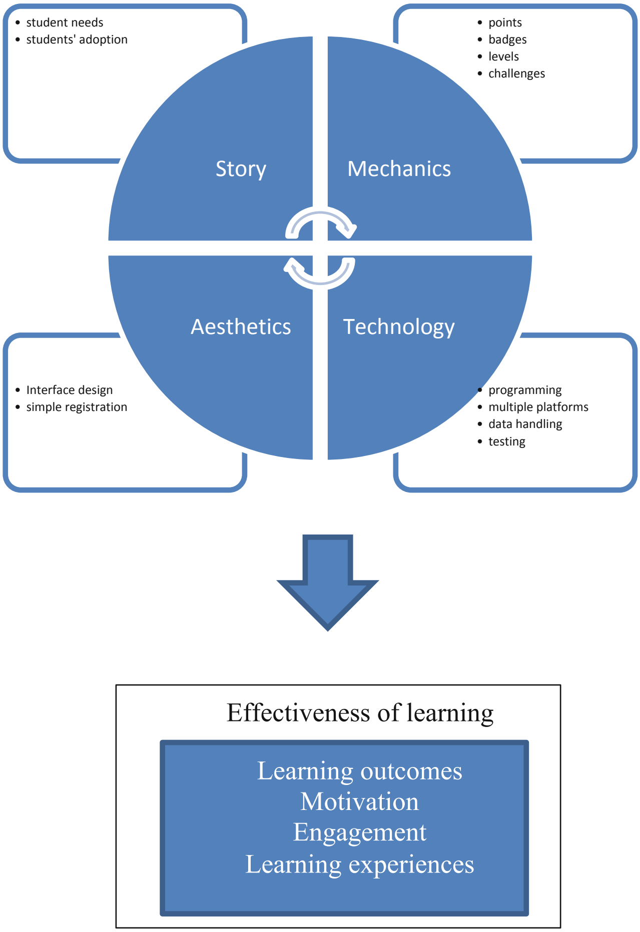

Fig. 4. Proposed research model of gamification application in mobile application education

4 Conclusion

The purpose of this study is to develop a research model regarding the application of gamification affecting students' learning outcomes in a mobile application development class. There are developed studies for gamification research models along with gamification case studies for applications in education, online communities and social networks, health and wellness, crowdsourcing, sustainability, orientation, computer science and engineering, research, marketing, computer-supported cooperative work. However, there is no study focusing on specific Information Systems classes using learning through the gamification process. This paper summarizes the previous gamification studies and proposes a research model to expand the usefulness of gamification in mobile application development education. Future research in this area using the model proposed, offers a unique opportunity to further pedagogical learning in other Information Systems classes not just mobile application development.

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Gamification of In-Flight Entertainment (IFE) to Motivate People to Relax: A Case Design

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Abstract. This study researched the gamification of in-flight entertainment (IFE). Some previous studies have focused on IFE technology implementation and hardware research; however, few studies have focused on the user's experience of IFE. In this thesis, based on the gamification theory, a somatosensory game was designed to encourage users to take the initiative to relax during long-distance flights. To verify the effectiveness of this design, a prototype with hardware (including a seat with integrated proximity sensors, using Arduino Leonardo's development board) and software (an analog IFE system with game, music, and video capabilities, and a designed somatosensory game) was developed. Two groups were tested: the control group with traditional IFE and the experimental group with an IFE which included elements of gamification. Three sets of data were measured: The State-Trait Anxiety Inventory (STAI), user experience questionnaire (UEQ), and physical movement duration time. Through analysis of the results, it can be concluded that the IFE with gamification was more novel and stimulating than the traditional IFE. In addition to motivating users to exercise more, the gamification-based IFE was also more effective at reducing anxiety than the traditional IFE.

Keywords: Gamification · In-flight entertainment · Long-distance flight · Somatosensory game · Body relax

1 Background

At 14:00 on May 5, 2017, China's self-developed jet-type aircraft C919 was successfully tested at Shanghai Pudong International Airport. This is an important milestone in the history of the development of China's civil aviation industry. China has become the third country in the world able to build large aircraft after Boeing and Air France. Economic development and cultural exchanges have allowed more and more people to travel by air between different cities and countries. Determining how to improve comfort in long-haul aviation is a major problem of most airlines.

A 2014 survey report from a travel website, TripAdvisor.com, showed [1] that the top flyer complaint about air travel was "Uncomfortable seats/limited legroom" (73%). When travelers were asked which amenities would most improve their in-flight experience, "more legroom" (35%) and "more comfortable seats" (32%) were their top answers.

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Although many designers have proposed concepts regarding more comfortable and more humane aircraft seats, most airlines still pursue maximizing commercial interests. In addition, most economy seats on aircrafts are still designed to be very narrow, remaining just within the scope permitted by international aviation regulations. What's more, single flight times are as long as possible, and passengers' activities are greatly affected. Some studies have shown that long-term flights can lead to a series of physical and psychological problems, such as deep vein thrombosis (DVT) [2, 3], limb numbness, edema, neck stiffness, mood anxiety and other ailments [4]. Many airlines provide paper instructions or videos for cabin relaxation exercises to remind passengers to relax their neck or other parts of the body, but Hao Liu et al. [5] showed that passengers are rarely willing to take the initiative to relax.

2 Current Research Status

2.1 In-Flight Entertainment (IFE) Research

In-flight entertainment (IFE) refers to the entertainment equipment provided to passengers in the passenger cabin during the flight. Passengers can listen to music, watch movies and TV shows, play games and engage in other entertainment activities. In the IFE field, there has been several in-depth researches (see Table 1).

Table 1. Current IFE research.

Year	Author	Title	Main research content
1999	Alamdari et al. [6]	"Airline in-flight entertainment: the passengers' perspective"	The paper points out that while IFE is not among the primary factors affecting passengers' choice of airline, it contributes greatly to passengers' satisfaction with airline services
2005	Sanfrod et al. [7]	"Aircraft passenger seat and in-flight entertainment integrated electronics"	Mainly from a technical perspective, the sensor is integrated into the IFE, and the power conversion and signal management system can be integrated into the seat
2006	Brady et al. [8]	"In-flight entertainment system with hand-out passenger terminals"	The study demonstrated an IFE system that allows passengers to access a digital network through a terminal
2007	Hao Liu et al. [5]	"In-flight entertainment system: state of the art and research directions"	This paper researches the latest IFE technology and development trends
2011	Westelaken et al. [9]	"Embedding gesture recognition into airplane seats for in-flight entertainment"	This is a study of IFE that can control games by integrating the pressure sensor on the seat and recognizing the gestures of the passengers' legs

(*continued*)

Table 1. (*continued*)

Year	Author	Title	Main research content
2013	Quintana et al. [10]	"Reading lamp-based visible light communication system for in-flight entertainment"	This paper explores the use of a reading lamp as an access point for a visible light communications (VLC) downlink channel. The presented system can be rapidly implemented and provides personalized in-flight entertainment and services by wireless media
2015	Boyer Jr, W. J. [11]	"In-flight entertainment system"	This is a study of an IFE system that integrates a touch screen display device with a tray table (e.g., an airplane tray table or a train tray table) to provide a superior media experience
2016	JA Frisco et al. [12]	"Aircraft in-flight entertainment system with enhanced seatback tray passenger control units and associated methods"	This is a study of an IFE system that includes an entertainment source, passenger seatback displays coupled to the entertainment source and passenger control units (PCUs)
2018	Kostopoulos et al. [13]	"Use Cases for 5G Networks Using Small Cells"	This research focused on the main use cases and scenarios in the context of 5G ESSENCE project, which considers in-flight communications and entertainment system

On the whole, the current research on IFE focused largely on the technical principles. There are few studies about IFE on specific content, user experience or other design fields. Westelaken et al. [14] designed a system that can control games by recognizing the gestures of the passengers' legs. However, the focus of Westelaken's research was on the implementation process of the technical solution instead of game designing; So this research is aimed at game designing and user experience of IFE.

2.2 Gamification

The term "gamification" is derived from the digital media industry. The first recorded use of the term can be traced back to 2008. The currently accepted definition of gamification is the use of game elements in nongaming scenarios [15]. In the gamification model proposed by Deterding (Fig. 1), gamification needs to satisfy two conditions: it must contain both *gaming* and *parting*. That means gamification uses parts of games to address nongame challenges.

To realize the game aspects of nongaming areas, we need to understand video games clearly. A successful video game is one whose game mechanics will determine

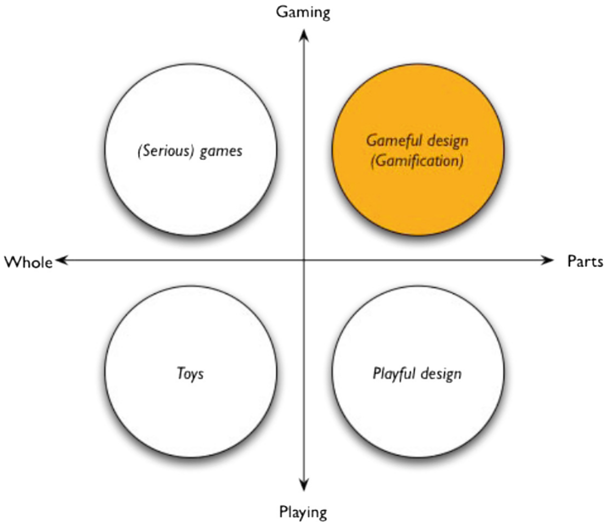

Fig. 1. Gamification model chart proposed by Deterding

how players interact in their game environment, how players move forward in the game and how players get rewards for certain actions, decisions or achievements. K. Werbach's study mentioned the use of points, badges and leaderboards (PBL) [16]. Points come in many forms, such as scores or reward points. Badges are awarded when players achieve certain scores or ranks. Leaderboards show the players' rankings and provide competitive motivation.

The following ten game mechanics are the most common in the research of Jesse Schell's [17] and other scholars. These mechanics are challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns, and win states.

Gamification applications have proven to be effective in many areas. Berkovsky et al. [18] designed a game that players could gain virtual game rewards in return for real physical activity performed. In the healthcare field, gamification has shown to be effective in motivating adults or children toward personal health and wellness [19, 20]. Gamification can be used as an incentive to help users treat or improve their anxiety symptoms [21]. Andreas Mühlberger, Rothbaum, B.O. et al. [22, 23] used VR exposure therapy to treat the fear of flying and significantly reduced the users' fear.

3 Methods

3.1 IFE Design

So how do we encourage users to take the initiative to relax through IFE?

By simple brainstorming and a literature survey, the answer came through three main design ideas:

1. *Use virtual reality (VR) to ease passengers' anxiety and fatigue with small games and music.*
2. *Incorporate different stages of the flight process, such as take-off and landing and flight into gamification, and allow the passengers to use their bodies to control the game.* Users will receive corresponding rewards (postcards with badges) for gaining different points, and the players can compete with other passengers on the aircraft to get higher VIP points of the airline.
3. *Use augmented reality (AR) technology to set the cabin environment and equipment as an AR triggers.* The passenger's electronic equipment can be used to interact with the equipment in the cabin as an interactive game with strong playability.

Combining the current economy-class layout and existing technology of the aircraft, the first solution requires a complete set of VR helmet equipment and positioning sensors, which is not very suitable in a small aircraft cabin. The AR interaction in the third solution requires passengers to move around, but the space on the plane is limited for activities. Therefore, this study adopted the second solution, which integrates the sensors on the aircraft seat to be used as a signal input to control the role in the game. When users move their heads or bodies to cover the sensor at the corresponding position, they will trigger the character in the game to move around. Users will obtain corresponding rewards at different levels and points.

Research framework (Fig. 2) includes four parts: the first part is analysis of the aviation problem and demand; the second part is program design, including the hardware plan and the software plan; the third part is testing and evaluation, mainly through the control experiment and checking the validity of the design with a subjective scale; and the last part includes the results and discussion.

Game prototype (Fig. 3) is mainly composed of a hardware control part and a software part. The hardware includes a seat with integrated proximity sensors (E18-D80NK), which converts the body's physical signals into digital signals. Arduino Leonardo's development board converts digital signals into keyboard button signals. The software section includes an analog IFE system with game, music and video capabilities, and a designed somatosensory game.

Game user interface (Fig. 4) mainly simulates an in-flight state. The user controls the aircraft to avoid random enemy aircraft. Shooting down different enemy aircraft allows players to earn different score rewards. There are five levels of the game, and each level of difficulty increases incrementally.

In order to encourage users to spend more time on the game (to increase the body's activity time), a leaderboard mechanism was designed in the game. All users in the

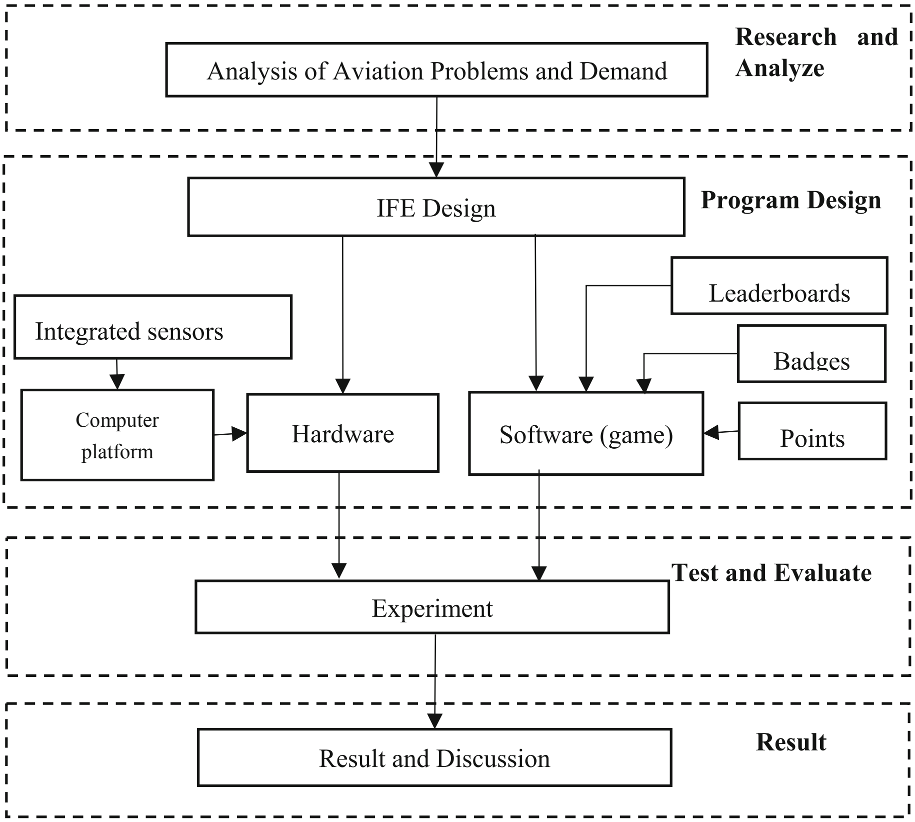

Fig. 2. Research framework

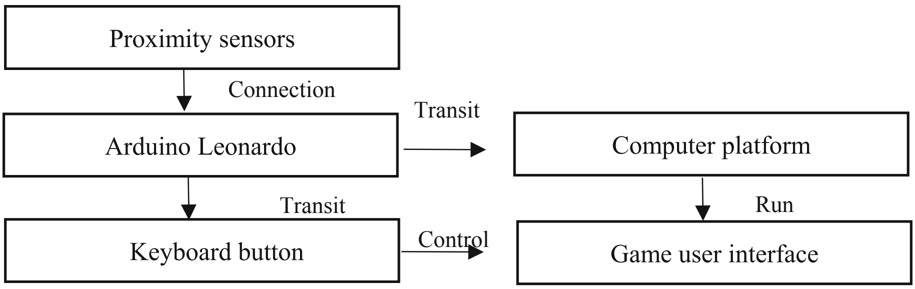

Fig. 3. Game prototype

same flight would appear on the leaderboard. At the end of the voyage, the top ten users could convert their score into airline VIP points which can be redeemed for some types of merchandise. In addition, a levels and badges system were designed in the game. Users could unlock different medals at different levels. A few days after the flight, the

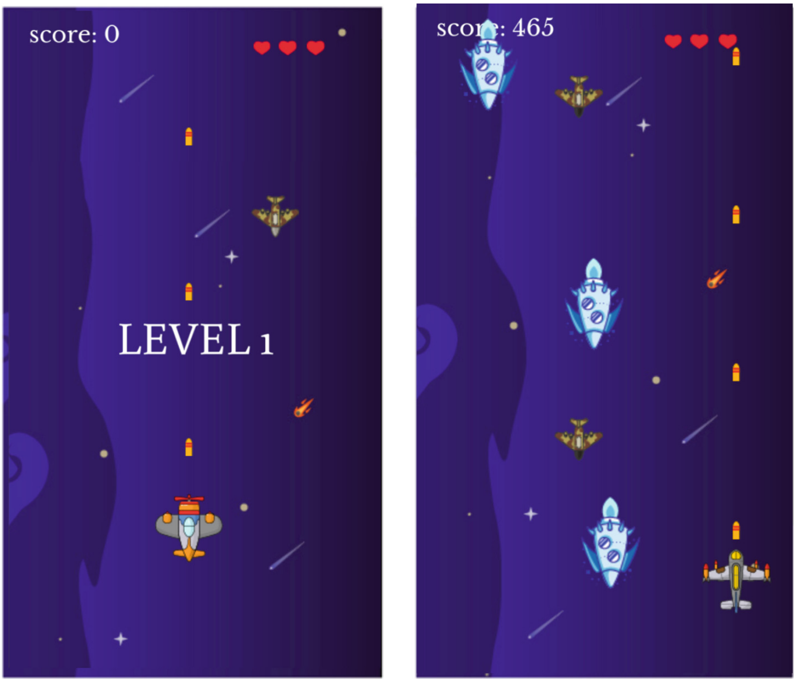

Fig. 4. Game user interface

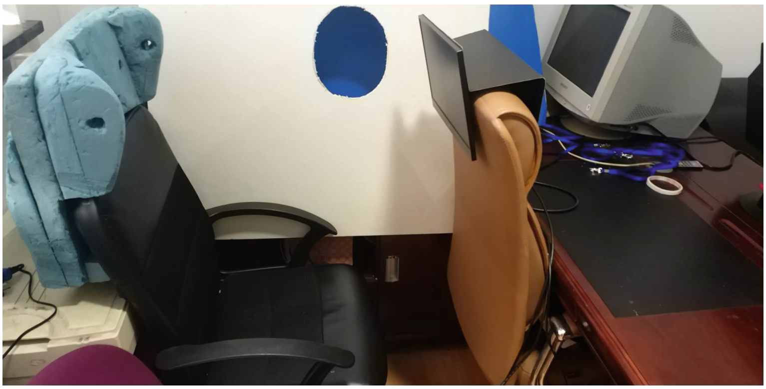

Fig. 5. A narrow simulation space of an economy-class seat

users would receive a commemorative postcard of the medal. The game was mainly developed on the Gamesalad platform. It was projected onto an 11-inch touch screen through a personal computer. Users could start the game by touching the screen, just like the normal IFE on the plane.

3.2 Experiment

In order to verify whether gamification can encourage users to take the initiative to relax, a narrow simulation space was built according to the economy-class space. The seat was equipped with a touch screen simulation IFE system behind the seat (Fig. 5). Researchers randomly divided 20 users into two groups. The experiment lasted for one hour.

Control Group (CG). The users in the control group could only use an ordinary IFE system. When the experiment was carried out for 45 min, the observer played a video that encouraged users to exercise. The users could ignore the video if they did not want to follow it.

Experimental Group (EG). The users in the experimental group could use an IFE system with a somatosensory game (compared to the ordinary IFE system). When the experiment was carried out for 45 min, the observer suggested the users to play a somatosensory game to play the somatosensory game. The observer explained the rules of the game. During the experiment, the observer recorded the users' movements on the seat through video and then analyzed the data through a behavioral analyzer after the experiment.

3.3 Measures

A total of 20 samples were tested in the experiment, with eight participants in the control group and four in the experimental group. The research mainly measured three aspects: exercise time, anxiety and user experience.

Behavior Analysis. By observing the users' movement during the experiment, the observer recorded the duration of each movement. The movements included moving arms (slightly raised hands were not recorded), moving legs, turning the head and turning the body a large degree.

State-Trait Anxiety Inventory (STAI). The State-Trait Anxiety Inventory (STAI) is a self-report survey containing two independent 20-item scales that measure state anxiety (A-State) and trait anxiety (A-Trait). It was developed by Spielberger et al. [24, 25]. In order to measure changes in anxiety values between EG and CG during the flight, participants were required to complete two questionnaires, one before the test (pre-STAI) and the other after the test (post-STAI). The higher the score, the greater the level of anxiety. The difference between the pre-STAI and post-STAI (d-STAI = post-STAI − pre-STAI) was measured.

User Experience Questionnaire (UEQ). The user experience questionnaire (UEQ) [26] covers a comprehensive impression of user experience. The 26-item questionnaire includes six factors: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty. In this study, participants were asked to finish the questionnaire on the overall IFE after the experiment.

4 Results

4.1 Behavior Analysis

In order to facilitate statistics, the average exercise time of each user in the corresponding time period was calculated every 5 min, as shown in the (Fig. 6) line chart.

As the line graph shows, the EG and the CG were basically the same in the period of 0–45 min, but at the 45-min mark of the experiment, there was a significant difference between the two groups: the exercise time of the control group (watching the

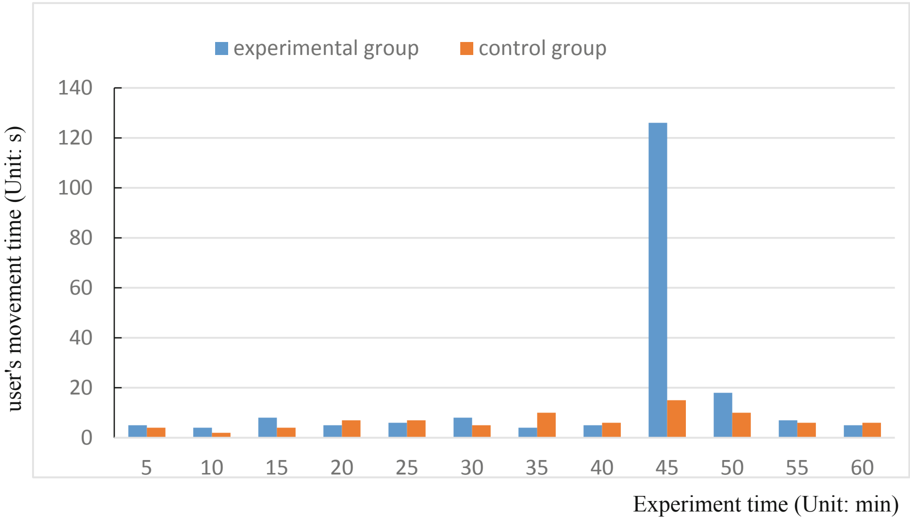

Fig. 6. Average exercise time of the user (every 5 min)

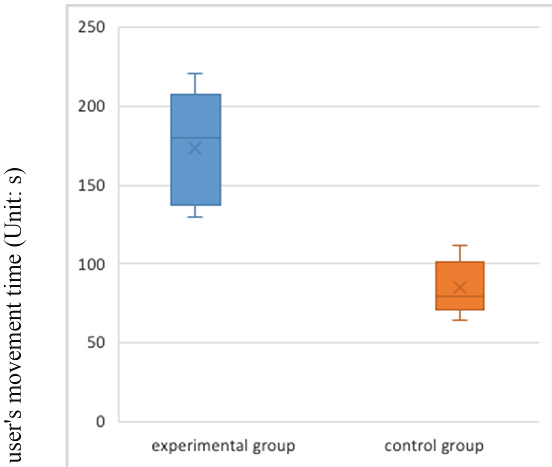

Fig. 7. A box plot of the cumulative time

video) was significantly lower than the experimental group (playing the game). Through the box plot (Fig. 7), the cumulative exercise time of the two user groups was significantly different after the t-test ($P = 0.001 < 0.05$).

Based on the above data, a preliminary conclusion can be drawn: the relaxation game was more motivating to the users than the traditional video.

4.2 State-Trait Anxiety Inventory (STAI)

Independent sample t-tests and paired sample t-tests were carried out in order to assess possible differences in state anxiety between EG and CG.

There are four sets of state anxiety inventory (S-AI) data: in the control group, they were before the test *(Mean = 34.6; SD = 4.8)* and after the test *(Mean = 38.8; SD = 5.3)*; In the experimental group they were before the test *(Mean = 39; SD = 8.1)* and after the test *(Mean = 30.2; SD = 6.7)*. Paired sample t-test data indicated that the STAI scores after testing had no significant difference between the EG and CG. However, there was significant difference *($p = 0.024 < 0.05$)* after running independent sample t-tests of d-STAI (post-STAI – pre-STAI) between the two sets of data (Fig. 8).

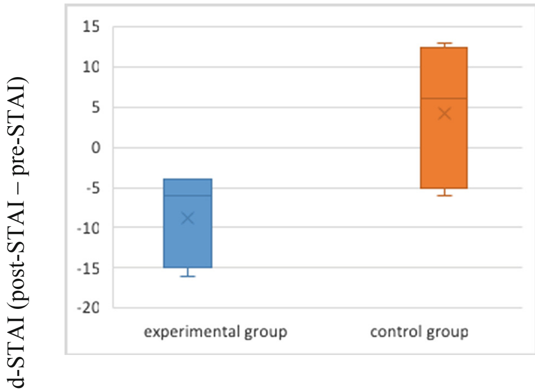

Fig. 8. Box plot of the difference between postSTAI and preSTAI

The data suggested that both traditional IFE and somatosensory games couldn't significantly reduce the anxiety caused by long flight, but compared with traditional IFE and video, somatosensory game was more effective in reducing anxiety.

4.3 User Experience Questionnaire (UEQ)

The average value of the two groups of users in the user experience questionnaire (UEQ) was compared by a t-test *($p = 0.001 < 0.05$)*. The results were significantly different. Novelty and stimulation had obvious advantages among the six factors, which indicated that the users' experience of interactive games was better than their experience of traditional IFE and video, especially in novelty and stimulation (Fig. 9).

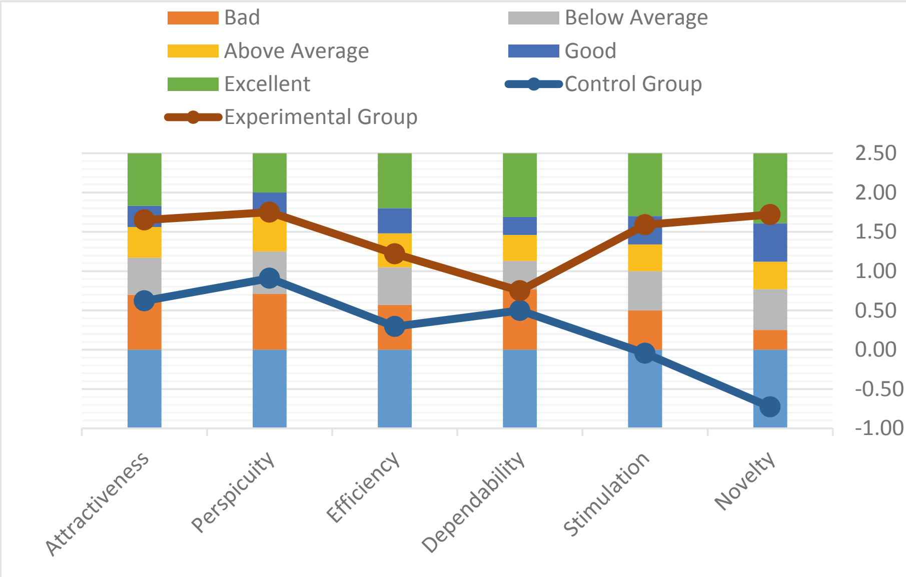

Fig. 9. Results of user experience questionnaire

5 Discussion and Conclusion

In order to reduce discomfort and anxiety caused by limited economy seat space during long-term flights, this study aimed to use gamification to explore more interesting and user-friendly relaxation methods to enhance passengers' long-distance flight experiences.

To determine whether gamification can really motivate users to relax, this study explored the following aspects: firstly, a points, badges, and leaderboards (PBL) mechanism was applied to IFE; different levels and rewards were designed, and a leaderboard mechanism was created to encourage competition between the airline passengers to win points (which could be redeemed for airline rewards). Secondly, to encourage the users to relax, head rotation and leg movement were used as the core control actions, which were recognized by the sensor and allowed users to control the game with their body. Thirdly, through the control experiment, the validity of the design was verified through physical exercise time, the State-Trait Anxiety Scale, and the user experience questionnaire. The preliminary experiments showed that the gamification-based IFE, compared with traditional IFE, was more novel and stimulating, and can motivate people to exercise more. In addition, it is more effective than traditional IFE in reducing users' anxiety and improving their flight experience.

Of course, there were many shortcomings in this study. For example, the hardware sensors in the experiment were not very sensitive, which caused the users to experience a certain delay in the game, which may have reduced the "Dependability" score in the user experience questionnaire.

At the same time, since the sensors need to be integrated into the flight seat, whether the game can be applied to existing aircraft remains to be further studied. Image recognition based on 3D cameras may be a better solution.

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"*Who's Texting?*" – Playful Game Experiences for Learning to Cope with Online Risks

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Abstract. This paper describes the development and evaluation of the innovative computer game *Hidden in the Park*, for 8–10 year old children. It is a mixed media game that includes classic game elements and Augmented Reality technology. It is a non-profit game designed for a playful game experience. But, it is also a serious game intended to raise young childrens' risk awareness in online interactions, to decrease the risk of becoming the subject of online sexual grooming. The game is intended to evoke thoughts and reflections related to players' decisions and their consequences. Furthermore, the game is based on research on true online grooming processes, which provides the basis for some central game mechanics. Game evaluations were carried out with 70 children in school settings. The results show that the participants perceived the game as fun and engaging, but that it also raised questions and reactions, as intended. *Hidden in the Park* will be released during 2019 and it will be available for free download.

Keywords: Computer game · Child-computer interaction · Game evaluation · Online risk awareness · Online sexual grooming

1 Introduction

This paper describes the development of the innovative computer game *Hidden in the Park*. The game is designed for a fun and engaging game experience, but it is also a serious game aimed to increase young childrens' (8–10 yrs.) risk awareness in online interactions, in order to decrease the risk of becoming the subject of online sexual grooming. The game is an adventure game, where each player hides a treasure in a park, and in return gets a set of clues to the hiding place. The players need to mind the clues so that other players cannot find the treasure. But, there are also game events where players need to make decisions, and then experience the outcome of those decisions.

It is quite common that young people are contacted online by people that they do not know, and it can be challenging to know how much personal information to share. Some of these unknown people engage in sexual grooming. Online sexual grooming is a process where adults contact children, to recruit and maintain a child's compliance for sexual purposes (Martellozzo 2012). This is a problem that has far reaching consequences, for the targeted children, their families, and in a wider perspective, the society.

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We have addressed the issue of childrens' online risk awareness by creating a non-profit game that allows children a concrete first-hand experience of deciding whether or not to reveal information, and the potential outcomes of those decision, but under safe conditions. The game mechanics underlying this process is based on our analysis of true online chat logs, derived from dialogues between children and later-convicted perpetrators in closed forums. Some of the perpetrator strategies were then transformed into game events. The game contains messages, similar to online chats or text messages, where players can choose whether or not to reveal a clue, bearing in mind that revealing a clue may or may not be a good idea in the long run. The game is designed for a fun, engaging, and playful user experience, but it is also a serious game intended to evoke thoughts and reflections that can be discussed after a play session.

The game is played by two to four players, and it comprises a classic board game, a tablet with Augmented Reality (AR)-technology, game pieces, and clue cards. The game is intended to be played in school settings, with a follow-up conversation about game events lead by teachers, so the game also includes pedagogical guiding material for teachers. The game development process was iterative, including game evaluations at four different stages, with a total of 70 children as participants, divided into 15 groups of players. The evaluations were carried out in elementary school settings, with gameplay observations followed by thematic group interviews to gather information of the participants' opinions of the game. The results from each phase of evaluations were fed back to the game developers to adapt the game in the best possible way to suit the target group, while still fulfilling the game's underlying intention of raised risk awareness.

In this paper we focus on the game development, its underlying research, and game evaluation. In the following sections, we first describe the research on grooming processes to provide some background and context to the addressed problem, and an explanation to some of the game mechanics. The next sections describes the game development process, followed by game evaluations involving the target group. The paper ends with a discussion.

2 Offender Behaviours as a Basis for Game Mechanics

The game mechanics are based on linguistic and thematic analyses of online offender behaviours. Attempts at such analyses have been made previously, but due to difficulties in obtaining true chat logs the analyses have been based on 'artificial' dialogues where adults pose as children in online forums. This may be researchers studying online sexual grooming (Bergen et al. 2013; O'Connell 2004) or police personnel trying to catch perpetrators (Mitchell et al. 2005). The most common data sets used are publically available chat logs from the Perverted Justice Foundation Incorporated (PJF) (http://www.perverted-justice.com.), where adults try to entrap possible predators by luring them into prosecutable behaviour (e.g., Aitken et al. 2018; Black et al. 2015; Williams et al. 2013). The PJ foundation has a training program for volunteers to serve as decoys during online interactions on different chatrooms. These decoys have been "*trained exclusively on how to make solid, easily prosecutable cases that are guaranteed to put internet predators in jail*" (http://www.perverted-justice.com/).

An often cited conclusion from previous research is that the grooming process escalates in sequential steps, or stages, as described by O'Connell (2004) who herself posed as a 12-year old child in online chatrooms. Other studies (e.g., Black et al. 2015; Williams et al. 2013) draw similar conclusions based on material from the PJF website, but with some differences concerning stages or themes, and their timing. Conclusions drawn from earlier research are problematic at best, as they draw mainly on research material from sources that are not representative for grooming processes involving children (cf. Aitken et al. 2018). Dialogues where adult decoys pose as children simply do not represent the true nature of grooming processes. What actually goes on is another type of dialogue where two adults use grooming techniques on each other, but for very different reasons. Leaving any moral or ethical discussions aside, descriptions of grooming processes based on research with adults posing as children, are not comparable to dialogues between actual children and potential perpetrators, when comparing strategies and dialogue structures.

We analysed PJF-material, but foremost true chat logs from a closed online forum, with children and later convicted offenders. The chat logs were obtained through cooperation with the Swedish police, courts of law, and the operators of a social networking site (SNS) in Sweden. The chat logs were anonymised by the SNS operators before delivery for ethical reasons, and therefore no consent from forum users was needed. The only information provided on forum users was stated gender and age. Our data set comprised ca. 500 A4-pages with dialogues selected from a corpus of ca. 12,000 pages. The material was thematically analysed and categorised using NVivo 10 software. The coding was done by both authors for inter-rater reliability. Where coding differed, the authors explored the categorisation until agreement was reached (cf., Whittle et al. 2013). We also analysed *decoy*-offender chat logs (ca. 100 pages, publically available on the PJF website), in the same way.

A comparison of decoy material and true offender-child/victim chat logs, reveals some similarities with previous research, but also substantial differences. The true chat logs reveal that the grooming process is far more complex than what is apparent in PJF-material; offender modus operandi differ, both in intra- and inter-offender comparisons. One and the same offender uses different techniques towards different young people, and a comparison between different offenders reveals several idiosyncrasies in their overall approaches to potential victims. Themes found in offender behaviours are also usually highly integrated, and not very sequential.

Another major difference lies in decoys' and childrens' responses. In the PJF-material, the "child" does not respond or act as an actual child, for several reasons. The decoy is an adult, and adults do not respond to requests of a sexual nature the same way as children do, regardless of previous training. Children do not (normally) agree to most things suggested by a possible perpetrator, while the decoys 'agree' to most any proposal, or even share personal information without being asked. Furthermore, the decoy has an agenda to coax another adult into performing an act that is prosecutable.

Both data sets include a number of recurring themes and strategies, also found in previous research, such as flattery, bribes, coercion, and secrecy. However, a crucial pattern or behaviour missing in previous research is *threats*. In true grooming processes, threats is one of the most common techniques used by perpetrators in order to get children to comply (which was also confirmed by the National Swedish police, the child sexual abuse unit). Adult decoys do not receive threats, seemingly because they are not needed since they ‘comply’ with offender requests. This is one of the facts that illustrates the difference in adult decoys’ agendas, and childrens’ behaviour.

Based on findings in the chat-log analysis, some of the most common offender strategies were converted into game mechanics to be incorporated in the game. The strategies are represented in the form of chat-like, or SMS messages, with flattery, coercion, bribes, and threats, but in a non-sexual and non-violent format.

3 The Game Development Process

The game was developed in two successive projects. The first project included basic research, game design, production of a hi-fi prototype with full functionality, and game evaluations involving the target group. The second project included development of the game prototype into a finalised and deliverable product, guiding material for teachers, and game evaluations with the target group.

3.1 Project 1: Foundations for the Game Design

The game’s design and purpose rests on four major elements, where one of them precedes the others (Fig. 1). The basic research on grooming processes and other related issues lead to the identification of a suitable target group, game mechanics that would metaphorically represent online contacts, and how to design the game to cater for fun, engagement, interactivity and tangibility.

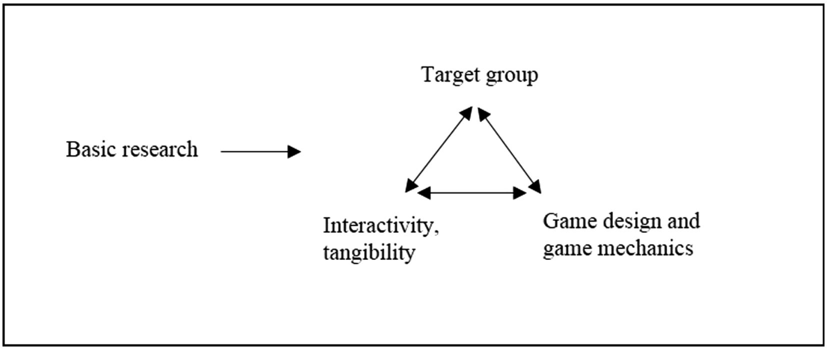

Fig. 1. The figure shows four major elements that formed the basis of the final game.

Based on our research we concluded that a suitable target group would be children aged 8–10 years. This group was chosen for two main reasons. Firstly, from the age of eight years, there is a dramatic increase in the number of Swedish children who use the internet, social media, and also send pictures and text messages (The Swedish Media Council 2017), presumably because they have gained enough reading and writing skills. Secondly, while children contacted for sexual purposes, in general are twelve years or older, the age of targeted children is decreasing. Measures for raised risk awareness are therefore needed from early ages, or at least before the age of twelve.

In relation to the chosen age group, we also needed to consider young children's cognitive development and reasoning capabilities. According to Piaget (1972; see also Wadsworth 2004), young children's reasoning and logic tends to be tied to available experience, and most children have difficulties in applying logic to abstract or hypothetical problems, or to reason about the future and possible consequences of their actions. However, it has also been emphasized for a long time that childrens' thinking skills do not develop in isolation, but instead are tied to physical actions and the environment, and that physical and social interactions are important for cognitive development and for learning to understand abstract ideas (e.g., Antle 2009, 2013; Gee 2003; Piaget 1972). Considering the importance of physical and social interaction, we wanted the game to be a multi-player game with a high degree of interactivity, and to include tangible objects. Tangible objects would provide physicality and a means to bridge the cognitive maturity of younger children, and the reasoning capabilities that develop at a later age. As such, the game would allow children to gain concrete first-hand experiences of an abstract problem, that is, choices and their potential negative outcomes in online contacts. As such, the game could contribute to increased risk awareness, but it also had to be a fun and engaging serious game (Susi et al. 2007).

As for the game design it was decided early on what basic components should be included in the game. It would consist of a game board with pieces to move, and a tablet with Augmented Reality (AR)-technology to enhance the play experience and to give the game a unique twist. Another central idea was to include offender strategies (discussed above) in the form of 'text messages' from an unknown character, as a metaphor for true online contacts. However, there could not be any frightening or sexual content so the offender strategies had to be adapted to the game context.

3.2 The Game Prototype

The final game concept and gameplay became a mixed media turn-based board game. The game comprises a classic game board, a tablet with Augmented Reality (AR)-technology, game pieces, clue cards, and it had a zoo theme (later changed to a park, see below). The tablet further contains mini-games and other game events, and it includes some voice acting. The AR-technology is used to display a 3D-version of the physical game board, in which each player hides a treasure (by touching the screen) and in return gets some clue cards to the hiding place. The players need to mind the clues to the hiding place so that other players cannot find the treasure. The tablet is also used for rolling a dice and to show the current position of all the game pieces, in parallel to the physical game board to help players keep track of the correct positions. Furthermore, simulated SMS messages appear in the tablet, sent to the players by an unknown character. This allows players to make choices whether or not to reveal information. The unknown character wants the players to take photos (with the tablet's camera) of their clue cards and send them in return. The character uses flattery, bribes, and coercion to 'lure' the players to take photos. If a player has taken a photo and sent it, the character can then later threaten to reveal the photo/clue card unless the player takes more photos. The game is designed for two to four players.

The prototype was developed in-house, and when it reached the stage of being playable, a group of eight children was involved for evaluation of the early game design on a few occasions. While the children played the game, two researchers were observers and one researcher provided technical support in case of problems. It proved valuable to involve the children, for several reasons. The aesthetics of the game needed to match young childrens' media world, and the language used in voice instructions (speech synthesis) and in-game dialogues needed to be adapted to the childrens' linguistic level. Features in the game were spontaneously commented upon by the children, and it was clear that our own grown-up ideas of fun did not always match the childrens' opinions. After all adaptations and changes the game was perceived as very fun and it was engaging. The children wanted to play several times and they liked the game concept of hiding a treasure and try to find someone else's treasure. Based on the early evaluations it was clear that further involvement of the target group was essential, and should be continued in the next project. The hi-fi prototype was also tested on the project's reference group, consisting of practitioners within the field of childrens' rights law, the National Swedish Police (the child sexual abuse unit), the Swedish Media Council, and the Change Attitude foundation (www.changeattitude.org) which was a co-operating partner in the project. The prototype received very positive critique, and comments like "this is a tool that's really needed". At the end of the first project, we had a fully functional and playable hi-fi prototype with all necessary game mechanics and AR-technology, even though it was somewhat unpolished in graphics and sound (Fig. 2). It should be noted that the game is not considered as a one-shot solution to prevent online sexual grooming. There are, for instance, a lot of written online safety instructions, which are valuable, but we believe the game to be a good pedagogical complement to already existing tools.

Fig. 2. The final prototype, with the tablet in AR-mode, showing an animated 3D-view of the two dimensional game board. (©Niklas Torstensson)

3.3 Project 2: Game Development

The second project was focused on developing the hi-fi game prototype into a finalised distributable product, and creating guiding material for teachers, and also game evaluation. The game production required co-operation with a professional game development company. We chose IUS Innovation, a Swedish game development company with a focus on pedagogical games for children. The prototype was handed over to IUS Innovation for further development, with some requirements; the final product had to include a game board and a tablet with AR-technology, and the game mechanics (content and structure in text messages) had to be preserved to fulfil the game's underlying purpose, while technological solutions would be their responsibility. It was also agreed that they were free to chose the graphical design and voice acting, but results from game evaluations with the target group would have to be considered.

An important consideration was the zoo-theme, and whether it would provoke negative opinions since there might be people who object to keeping animals in zoos. To avoid controversies, it was decided to change the theme to a park. By the time the game was ready for an initial evaluation, the graphics had been replaced with a more colourful expression and more animations. The speech synthesis had been replaced with voice acting and there were new mini-games. The in-game instructional texts for mini-games and other events had also been replaced. The simplistic avatars that represented players' movement after rolling the dice were replaced with animated animal avatars (Fig. 3). The game was further optimised for battery time and adapted to run on Android tablets (Android 5.1 and newer versions) and Apple iPads (iOS 9.0 and newer versions).

Fig. 3. The game board and one set of clue cards lie on the table, and the tablet shows the first image that appears on the screen when Hidden in the Park ("Parkgömmet" in Swedish) is started. (©Niklas Torstensson)

The whole process of pre-production, Alpha and Beta versions of the game, and game evaluations lasted four months. The development of the accompanying teacher material was the responsibility of our project partner, the Change Attitude Foundation. This work started when the game had been evaluated to the point that no more major changes were needed, and the material was finalised within a few months. The game will be launched during 2019 and will be available for free on Appstore and GooglePlay, including the app, game board, and clue cards. The game development during the Beta phase was iterative with game evaluations of four successive versions of the game, which is described in the next section.

4 Game Evaluation

There are many different ways to evaluate games and other technological products, but when involving children as participants there are many challenges. A lot of work has been focused on finding suitable methodologies for design and evaluation with and for children (Read and Markopoulus 2013). There are studies with evaluations of methods specifically tailored for children as participants, and studies where children participate as users of existing methods (e.g., van Kesteren et al. 2003; Khanum and Trivedi 2012; Salian et al. 2013; Sim and Horton 2012). The results show that while some part of one or the other method works well, there are also problems such as childrens' limited attention span, verbalisation, and understanding of surveys and ratings, etc.

For our game evaluations we chose to use the all familiar techniques of observation and interview, rather than to wrestle with problems in some existing method involving children as participants. The focus of the observations was whether the game mechanics would work as intended, childrens' comprehension of the game and how to play, and above all, whether the game would evoke reflections and thoughts regarding game events ensuing from the text messages. Each game session would be followed by a thematic semi-structured group interview with the players to gain information on their perceptions and opinions about the game. The interviews had to be kept rather short so the children would not become restless or bored. At the same time, we assumed that group interviews with children who know each other would work well. The game would be fresh in mind, and knowing each other, the children could discuss freely and also trigger each others' memories. The interview included a few themes:

- How did you find the game? Did you find anything especially good or fun?
- Was there something you didn't like? Is there anything that needs to be changed?
- What do you think about the graphics/the animals/the different sounds in the game?
- What do you think about the voice in the game?
- What do you think about the phone messages?
- Who do you think sends the messages?
- Is there anything else you want to add?

Depending on the childrens' answers the discussions covered many different topics, but the interviewer led the discussion to cover the above topics. There were also a number of follow-up questions to gain more details, like 'can you tell me *what* it is that's fun/boring?'.

The evaluations were carried out at three different elementary schools. Although the target group is 8–10 year old children, we included grades 2–6 (8–12 yrs.) to see if the game would actually best suit 8–10 year old children. As seen in Table 1, three boys were seven years old, but they were second graders. In sum, 70 children participated and consent forms were collected from caregivers and teachers.

Table 1. A summary of the number of participants, and their ages.

Participants		
Age	Boy	Girl
7	3	
8	3	2
9	6	4
10	4	6
11	13	11
12	9	9
Sum	**38**	**32**

Teachers decided which children would play together, usually in groups of three or four children, but on two occasions children played in teams of two (2 × 4 players). In sum, there were 15 groups of players. The teachers had been informed that they could be present during the gameplay and the interview. For each play session, one researcher acted as an instructor and interviewer, and two researchers were observers. Each play session was followed by a focus group interview with some thematic questions concerning the players' perception and liking of the game. The play sessions were audio recorded and notes were taken. The gameplay lasted 20–40 min, and the interviews lasted 15–20 min.

The collected data was summarised into items that worked well and items that needed attention. For items that needed to be changed the researchers provided detailed information on why something did not work and how it should be changed. After each round of evaluations, the results were fed back to the development team at IUS Innovation. Each round of feedback and subsequent changes to the game, lead to further evaluations. Finally, when no new or crucial information was found, no further evaluations were carried out. In sum, four successive versions of the game were evaluated and the results are described in the next section.

5 Results

On an overall level the game was perceived as very fun, entertaining, and as something new the children had not seen before (the combination of AR-technology and the board game). The most common comments were that it was "*Cool!*", "*A fun game!*", "*The mini-games are fun!*", and "*Where can I by it?*" (all citations are translated from Swedish). It was clear from the observations that the game also was engaging and most players were really active, with lots of discussions about what a player should or should not do. The children were very good at keeping track of each others' positions on the game board and the advancement of game pieces, which in itself became a competition within the overall gameplay. Likewise, they were very good at keeping track of each player's number of coins. In reality, neither positions on the game board or the number of coins are essential for the game's outcome, but they contribute with a competitive element that seems to be quite important from the players' perspective.

Despite the positives, our first observations showed that the game had been too elaborated; the graphics were too complex and there were too much written instructions, for instance, on how to play a mini-game. These issues caused a cognitive overload and problems with comprehension of the gameplay. The written mini-game instructions were simply too long, too abstract, and had some words the children did not understand. This may well be an example of difficulties in young childrens' understanding of the relation between a concrete phenomenon, in this case how to play a mini-game, and an abstract description thereof. In a similar vein, written online safety-instructions may be too abstract and difficult to relate to one's own online activities, presumably due to limited logic-abstract reasoning capabilities. Furthermore, the long instructions were problematic for children with limited reading skills; the effort of reading, and stumbling on difficult words turned the gameplay into a reading exercise, and discussions about the meaning of some unknown words. The children did however, help each other in reading the texts, but the language problems drew attention away from the gameplay. After a few iterations the language problems were solved. The texts were shortened and complicated words were eliminated. Instructions regarding the mini-games were also transformed into animated graphic representations instead of written explanations.

The other major issue was the many vibrant colours and the amount of details, which caused confusion and perceptual cognitive overload. For instance, the game pieces and the clue cards have separate colours (blue, green, etc.), and there are game events that are related to the colours. But, there were also a lot of graphical elements in all colours that were not related to the gameplay. All the colours caused confusion and drew attention away from the elements that should have been noticed. The graphics had to be simplified, to contain less colours and symbols, to instead draw attention to elements that matter. When the language and colour issues had been solved, the gameplay worked as intended. However, the youngest children needed some assistance in the first round of the game, when they hide their treasures, to get the tablet to focus properly on the game board (Fig. 4).

The interviews provided a lot of information about the childrens' views and opinions that were not observable. On the positive side was the 'coolness' of the tablet, especially the 3D-view, and that the game was fun. The most fun parts were the competition to find someone else's treasure and the mini-games. The children liked the animal avatars and the voice acting that tells, for instance, whose turn it is to roll the dice. There were very few negative comments, but some mentioned the 'strange words' they had not understood. However, probing into the matter whether there was anything they did not like, there were comments and questions about the unknown character and who that might be. As one participant said receiving a text message, "*Who the heck is that?*", and the players guessed it could be 'the computer', 'the teacher', or 'one of the

Fig. 4. A player who is about to chose a hiding place for his treasure, at the beginning of the game. (©Niklas Torstensson)

researchers'. Some also found it disturbing that the unknown character wanted the players to take photos since that 'person' sometimes showed them to the other players.

One important matter in the game, although it might seem counter-intuitive, is that children actually do take photos of their clues in response to the unknown character. Taking a photo provides the negative experience of sending a picture to someone unknown, who then shows the picture/clue card to the other players. In all the evaluations, the easiest trap the children fell into was to take a photo by being bribed with a mini-game, but they did not realise they had been manipulated. This was true especially for the younger children, who instead focused on what they got in return. There were also very few reflections among the younger children on whether it could be good or bad to take a photo. It was not until clues started to be revealed that some children realised that taking photos perhaps was not a good idea. At that point however, the unknown character may threaten to reveal an already sent photo unless the players sends another one. The older children (12 yrs.) on the other hand, more often picked up that someone was trying to lure them into revealing their clue cards. For instance, two older children that played as a team discussed if they should take a photo, when one of them firmly reached forward and pushed the 'no'-button and said, "*No! Cause they can't know where our treasure is!*"

To summarise our impressions, the game was perceived differently from the childrens' perspective, compared to what we as researchers saw. Although 70 children of varying ages is a limited group of players, it seems fairly safe to conclude that Hidden in the Park is first and foremost perceived as a fun game, and not as some kind of 'learning game' (cf. Susi et al. 2007). In our view, children perceive the game as fun and playing in groups provides a social dimension that enhances the play experience as seen by the players' engagement and vivid discussions. But, the game also evokes reflections and questions, just as intended. Two telling examples are the young players who said "*He's so mean…He's not listening! Why's it like that?….Is it just 'cause one* *has to do as he says..?*" (the unknown character tries to coerce the player to take a photo), and "*What happens if you say 'No'?*" (decline a request to take a photo). These kinds of reflections and questions serve as a starting point for follow-up conversations, where game events can be discussed and related to everyday interactions online, to increase young peoples' risk awareness. Table 2 below shows a selection of citations that exemplify the players' and our different perspective.

Table 2. Citations collected during gameplay sessions.

Childrens' perspective	Researchers' perspective
• "*Fun!*", "*Good!*", "*Cool!*" • "*I like everything!*" • "*It's fun to play against each other!*" • "*When one picks it up* [the tablet] *and looks, and it actually looks real!*" • "*The fart-game was fun!*" [the sounds in one of the mini-games] • "*It was good and fun, I wish I had it at home!*" • "*The animals and the 3D-world are good and cool!*" • "*The pig is the coolest!*" • "*The voice is good so you know what to do.*"	• "*It doesn't like me*" [said about the unknown character] • "*I didn't like when he wrote mean things*" [threats] • "*I shouldn't have taken so many photos*" • "*Who the heck is that?*" • "*He's so mean…He's not listening! Why's it like that?….Is it just 'cause one has to do as he says..?*" • "*What happens if you say 'No'?*" • "*To who am I sending the photo?*" • "*Who's actually texting?*" • "*Do I have to send pictures?*"

As for different ages of participants (7–12 yrs.), and the chosen target group of 8–10 year old children, our conclusion is that the game is suitable for the target group. The game is probably too complex for children under the age of eight to comprehend, and it requires reading skills that are good enough not to steal the attention away from the gameplay. Also, the game does not fulfil its purpose for children that are cognitively more mature than average 10 year olds, since they can more easily see the game's underlying purpose.

6 Discussion

This paper has described the development of, and the underlying research for, the innovative game *Hidden in the Park*, which is aimed to raise young people's risk awareness in online interactions. It is a fun adventure game that provides a playful experience and accords with childrens' media culture. But, it is also a serious game intended to evoke reflections and questions that can serve as a starting point for follow-up discussions. We observed that the game indeed evokes reactions, but also that especially younger children did not seem to think much about the outcomes of decisions made in the game. Instead they focused on what they got in return when asked a 'favour' by an unknown character. The game is a metaphor for what can happen online, and thereby also a tool that allows children to experience certain decisions and their outcomes, but under safe conditions. A follow-up conversation is important since that is an opportunity to relate in-game events to childrens' everyday online activities and risk awareness. However, there were no follow-up conversations during the evaluations since focus was the game's design and game mechanics. On the other hand, what we found was that the game was received as fun, and that it was entertaining and engaging. Our conclusion is that the game in itself can be played as a 'fun game', and questions regarding the text messages, during the evaluations, past by as objects of discussion among the players, without any definitive answers.

As for evaluation methods, there can be many problems when involving children as participants. We chose to use observations and group interviews, which turned out to be a good choice in this particular case. The game is engaging and play sessions were highly interactive, both physically and socially. With focus on the game and each other, the children seemed to take very little notice of the researchers observing them, and the instructor/researcher became more of a person to ask questions rather than some 'strange adult'. The interviews worked well since the groups of players knew each other, and they had just a shared an experience of a game none of them had seen before. As the interviews were conducted right after the play sessions, most of the children seemed to still be in a 'gaming mode' and were very excited to talk about the game and to share their opinions. It was also valuable that they were in groups since they triggered each others memories and the group dynamics contributed to more information rich data. To involve the target group in the game evaluations proved invaluable since surely childrens' and adults' views on what constitutes 'fun' is likely to differ considerably.

One issue that remains unanswered is whether the game has any long term effects concerning raised risk awareness. At this point we have to acknowledge that we do not know whether the game will have any long lasting effects, since that would require some follow-up studies. Such studies have not been possible since the game was only recently finalised. Another issue not discussed in this paper concerns the pedagogical guiding material for teachers. The material was finalised by our project partner, the Change Attitude Foundation, and we have evaluated teachers' use of the game and the material in class room settings, where the teachers also have led follow-up conversations of game events. The results of those evaluations are however, the topic of another paper.

On a side note, we find it worthy to mention a most important key to success in the development of the game prototype, and the subsequent *Hidden in the Park*. The work was intense and as it turned out, the realisation of the game concept is the result of an interdisciplinary research team that included expertise from user experience design, cognitive science, linguistics, narratology, game studies and game development, including programming, design, graphics, sound, and game writing.

In conclusion, the game is fun to play, which is perhaps best proved by the children's recurring question "*When can we buy it?*". The game will be launched in 2019 as a non-profit game to be downloaded for free through platforms like Google-Play and Appstore. There is no claim that the game is a 'silver bullet' or a one-shot solution to cope with online risks, but rather an innovative and complementary tool to other existing preventive measures for online risk behaviour. It is rather a digital tool to address a digital problem.

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Encourage Self-exploration Through an Interactive Chinese Scroll Painting Design

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Abstract. Gamification design enhances the user's interest in things and thus makes the culture more widely available and easier to understand. This work attempts to transform a traditional viewing experience of scroll paintings into an immersive and playful interaction, allowing viewers to better appreciate these scroll paintings and understand the history behind them. We designed an immersive cultural heritage digital experience device, taking the "Han Xizai evening banquet" as an example. We hope to find an interesting method to encourage viewers to explore these paintings proactively by the interactive exhibition. It also helps the public to understand the charm of Chinese traditional paintings better.

Keywords: Interaction design · Spatial interface · Chinese painting · Interactive exhibition

1 Introduction

Scroll Painting, as the most general type of Chinese traditional painting, has a narrative feature, related historical stories or image legends. These scroll paintings are not only beautiful artworks but also precious historical data. Viewers will learn relevant culture and history while appreciating paintings.

However, the public in modern society is more interested in novelties, and the attention of traditional Chinese paintings is getting lower and lower. As multimedia technology becomes more developed, we hope to find a kind of gamification design method to encourage viewers to explore these paintings proactively. Through the interaction, viewers can understand the stories of these traditional paintings better, so as to feel the charm of traditional Chinese paintings. We chose the famous Chinese scroll painting "Han Xizai Evening Banquet" as an example and designed "Digital Han Xizai Evening Banquet".

1.1 Chinese Scroll Paintings

Chinese Scroll Paintings use large aspect ratios and composition to convey a special visual experience to the viewers. Unlike western oil paintings, Chinese Scroll paintings transform spatial and causal relationships through elaboration.

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Fig. 1. Han Xizai evening banquet

The most significant feature of Chinese painting is the cavalier perspective method (see Fig. 1). Different from the focus perspective method, cavalier perspective moves the viewpoint as the artist demands, and the scene in the picture would not be limit by the field of view. One picture may have several viewpoints. In addition, the different time and space in a painting is another feature of Chinese scroll painting, which means according to the story, events and characters appearing in different time and space in one painting, one character may appear on a picture many times. These two features provide conditions for storytelling, such as "Han Xizai Evening Banquet" and "Lo River Map", and draw a lot of scenes from right to left to express the whole story.

1.2 "Han Xizai Evening Banquet"

"Han Xizai Evening Banquet" is one of the most famous Chinese traditional paintings in China. It is painted by Gu Hongzhong in Southern Tang Dynasty. This picture shows the scene of an evening banquet organized by Han Xizai, who is a famous chancellor in Southern Tang Dynasty (see Fig. 2).

The whole picture divided into 5 scenes: Listened to Pipa, Appreciated dancing, Take a break, Enjoyed melodious music, See guests off, showed stages from beginning to ending of the banquet, the painting style is graceful and meticulous and the composition of the picture is unique. There are many historical people and furniture in this painting, this painting is not only a beautiful painting had aesthetic values, but also a kind of precious historical data.

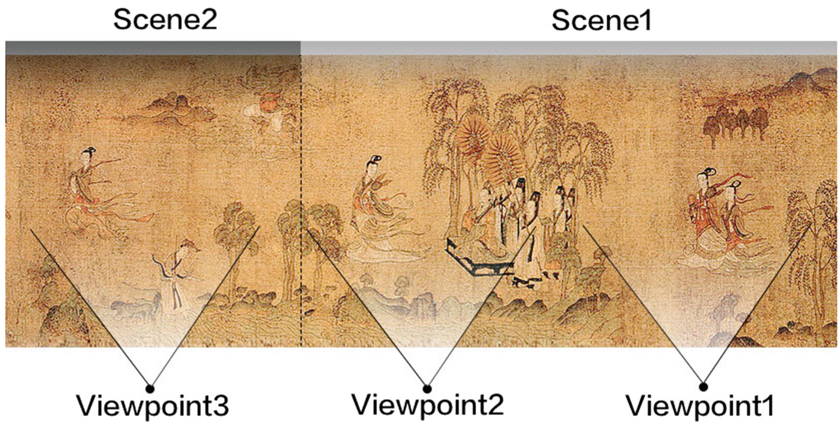

Fig. 2. Schematic of Cavalier perspective. One picture had multiple viewpoint.

2 Related Works

Until recently, some museums and companies have also used traditional scroll paintings for digital exhibitions. Compared with traditional exhibitions, the digital exhibition avoids possible damage to the original things from touches. It also has the ability to reveal background knowledge [1]. At the 2010 Shanghai World Expo, Crystal Digital Technology Co., LTD made an animated film "Life Along the Bian River at the Pure Brightness Festival" (Bian River scroll for short, it is the most famous Scroll paintings). This exhibition displayed 3D animation on a giant white wall of 128 m long, using 12 projectors to present life of the ancient people. Likewise, the National Museum of China exhibited an animated film "The Qianlong Southern Inspection Tour", displayed on a screen, which is 30 m long and 4 m high. However, both projects focus on watching, but there is no interactive design.

In 2007, the National Palace Museum in Taibei exhibited digital Bian River Scroll exhibition that could interact with it. When visitors touched some specific areas in this digital painting, the corresponding movies would jump out of the painting and start to play. Although this exhibition possessed interactive function, it had a poor immersive experience.

The Palace Museum in Beijing also exhibited an interactive project [2]. On a large screen with a higher resolution, viewers can appreciate the original Bian River Scroll image without animation. Viewers zoom in on the image with two hands and enjoy more details. The voice box would play corresponding environment sounds and dialogues, which helps viewers to understand the knowledge about the painting.

These projects are attractive and gained favorable evaluation, but they all have a monotonous way to interact with visitors. Visitors interaction is limited to gesture and hearing, and there is no way to experience diverse ways to enjoy these paintings. We hope the interactive patterns can be integrated into space, and it will take more novelty experiences and enhance the immersive feel.

3 Concept and Design Method

3.1 From "Seeing" to "Participating"

Each Chinese painting has many brilliant details, and they are emphasis area that the viewer should follow. Such as "Han Xizai Evening Banquet", Encouraging viewers explore this area by themselves is thought when designed interactive way. Viewers will get the knowledge about these details.

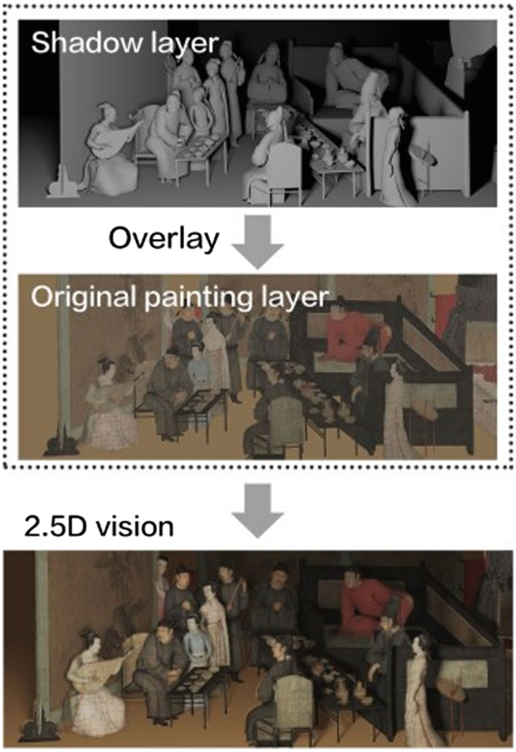

Fig. 3. How to create "2.5D" vision: achromatic shadow layer overlaid with original painting.

The traditional digital display of ancient Chinese art tends to focus on the "seeing" part, while we believe that "participating" can immerse viewers in the painting better. Such as "Han Xizai Evening Banquet", it encourages viewers to explore these areas themselves while interacting. Viewers will gain knowledge about these details instead of just lightening the scenes. As the interactive area lights up, some other relevant information will be shown, including commentary voice, dance animations and conversion to other scenes.

3.2 Encouraging Exploration

Viewers should use the handles to activate these areas, as the handle items are a hint of the pointing device and the exploration activity. At the digital Han Xizai Evening Banquet, the handles were designed to be an electronic candle for the banquet theme. The viewers could use this electronic candle to illuminate the scene of this painting and explore freely. The intensity and angle of light will follow the position of viewers. This interactive approach immerses viewers as if they are participating in this banquet.

More than just lighting up the scene. When the interactive area is lightened, other related works will be displayed. Includes comment voice, dance animations or transitions to other scenes.

3.3 Interactive Narrative

In this painting, different time and space features will appear at the same time. Han Xizai and other characters in this scroll painting appear many times. It is an interesting way to analyze the story line through these characters with different postures and clothes in each scene. As a design concept, when viewers trigger specific interactive areas like some characters or furniture, the scene will be converted into other relevant scenes, and the scene that the viewer will see depends on themselves which is decided by their choice rather than in sequence. Multiple choices make various view sequence, providing viewers a different chance to understand. In order to make this narrative easier for the viewers, we divided it into five parts, representing five scenarios: banquets, watching dance, banquet break, flute blowing, and farewell to guests.

3.4 Reappearance of Ancient Scene

To enhance immersion, we add a shadow layer on the original painting to create a sense of space. However, in order to preserve the plane style and scatter perspective of Chinese painting, we redesign the graphics and try to balance the 3D and 2D. Called "2.5D" vision. "2.5D" vision consists of 2 layers: shadow layer and original painting layer, achromatic shadow overlaid with original painting (see Fig. 3).

Original painting layer is reconstructed in 3D max instead of using original painting photo directly, so there is a perspective change and enhance a sense of space when the scene is converting. However, "scattering perspective" in scroll painting contradicts "focus perspective", so things are distorted and weird in the rebuilt space. It will look like the original image only when the camera is set at a specific position.

When setting up 2D characters in the 3D space we built (see Fig. 4), we can move the camera in a limited area and render the sequence images. It seems original painting possess subtle perspective change. These images are played during scenes' conversion.

Fig. 4. Rebuild scene space, set 2D character in 3D space that we built. Look at this scene from above.

4 Interaction with Candles

4.1 Candle and the Spatial Interface

Candle and The Spatial Interface The viewers' activities within a certain range of space will react to the painting. We use handle prop as the medium between viewers and the painting. Considering the ancient Chinese style, we designed the shape of handle prop as a candle. Viewers use the electronic candle to interact with digital painting.

4.2 Interaction Styles

Interaction Styles There are mainly four ways of interaction in the spatial interface, (a) Viewers use handle prop to activate some interactive points, then launch the interactive and encourage viewers to experience. (b) Viewers can use handle prop to explore the scene of painting freely. In order to encourage viewers to explore, the painting will be reflected in a moving way, such as the area where viewers stand will illuminate or sound the commentary voice played here. (c) Handle prop also used as the conversion switch, which is used by viewers use it to select a specific area to activate scene converting. (d) Designing special interactive effects in some wonderful scenes can make viewers deeply touched. For instance, there is a scene depicting four female company with Han Xizai resting in "Han Xizai Evening Banquet". This scene has a privacy atmosphere, therefore the interactive effect is a dim light that squeezes through the door, trying to create a peeping effect for viewers (Fig. 5).

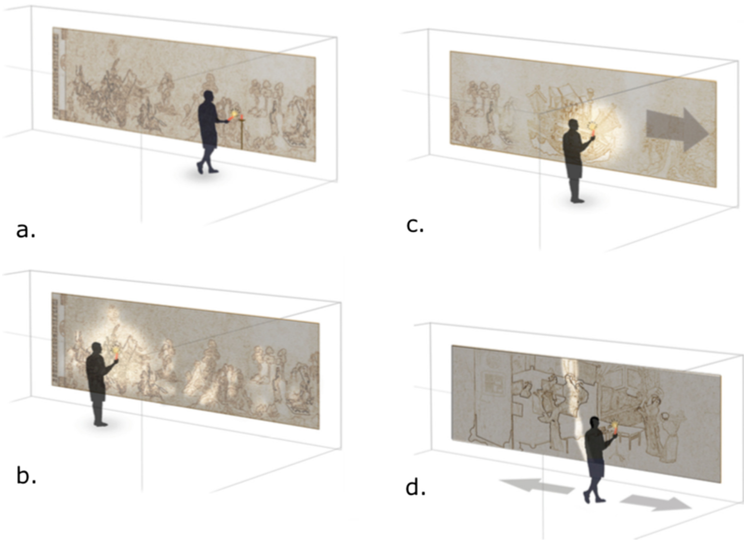

Fig. 5. Interaction styles

5 Implementation

Our installation consists of a high-precision indoor positioning system; two rear-projections units; an 8 m wide, 3 m high projection wall; two mainframes (for positioning and projection, respectively); six long cables and switches. When the device is arranged, the positioning system and the two hosts are connected through the switch and the network, and finally, the host obtains the candle position information and displays the corresponding picture on the projection wall with a projection.

5.1 Indoor Localization System

We utilize a high-accuracy indoor localization system for perspective-driven interaction. The system consists of four base stations and a tracking tag, which is embedded into a candle-like object (Fig. 6). With the aim of Ultra-Wide Bandwidth Microwave (UWB) Time Difference of Arrival (TDoA) Localization technology, we can acquire a localization accuracy of the tag around 10 cm. Computer calls display images according to the localization. Therefore, the location of viewers could be followed with this system and reflect in a display.

5.2 Light and Shadow Effect

In the actual implementation, in order to make the user get a better experience, and in order to make the interaction effect closer to the narrative, we have designed different light and shadow effects for the five scenes. As shown in the

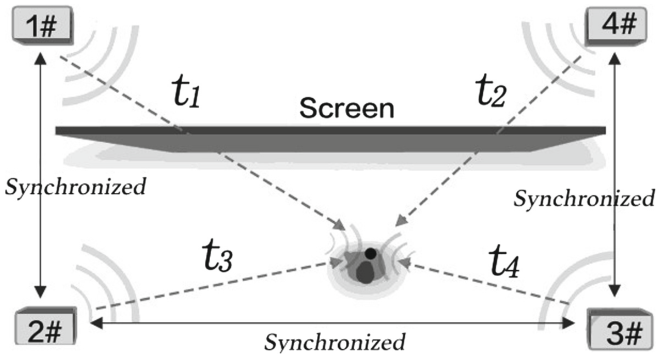

Fig. 6. A high-accuracy indoor localization system

figure, in the first scene, the audience uses the candle to light the candlestick hidden in the picture, which finally makes the picture brighter and brighter and shows the effect of candlelight flickering. The candlelight of the audience in the second act will illuminate the face of each character on the screen to focus the attention of the audience. The third act, due to its special privacy atmosphere, is designed to look inward through the door slits, thus causing the bright part to appear as a sliver and moving in the opposite direction to the candle. The fourth act shows a grand performance, so the light effect is designed as a stage lighting that illuminates in a global context. The fifth act renders the parting atmosphere, so the shadow of the character is added to the effect of the illuminating effect. When the candlelight is far away from the character, the shadow will gradually lengthen, which further reflects the gradual drift away from the farewell.

6 Observation

Our installations were successfully exhibited in Beijing, Shanghai, Nanjing, Shenzhen and other places and received feedback from lots of users. More than a thousand viewers experienced our interactive narrative system, and most of them thought that this interactive design had greatly enhanced their interest in the Han Xizai Evening Banquet. The viewers described their experiences in a smooth, natural, immersive, and interesting way (Fig. 7).

About 60% of the viewers did not understand the story behind this painting. However, they showed further understanding and interest in the painting after this experience. Some viewers with Chinese art expertise said that the interaction created a good atmosphere and conveyed accurately. For example in the third act, the lighting simulation is taken from the crack at the door to Han Xizai's house, which restores the perspective of the artist's observation and recording of this evening banquet. 90% of the viewers were interested in the positioning technology because of the smooth interaction. They also cared about other application scenarios of the technology (Fig. 8).

Fig. 7. Different effect in each scene

Fig. 8. A viewer experiences on site

Some viewers give us many useful suggestions:

- Add LED lighting effects off/on the candle to make it more realistic about the environment.
- Lowering the screen so that the characters of the painting are as high as the viewers.
- Narrowing the scope of interaction so that they moved within the space.
- In terms of exhibitions, some curators hope that the exhibition environment will be more subtle and classical, such as adding some traditional ornaments to decorate.

There are still some disputes that need us to discuss in the future:

- Whether characters can be increased more movements, such as interact with other characters in the painting or enlarge the local details.
- Some viewers think that the different ways of interacting each scene are very attractive, eliminating fatigue, while others think that changes in interaction make them confused.

7 Discussion

For visual effects and device performance, one person handling interactive props can achieve the best effects in the current design. However, there are many viewers in a large hall, and only one interactive project is inefficient, therefore, multiple handles and multiple interaction methods should be considered.

This design encourages viewers to learn about Han Xizai Evening Banquet through multiple-choose narration to emphasize interesting interactions. While some art historians have the opposite opinion of this design style. Many traditional Chinese paintings have complex controversies in related academic circles. Some historians believe that show academic and objective knowledge accurately is more important than interesting popular education. Serious cultural education contradicts entertainment, which is more important. This is a discussion that worth exploring.

8 Conclusion

Through design "Digital Han Xizai Evening Banquet", we hope our research method is suitable to other digital scroll paintings, with rich visual effects and interactive ways to present more brilliant characteristic and attract more public attention to Chinese scroll paintings.

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Rewards in Gamification

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Abstract. While games are reaching staggering levels of popularity, educators starts to apply game mechanics in education to motivate students' learning interesting and effectiveness. Gamification provides a fairly relaxing learning environment and offers various rewards in the application. Therefore, gamification becomes a powerful method influencing and motivating students in education. Despite the proliferation of motivations studies under game rewards in gamification, little is known about optimum of rewarding strategies, such as how often we should award students and when we should provide rewards to the students in the gamification applications. This study is the first empirical research looking for timing and frequency of rewards for students in a gamification application.

Keywords: Game · Gamification · Motivation · Rewards

1 Introduction

New technologies are always adopted as tools to support learning across education and training domains. Two years ago, Internet technology was adopted in online education; fifteen years ago, mobile devices were adopted in education and training for distance learning and self-learning support; ten years ago, cloud computing technology was adopted in social network and online community education; five years ago, the idea of game gave birth to gamification in education and training. A well-known definition of gamification was introduced by Deterding et al. [1]: the use of game design elements in non-game context. The purpose of gamification is to adopt game design ideas in non-game context to motivate users' retention to the products or services, improve users' engagement and loyalty [2, 3]. Organizations adopted gamification to increase initiation and retention of desired behaviors [4].

MarketsandMarkets [5] estimates that gamification market will grow from USD 1.65 Billion in 2015 to USD 11.10 Billion by 2020, and the education gamification market is expected to grow from 93 million U.S. dollars in 2015 to nearly 1.5 billion U.S. dollars in 2020 [6]. Today, gamification has been applied into variety of areas, such as education, online communities and social networks, health and wellness, crowdsourcing, sustainability, orientation, computer science and engineering, research, marketing, computer-supported cooperative work and other applied research areas [7]. Gamification borrows elements from game design to attract users into a more "fun" and

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enjoyable virtual environment as to encourage users to learn and complete desired tasks. The gamification applications provide a goal-oriented framework that enables user to get virtual rewards after they pursue and complete the designed tasks in the application. In education, motivation is regarded as one of the most important factors leading to academic success [8, 9]. Therefore, the purpose of gamification in education is to motivate students and increase their engagement with an education or training application and to improve their adoption and retention by removing obstacles preventing behaviors with enjoyment experiences [10].

People by nature are most likely to accept and interested in active interactions comparing to passive interactions [11]. The methods to motivate students in gamification are to establish active interactions in the learning process rather than passive instructions, such as lectures in class. Change and Wei [12] identified categories of educational interactions in gamification:

- Learner-content interaction: includes self-expression, pattern recognition, time pressure, and status;
- Learner-instructor interaction: includes goal settings, instruction, and rewards;
- Learner-learner interaction: includes reputation points, peer tutoring, competition, altruism, group identification, and peer appraisal.

In Learner-instructor interaction, reward is borrowed from game elements. It is a crucial motivation factor that affects students' perception of the benefits of the gamification application [13–15]. However, the question of how rewards were distributed in the gamification applications needs further exploration [16, 17]. This research is to study the effectiveness of rewards in educational gamification applications. This is the first theoretical study focusing solely on effectiveness of rewards in education domain for gamification.

2 Literature Review

2.1 Motivation Theories

Gamification is an integration of game design elements and non-game context in order to increase users' motivation. Psychologists studied motivation over decades. In the Self-Determination Theory (SDT), Deci and Ryan [18] defined two types of human motivations: intrinsic and extrinsic. Intrinsic motivation is built on a person's internal achievement or perception, such as enjoyment, satisfaction, or other positive feelings. Extrinsic motivation invokes a person's motivation from external rewards and stimulations, such as money, praise, or something which could reduce or avoid any detriments. Traditionally, extrinsic motivation receives less impaction than intrinsic motivation, and the learning outcomes from educational perspective is weaker from extrinsic motivation [19]. However, extrinsic motivation plays a more important role in gamification applications [20]. Based on the original SDT, Deci and Ryan [21] expanded the theory with four motivation types including three extrinsic motivations: identified regulations, introjected regulations, and external regulations. They argued that when a person feels extrinsic pressure, he/she tends to turn it to an intrinsic pressure. Therefore, more extrinsic regulations are internalized, the more intrinsic motivation will be resembled or generated. This expanded theory combines both psychological needs and cognition desires demonstrating needs for autonomy, competence, and relatedness.

The theory of 16 basic desires [22] identified 16 basic and innate human desire associated in our lives: Order, Power, Independence, Curiosity, Acceptance, Saving, Idealism, Honor, Social Contact, Family, Status, Vengeance, Romance, Eating, Physical Activity, and Tranquility. Since the 16 desires cover all aspects of human characteristics, and game and learning motivation may not relate to most of these factors, this theory is rarely been adopted by researchers in gamification studies.

Similar to the theory of 16 basic desires, Maslow [23] used a hierarchy structure with five levels to explain people needs, which motive people's actions (see Fig. 1):

Fig. 1. Maslow's hierarchy of needs

- Physiological Level: air, food, water, sex, sleep, excretion, etc.
- Safety Level: health, personal well-being, financial and employment stability, security against accidents, etc.
- Belonging Level: love, intimacy, friendship, family, social cohesion, etc.
- Esteem level: self-esteem, confidence, achievement, respects, etc.
- Top level: self-actualization: pursuing inner talent creativity, fulfillment.

According to Maslow [23], behavior is need-based and dynamic. Along with the satisfaction of lower level needs, people tend to pursue higher level and mental needs.

Another theory explained behavior changes is Fogg's behavior model [24], which identified the relationships among three factors: motivation, ability, and trigger. According to this theory, all behavior actions need to satisfy three conditions at the same time: (1) sufficient motivation; (2) enough ability to perform the behavior; (3) there is a trigger to activate the behavior (see Fig. 2).

The Flow theory [25] demonstrates that the balance of difficulty and skills will create a motivational flow. Flow is also a balance between task difficulty and skills to handle the tasks. Whenever the challenge and skills fill in the right flow, people will experience enjoyment and gratification. However, if the challenge is higher than the

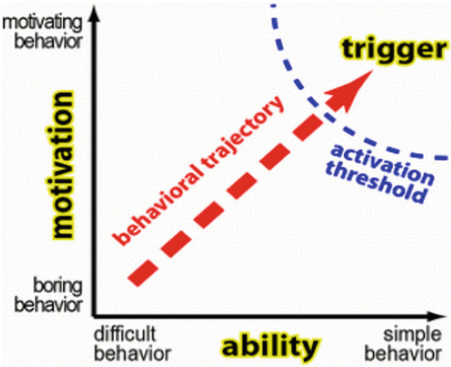

Fig. 2. Fogg's behavioral model

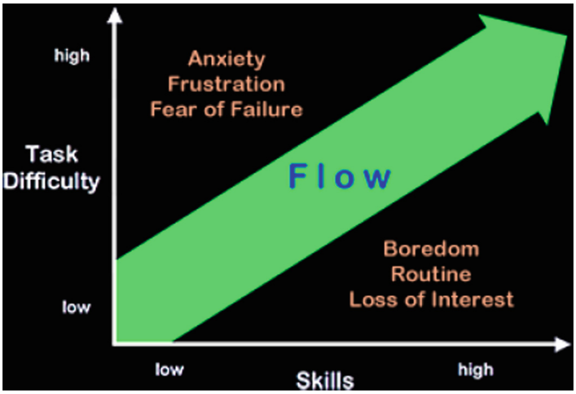

Fig. 3. Flow theory

corresponding skills, people will experience anxiety and frustration, whereas, on the opposite way, boredom may occur (see Fig. 3).

2.2 Aspect of Gamification

Researchers tried to use frameworks to explain gamification concepts. Since gamification employs game-thinking and playful design in non-game context, subjective feelings of users will influence the final performance in the gamification applications. Therefore, researchers developed frameworks to help designers understand strengths and weaknesses of the game design. Among these frameworks, Mechanics, Dynamics, and Aesthetics (MDA) [26] is a well-known model adopted and expanded in many studies. Mechanics regulates all the rules and components in the game, such as gravity rule in a game. Dynamics show the results created by mechanics, but could not be implemented or managed directly in the game [27]. Aesthetics describes game players' feelings in the game, including sensation, challenge, discovery, fellowship, expression, fantasy, submission, and narrative.

Robson et al. [28] demonstrated a framework with three constructs: Mechanics, Dynamics, and Emotions (MDE). Mechanics include all the settings and rules in the game. Dynamics refers to players' behaviors in the gamification applications. Emotions represent players' subjective opinions and feelings about the applications. MED emphasizes the importance of emotional characteristics in motivating human behaviors.

Friedrich et al. [29] proposed a different three dimensional model: Dynamics, Mechanics, and Components (DMC) to demonstrate gamification concepts. In this model, Dynamics summarize game players' feelings of emotions, progression, narrative, relationships, and constraints. Mechanics include internal factors, such as challenges, chance, competition, meaningful stories, and time pressure, and external factors, such as feedback, performance graphs, virtual goods, rewards, status, and levels. Components consist of all the game elements designed in the games, such as achievements, avatars, badges, collections, content unlocking, countdown clock, gifting, leaderboards, levels, points, progress bar, quests, rating, teams, and virtual goods.

A widely acknowledged game design framework is the Elemental Tetrad Model [30]. There are four constructs in the proposed model: Story, Mechanics, Aesthetics, and Technology. The story element provides a platform with a meaningful context to offer players a cognitive system to understand, explore, and consume. The mechanics element regulate the basic rules and structural aspects of the game, such as a gravity effect from real world. Additionally, mechanics defines the success of tasks of each level in the game and rewards to the players. It is a protocol or contract between the game and players to limit players' in-game behaviors, control and enable players' desired achievement. In an open world game with artificial intelligence, the mechanics provide a dynamic, flexible, and open-end environment for players to create unique and customized experiences. The aesthetics element refers to players' feelings of a game from graphical design and human-computer Interface (HCI) perspectives. It interrelates with story element closely offering game players an immersive experience in virtual world. The last element, technology, provides hardware support for the game to guarantee game players enjoying the game without technical issues. It also expand game players' experiences with certain technologies. For instance, the Internet connection will enable multiple players to play the same game at the same time on a server, which gives players social network experiences.

2.3 Player Types in Gamification

Game players' characteristics should be considered as a key aspect in a gamification design [31]. Adopted Bartle's [32] two dimensional model with player orientation and player competitiveness, Robson et al. [16] defined four types of players in gamification: strivers, slayers, scholars, and socialites. Strivers are the players with high competitiveness and self-orientation. These players always try to reach the best personal score or gain highest self-performance. Slayers, with high player competitiveness and more social personality, are more interested in comparing with other players in game achievement. Scholars are players with low competitiveness and more self-orientation. Understanding and learning experience is more important for scholars in the game. Lastly, with low player competitiveness and high socialization, socialites prefer to build social relationships in the game.

Additionally, Alsawaier [33] proposed another format of player types developed based on Bartle's study [32]:

1. Killers: those who compete and play against other gamers.
2. Achievers: those who achieve status due to a high level of performance.
3. Explorers: those who collect virtual goods and discover things.
4. Socializers: those who are good team players and collaborate with others in the game environment.

Recently, according to BrainHex player typology study [34], Lopez and Tucker [31] developed a list of Hexad player types: Philanthropists, disruptors, socialisers, free spirits, achievers, and players.

2.4 Game Design Elements

Game design elements are basic cells to build up the game. Deterding et al. [35] identified five levels of game design elements, which should align with gamified no-game context in gamification (see Table 1).

Table 1. Levels of game design elements.

Level	Description	Game elements
Game interface Design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leaderboard, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	MDA Model: Mechanics, Dynamics and Aesthetics; challenge, fantasy, curiosity; game design atoms; Core elements of the gaming experience
Game design methods	Game design-specific practices and processes	Play-testing, play-centric design, value conscious game design

2.5 Rewards

Reward is one of the important game design elements in gamification to encourage users keep acting in the gamified context. Reward systems in gamification strengthen the relationships between users and the gamification system [36]. Hallford and Hallford [37] classified rewards into four categories: glory, sustenance, access, and facility.

Glory is an "intangible" reward that will not give direct impact on the game play, but will influence users' intrinsic motivation. Sustenance is a type of rewards that has collecting and social comparison value for practical game use. Access unlock paths or access after users reach certain requirements. Facility is a reward that will enhance users' ability in the gamified applications. Typical game rewards are listed in Table 2.

Table 2. Game rewards.

Reward type	Rewards	References
Glory	Score, badges, honored virtual items, achievement, feedback, plot animations and pictures, leaderboard, medal, likes from other players, kudo	[17, 38–40]
Sustenance	Resources	[17]
Access	Unlocking mechanisms	[17]
Facility	Currency, points, level, virtual items/tangible rewards	[17]

3 Research Model

Bratuskins [41] argued that game reward systems can boost loyalty and even sales. Rewards motivate users, improve their dedication, give them both real-life and gaming experiences, and, eventually, retain them in the game. In education, gamification is adopted to educate and training students for learning purposes. Therefore, motivation in educational gamification is crucial for learning outcomes from students. Rewards are identified as a core strategy to encourage students completing their learning tasks in the gamification applications [42]. Most of current game rewards studies focus on motivation results of rewards in the games [7, 39, 43, 44]. However, there is no empirical studies in educational gamification working on rewarding strategies, such as how often we should award students and when we should provide rewards to the students in the gamification applications.

Timing of rewards is critical in the gamification applications [16]. If a reward is given too early before students' certain actions, students will feel easy to earn rewards and also less challenge in the application, which will eventually decrease their motivation. On the other side, if a reward given is delayed, students will think that it is not worthy completing certain challenge. Or, right after they complete that challenge and the expecting rewards is not delivered to them, their motivation will also be degraded. Therefore, we propose that timing of rewards in an educational gamification application will influence students' motivation toward learning and the following hypothesis:

H1a. Decreasing the time between task completion and rewards delivery will positively influence students' motivation toward learning.

H1b. Increasing the time between task completion and rewards delivery will negatively influence students' motivation toward learning.

Frequency of rewards is also important in motivating students' learning [45]. Won and Leber [45] found that observers in their experiments were highly sensitive to the reward frequency. This led to our following hypothesis:

H2. Frequency of rewarding in an educational gamification application will positively influence students' motivation toward learning.

4 Conclusions

The main purpose is to study the optimum of reward systems in educational gamification. Although the importance of rewards in gamification has been supported by many studies [7, 39, 43, 44], the question of optimizing the effectiveness of reward systems still needs further exploration [17]. In this study, we reviewed current studies related to reward systems in gamification and identified the needs for understanding timing and frequency of reward systems. We proposed two hypotheses, one for timing and one for frequency. Next step, we will use experimental design to collect analyze data and test the hypotheses.

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