21ST INTERNATIONAL CONFERENCE

ON

INTELLIGENT GAMES AND SIMULATION

GAME-ON® 2020

EDITED BY

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September 24-25, 2020

Universidade de Aveiro

Digimedia

Aveiro

PORTUGAL

A Publication of EUROSIS-ETI

21ST International Conference

on

Intelligent Games and Simulation

AVEIRO, PORTUGAL

SEPTEMBER 24 - 25, 2020

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A CIP Catalogue record for this book is available from the Royal Library of Belgium under nr.12620

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EUROSIS is a Division of ETI Bv, The European Technology Institute, Torhoutsesteenweg 162, Box 04.02, B-8400 Ostend, Belgium

Printed in Belgium by Reproduct NV, Ghent, Belgium
Cover Design by C-Design Bvba, Wielsbeke, Belgium
Cover Art by Larian Studios

EUROSIS-ETI Publication

ISBN: 978-9492859-11-2
EAN: 978-9492859-11-2

Preface

Dear Participants,

All aboard! Welcome to the 21st GAME-ON® conference at challenging times. This year's event is being hosted by the Department of Communication and Art, DigiMedia Research Centre at the University of Aveiro from 24th to 25th of September 2020.

Aveiro is a city that has emerged from the sea, unraveling both salty and sweet stories that every breeze from the past is a leap forward to the future. Conch shell blowing will announce the coming of typical boats of Aveiro called 'moliceiros', while discovering the traceability of fish and the legend of Ramiro and the Moliceiro.

Although we are living a challenging time with the COVID-19 outbreak, we like to think that such Aveiro historical ambassadors as Princess Santa Joana, the journalist José Estevão, and the Saint Gonçalinho will remind us the strength and determination of people to navigate and cross every wave. Exemplar buildings from internationally known Portuguese architects such as Siza Vieira or Souto Moura can also be found at our University campus. We really hope you enjoy your time with us in Aveiro as we are very grateful to co-organize the European GAME-ON 2020® Conference.

The game industry has been evolving over the years to integrate a much more humanistic player-centric approach and never has the exchanging of different knowledge bases from different field areas (e.g. Artificial Intelligence, Psychology, Gameplay Experience) been so important to game research and collaboration between academia and industry. Some of the topics reflected in the paper's included in these proceedings result from this transdisciplinary approach, which are Co-creation and Game Design, Artificial Intelligence and Content Generation in Games, Multi-modality and Tabletop Game-playing, Player Affect and Modelling, and the use of different game elements and techniques in daily life routines.

This 21st edition of GAME-ON® continues with the privilege of having exceptional keynote speakers, who will certainly inspire enthusiasm in all the audience. Davide Gadia, from Università degli Studi di Milano, will be sharing how Procedural Content Generation can be exploited in game content creation both based on evolutionary algorithms and artificial intelligence. Maxim Mozgovoy, from the University of Aizu, will draw our attention to some of the lessons learnt with the gamification of language learning, namely its potential and challenges. Francisco José Perales López, from Universitat de les Illes Balears, will be sharing how a virtual reality environment can play a role in pain management using Binaural Acoustic Simulation.

GAMEON 2020® will also count with a workshop on the use of modern board game mechanics to develop simple analog serious games for planning processes. Micael Sousa, a researcher from CITTA/University of Coimbra will be leading this workshop, with a very promising activity contextualized in the hobby board game culture.

Preface

This conference would not succeed without the effort and team dedication. A special acknowledgment is due to José Nunes, Nelson Zagalo and Carolina Abrantes for helping our department to physically and virtually host the conference. This is extended to all the attendees, authors, speakers, reviewers and members of the scientific board in making this conference possible, with utmost scientific quality, especially in these times of uncertainty and harsh working conditions. Last but not least, our special thanks also goes to Philippe Geril for the partnership, encouragement and precious guidance on this GAME-ON 2020® adventure. Many thanks!

Finally, our gratitude extends institutionally to the DigiMedia Research Centre and the Department of Communication and Art, University of Aveiro, for hosting this event.

Aveiro, September 2020

Ana Isabel Veloso
Óscar Mealha
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KEYWORDS
Gamification, Service Design, Human-Centred Design, Customer Journey, Co-Creation, Participatory Design

ABSTRACT

We live in a world where co-creation with customers, partners and stakeholders is increasingly common in complex organizational development situations. In terms of gamification, employee motivation, consumer involvement, service design process and collaboration, people want to influence and co-create environments, tasks and solutions (Abril 2007). This case study used gamified service design by employing gamification elements in the design process and used a solution prototyping tool, Comicubes, as a gamification and playification tool to design new airport security services. In the case study described in this paper, 72 Finnish university students of marketing participated in workshops organized in October 2019. The co-creation workshops used the gamified service design approach in combination with customer journey visualization as participants envisioned and designed new airport security services. Our study presents how the students used game elements, such as aesthetics, theme and story, and rewards by co-creating gamified security services, which were envisioned to lead to successful security service experiences.

INTRODUCTION

According to Nicholson (2012), meaningful gamification "is the integration of user-centered game design elements into non-game contexts". This case study describes the design of gamified service design processes, which employ gamification elements in the design process and use a solution prototyping tool, Comicubes, as a gamification and playification tool to design and co-create new airport security services. The case study invited Finnish university students of marketing to participate in three groups during 3 case study days, over which the workshops were organized. The duration of each workshop including an introductory section was approximately 3 hours.

Co-creation has been defined as the participation of end- users in the process of developing a product or a service (Von Hippel 1987). According to Koning et al. (2016) the co-creation term has been approached by four different models, which are: the co- creation spectrum, the co-creation types, the co-creation steps and joint space of co-creation. The types of co-creation define the process by identifying three criteria: when the co-creation happens, the amount of direct benefit or change is produced, and the level of collaboration among the participants increases. Therefore, co-creation tends to refer to the active involvement of end- users sharing ideas with firms at various stages of the production process (De Koning et al. 2016). Gamified service design process as the core principle of co-creation means engaging people to create valuable experiences together, while enhancing new product development or new service design, or change existing product or service. Employee engagement is the positive feeling that employees have towards their jobs and the motivation and effort put into it (Macey & Schneider 2008). Burke (2014) has described that gamification is a method to digitally engage rather than personally engage, meaning that players interact with computers, smartphones, wearable monitors or other digital devices. However, experience design describes the journey players take, engaging with elements such as game play, play space and story line (Burke 2014). Gamification, as the definition suggests, will help organizations to increase employee (in this case workshop participants') engagement and motivation. A gamified service design process uses gamification elements in the design process and solution prototyping tools, such as the Comicubes as a gamification and playification tool to design and co-create new services and products.

In this study, we present the results of three workshops, in which (n=72) university students participated through co-creation. The workshops used the gamified service design process approach, when the participants envisioned and developed concepts for new airport security services. This paper presents gamified service design processes to improve marketing students' engagement through co-creation by:

1. Understanding the motivations of the participants in relation to the gamified service design method and use of the Comicubes tool. And:

2. Determining the game mechanics used to overcome to identified challenges by brainstorming and co-creating new

services, which at the same time support the motivation of the participants.

After defining gamified service design in section 2. the authors will explain the co-creation and design process engaging students with gamified service design processes. In section 3. the authors present the research design and methods of how the students first co-created new solutions for the airport security services, and then narrated their envisioned services with the help of the service design concept of customer journeys. Section 4. shows the results of the study, and section 5. presents a discussion and conclusions of the study.

SERVICE DESIGN AND THE GAMIFIED SERVICE DESIGN PROCESS

Moritz' (2007) definition of the concept of service design follows: "*Service design helps to innovate (create new) or improve (existing) services to make them more useful, usable, desirable for customers and efficient as well as effective for organizations. Service design is a new holistic, multi-disciplinary, integrative field*" (Moritz 2007). Service design is an interdisciplinary approach that combines different methods and tools from various disciplines. It is a new way of thinking as opposed to a new stand-alone academic discipline. "*Service design as a practice generally results in the design of systems and processes aimed at providing a holistic service to the user*". Services are dynamic processes like games—playing a game takes place over a certain period of time same during which players experience certain moments to reach a certain level. This service timeline is crucial to consider when designing services, since the rhythm of a service influences the mood of a customer or a player. We might get bored if something progresses too slow (e.g. waiting in line at the airport security check-in), or we might get stressed out if it goes too fast (e.g. rushing through the airport security check).

Co-creation is a core aspect of the service design philosophy (Stickdorn & Schnider 2011). Co-creation has emerged in connection with the service design and human centered design approaches, where the attention was focused on empowering people for decision making processes and working practices. In service design, people contribute to the design processes, and for this reason the connection with co- creation is strong. However, often in the service design approach, co-creation is subordinated to co-design, to which a more relevant role is assigned, representing the collaboration process. By applying co-creative techniques, the focus should be on people as proactive participants, rather than as passive consumers of a service. In terms of gamified service design and co-creation processes the participants also behaved as co-players.

The process of games is related to the engagements and for this reason gamification can be implemented at various levels with respect to integration of game mechanics with the underlying activities being performed. The use of game mechanics, such as rules and dynamics of the game intend to make the gamified serviced design process more enjoyable and engaging. For example, a scoring mechanism represents a game mechanic that can be used to reward some action from the user. In this way, and leaning on the seven elements of games listed by Avedon (1971) gamified services require to the least procedures of action, rules of governing the action, patterns for participant interaction, and a pay-off, represented in many cases by the scoring mechanism. The different levels of gamification are presented in the following: At a *superficial level*, the game mechanics are used independent of design activity of being performed, for example 10 points for every design activity undertaken. At an *integrated level*, the game mechanics are integrated into the activity being performed, for example, points are provided based on the progress, quality of work etc. At the deepest level, *embedded*, the activity is designed based on the mechanics, for example, an activity is divided into multiple sub-tasks each providing a stage in a find new solutions with collaboration work (Neeli 2012).

In this study, the gamified service design process approach was used with the aim to co-create and make participation more engaging in order to connect university students from different backgrounds, bring them together by allowing them to use a solution prototyping tool (Comicubes) that they found meaningful and useful in envisioning and co-creating new gamified airport security services. As the study demonstrates, gamified service design can be seen as the glue between different disciplines, which offers a shared, approachable and neutral set of terms and activities for cross-disciplinary cooperation (Stickdorn et al. 2018).

Co-Creation and Design by Engaging Students with the Gamified Service Design Process

To understand service timing, researchers must start from a value co-creation perspective. Lusch and Vargo (2006) argue that "value can only be created with and determined by the user in the 'consumption' process and through use or what is referred to as value-in use" (Lusch & Vargo 2006, 284). In this case study, all students who participated in the workshops have their earlier experiences of airport security: They have been traveling by flying and went through the airport security system. Co-creation "involves the customer's participation in the creation of the core offering itself. The theme of the workshops in this case study evolved from the pure interest of the authors, who have observed that going through airport security is normally a distressing experience, which is boringly executed at all airports. Our aim is to prove that a pleasant airport security experience could be one of the key issues when choosing airports to use while traveling. If the airport security would be developed into a more interesting and enjoyable experience for travelers, many stressful situations could be resolved. In our thinking, this can be reached through shared inventiveness, co-design, or shared service innovation through gamification, and can occur with customers and any other partners in the future value network. From this perspective, a service provider does not design and deliver service to customers at one or more specific points in time. Rather, customers co-create value, for example, with the airport security company through many interactions over time – where both customers

and companies are a 'source of competence' (Prahalad & Ramaswamy 2000, 2004). Customers and service providers are dynamically adjusting their behavior as the service experience evolves. The customers, in this case students of marketing, engage in spontaneous, discretionary behaviors over time that uniquely customize the service experience. The nature and extent of their participation is influenced by their goals, for example how fast they want to go through the airport security service or which kind of fun elements they want their experience to include, as role clarity and capabilities are involved their roles (Bolton & Saxena-Iyer 2009). In the tourism industry, to which airport security services also belong, there are a many discrete service encounters that create the (holistic) customer experience. Each encounter is an opportunity to emotionally engage the customer often with a human touch. For example, during the airport security check "turned into a gamified service", the experience might enfold as a quickly experienced gameplay service in which one needs to play in how fast one can go through the security service (meaning that you optimize all the little details, for example, traveling with simple hand luggage and not carrying any extra items in the luggage). The timing of small details must match the customer as in this case students' needs to deliver a superior experience. In this instance, customers enjoy a special moment during the airport security service because there is extra value and excitement for the travelers delivered by gamification. In contrast, small details that contribute to service excellence must fit with the user's needs at a particular moment in time – like in the series of workshops presented here—and recognizing what has taken place previously during the customer journey (Bolton et al. 2008). The service timing– the gamified service design needs to fit the student's context–becomes critical. According to gamified service design triggered by and designed with the Comicubes solutions prototype, airport security services should be designed and delivered based on how users are responding– and will respond to–to their environment (the environment of the airport security check point).

RESEARCH DESIGN AND METHODS

In order to clarify the relationship between gamification and co-creation, a key research question is proposed: How does gamification support co-creation, for example, the participation, interaction and interchange of ideas among multi-actors in the development of new gamified airport security service?

Case study research was the method adopted to understand the unexplored relationship between gamification and co-creation-related collaborative innovation practices with the Comicubes solution prototyping tool. This method is appropriate as it facilitates a more comprehensive understanding of such an emergent phenomenon. (Goffin et al. 2018) The study reported in this paper comes out of the scientifically-based interest to obtain a better and deeper understanding of the airport security service and how related systems could be gamified in terms of the service process in respect to airport business and alignment between gamification and business requirements (Bruman & Bell 2007). The methodology of this case study is inspired of the interpretive and social thinking adopting a position (Mathiassen & Nielsen 2008), and is predominantly qualitative (Taylor 2002). This study has been developed taking into account the characteristics of the airport security services that can be generated by implementing gamified elements for services. In this case study, co-creation has emerged in connection with the human-centred design and service design approaches, where the attention was focused on empowering participation for gamified service design process and using the solutions prototyping tool Comicubes.

The method applied in the study is based on service design tool and solution prototype Comicubes, which has been previously used in co-creation workshops, for example, for envisioning customer journeys. We suggest that the Comicubes could be used as a basis for creating performance-based prototypes. The Comicubes is a creative prototyping tool, a hybrid combining images with a physical, three-dimensional cardboard cubes. Hybridity means that the cube as physical artefact can be given a digital layer or digital elements. Hybridity may occur in many ways in a plaything and in the prototyping. For example, the Comicubes can be given a digital layer, through information embedded in images, through which sound, pictures or video material can be added. (Heljakka & Ihamäki 2016) We describe the use of the Comicubes solution prototype as a method in which users are observed engaging in planned activities around prototypes of proposed solutions. There are two types of solutions prototypes that are used in this method: 1) Appearance Prototype, which simulates the appearance of the intended offerings, and 2) Performance Prototype, which primarily simulates the functions of the intended offerings. Through the observation on these prototypes, user experiences are revealed to validate or invalidate assumptions about proposed solutions (Kumur 2013). In our study, it is important to note that the solution prototypes co-created with the Comicubes are tested and validated in a simulated environment of an airport security service in a university classroom, *not* at an actual airport. Information is gathered through observing the interaction in the groups of students and is recorded with video and by taking photographs. The observations are then analyzed to understand students' design experiences and the impact they might have on proposed solutions.

This paper brings together the results of a series of three workshops conducted in association with gamified service design workshops for participants/students of marketing (n=72) from a university in Finland, where the School of Economics is based. The collection of qualitative case studies presented in this paper present an approach to research that facilitates exploration of interaction design within its context using a variety of data sources, for example, the service design method, gamification frameworks and the playful experience model. This ensures that the issue is not explored through one lens only, but rather a variety of lenses, which allows for multiple facets of the phenomenon to be revealed and understood. The design tasks and results of the workshops will be discussed in the next part of the paper. The following Table 1. presents the number of participants who joined the three workshops:

Table 1. Number of case study participants (three workshops).

Class 1/ case study 1	*Class 2/ case study 2*	*Class 3/case study 3*
24	23	25

In our study, two researchers who are experts of gamified (playified and toyified) service design, managed the workshops by functioning as facilitators, empowering students to make decisions for their gamified service development process. The study includes material from three workshops organized in October 2019, in which participants (university students with a background in marketing) were divided in 3 classes, having 23-25 participants joining each workshop. As each workshop had more than 20 students participating, we separated each class in 4-5 different groups. Each group received a certain amount of Comicubes (5 to 7 pieces each), which are giant cardboard cubes, approximately 40-40-40cm by size. The workshops started with a 20 minutes introduction to the basics of gamification and by giving examples of gamified services. We explained the basics of service design and introduced the concept of the gamified customer journey. After the introduction, we showed a commercial video for the security service at the main Finnish airport and gave each group of students the assignment to improve the current airport security service experience by designing a gamified airport security service. The duration of each session was approximately 2,5 hours and during the next day we recorded and analyzed the developed gamified customer journeys and re-designed the gamified customer journey of the airport security service further. The student groups used the Comicubes tool to communicate their gamified customer journeys by storytelling. With the help of the Comicubes prototyping tool consisting of the cardboard cubes, they also made physical prototypes of the gamified airport security service in which they designed activities familiar from game play (see Figure 1-3).

RESULTS

Gamification has been increasingly used as a process of enhancing the co-creation process with motivational affordances to invoke gameful experiences and further outcomes. Ultimately, a gamified service design process is changing the way individuals view and experience the process. This, in turn, is altering how gamified service design processes are planned and operate for individuals and groups of students. In other words, it is a total 'game changer'. In fact, findings demonstrate that gamification provides a more structured and engaging platform for multi-actor dialogue, mutual understanding, alignment of goals, creative experience sharing and concept development. Regardless of how meaningful gamification can be to the co-design of new solutions, only a few studies have explored the relationship between game approaches and co-creation. In fact, current literature from the perspective of participatory design studies describes scenarios where designers and non-designers apply game elements to make cocreation more ludic and accessible, typically supporting visioning, storytelling and prototyping tasks. (Klapztein & Cipolla 2016, Ihamäki & Heljakka 2017, Ihamäki & Heljakka 2019)

The main goal of the first step of the preliminary study conducted as a series of workshops was to gather insight on collaborative innovation practices from the students that participated in a co-creating gamified security services and by narrating the user experiences of different customer groups using their envisioned gamified security services. The observations contribute to a better understanding of the key drivers and constraints of collaborative innovation practices in the context of airport security services.

Service Design professionals have taken notice of the gamification trend and have attempted to apply the motivational potential of games to various non-gaming contexts in order to foster user engagement by rewarding and directing attention to particular touchpoints in the customer journey. Klapztein and Cipolla (2016) have made an extensive review about motivational concepts in game design, which have been grouped into seven game activity components: *voluntariness*, *rules*, *control*, *objective*, *feedback*, *social interaction* and *perception* (Klapztein & Cipolla 2016). These activity components were used as a theoretical starting point for the workshop participants to use in thinking about how to gamify their envisioned, new airport security services.

For a summary of the detailed findings, please see Appendix. Table 2: "Synthesis of motivational factors with the result of the gamified airport security service based on Klapztein and Cipolla (2016)", in which the authors have collected and synthesized the main results of the series of workshops.

The findings from the workshop strengthen the view and possibility to envision enjoyable, game-like experiences for others, which of gamification enhances the co-creation process by providing collective creative experiences for participants. Representative quotes from the participants' debriefing interview collected immediately after the gamification of the customer journey workshop, reinforce the importance of the structured approach and quality of the solution theme gamified airport security service.

Figure 1. and Figure 2. Student groups brainstorm with the Comicubes and co-create customer journeys for gamified airport security systems.

To give examples, participants commented the task given in the workshop, as follows: “the [Comi]cubes are enjoyable to work with, and they fit well in group working”. Moreover, students also experienced that collaborative working with the Comicubes is playful: some of the groups even played with the cubes as if they were a construction toy. They built and created slide and ladder-like structures (vertically, see Figure 3.) with the cubes. Some students commented that “creativity starts with the Comicubes”, or “the Comicubes lubricate creativity”. Another group of students employed the different sides of the cubes horizontally, so that they were able to envision different dimensions of the co-created airport security service. The use of a physical tool, Comicubes, was experienced by the players to provide assistance in approaching the given task through rapid prototyping. For example, one student said that with the cubes, the group “designed the different airport security check lines by drawing trails how to move through the security check point line and understood at the same time how easy the tool was to use when designing their ideas onto the cubes”. Another comment that was made about using Comicubes in playful way was given by a student: “I started building a tower with the [Comi]cubes and I felt the excitement brought in by the creativity of our group to implement gamification in the [envisioned] airport security service”.

Figure 3. A student group presents their idea of a gamified airport security system.

As observed by the researchers, all participating students quickly took over the Comicubes tool and gained momentum in their brainstorming. Comicubes invited them to a creative play situation, in which the students enthusiastically embarked on helping them to come up with ideas for gamified and improved security check services.

DISCUSSION AND CONCLUSIONS

A gamified service design process allows collaboration and co-creation with students during the design and execution phases. In our workshops, students ranged along a continuum from those who prefer little participation to those who sought to spontaneously co-create. The series of case studies presented in this paper were prepared to work with students who have diverse goals, resources and capabilities to generate ideas for innovative gamified airport security services. This also means that in the innovations and improvements to the airport security services envisioned in the three workshops require iterative learning as well as adaptation as an individual customer’s envisioned service experience unfolds.

The empirical data analyzed in the paper has been used to gain insight into the link between gamification and value co-creation in a service design workshop. As the workshops described were conducted in a simulated environment and not the real context of an airport, it is in place to consider the conducted study as an exploratory one only investigating the possibilities and potentialities of gamifying the described security service, not the implications of actual use. However, the findings of our study suggest that gamification plays a key role in supporting the co-creation by using a physical tool like the Comicubes for solution prototyping in order to co-create new services, outlined in four building blocks: group dialogue, structured approach, quality of the solution or service development and creativity.

Finally, as our case study illustrates, gamification enhances co-creation by providing groupwork and a peer-to- peer structured approach that ensures close interaction between different actors, encourages contributions from all participants and support high-quality knowledge creation in an open and creative environment. We believe the power of play with materials to extend to the realm of envisioning and designing new experiences in combination with using game elements to brainstorm and co-create concepts. Furthermore, in this study the value comes from the combination of the two key factors, that is, the engagement with a (toy-like and large-scale) solution prototyping tool like Comicubes in combination with the co- creation of a service design concept customer journey as a service design process. Play is an essential trait of evolutionary success and one of the strongest drivers of human behavior: In fact, it is constituent to almost every aspect of creative work. As a result, fun-seeking tasks together with the Comicubes prototyping tool facilitate workshop participants to narrate their designs and to envision motivational experiences to attract potential future users of service design.

As shown in the paper, the use of gamification together with a physical service design tool to solve a task to improve a challenging system known to exist at most airports, our study has shown positive results, which reinforce the notion that gamification works particularly well when applied to a situation where new airport gamified service is co-created by university students, i.e. multi-actors with different roles, backgrounds, and knowledge. Proper multi-actor engagement comes from intangible factors like motivation and novelty, as well as from more concrete ones, like successful narrations of high-quality concepts based on use of a tangible ideation tool, like the Comicubes.

Our aim is to take this design challenge into a real airport environment and challenge the current providers of the security service to think about what the kind of solutions could be co-created with customers to improve the security checking process by asking what kind of gamification of service design and new types of interaction with the service could bring to the future of airport security services, for example, by providing game-like elements into the customer journeys.

ACKNOWLEDGEMENTS

We wish to express our gratitude to Dr. Kati Suomi at Univeristy of Turku, School of Economics, Pori Unit this opportunity to make this study and all student for their participation in the workshops. Study is part of Gamecoast Network's workshop series in collaboration with Pori Laboratory of Play, which tests the application of gamification of service design real-life context.

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BIOGRAPHIES

PIRITA IHAMÄKI International business developer and researcher, PhD, currently works as the leader of the Gamecoast Network (part of the Robocoast DIH consortium) developing new gamified services to extend new technology innovations. Previously, Ihamäki has worked as a researcher at different universities, involved in product development and developed new methods for the study of user experience. She is a leading expert in the exploitation of geocaching, as well as the utilization of developed models of user experiences of treasure hunt games in tourism and educational contexts. Her research interests include social robots, gamified service design, Internet of Toys, toy tourism and co-creation.

KATRIINA HELJAKKA (Doctor of Arts) is a researcher at University of Turku (digital culture studies). Her background is in game design and research on toys and play. Previously, she has worked in the Academy of Finland funded research projects Ludification and Emergence of Playful Culture and Centre of Excellence in Game Culture Studies, and the Business Finland project Hybrid Social Play. Heljakka currently studies connected toys, playful environments, tools and techniques in the workspace, and the visual, material, digital and social cultures of play with her research group at Pori Laboratory of Play.

APPENDIX. Table 2: Synthesis of motivational factors with the result of the gamified airport security service based on Klapztein & Cipolla (2016).

Motivational components	Key Concept	Customer Perspective	Engagement	Reward
Voluntariness	Voluntary participation; the user is willing to use the gamified security service based on their enjoyment when queuing for the security screening.	Activities are set in motion through customer participation. Involved voluntary activities triggers people's interest. The idea of Group 2 (in workshop 2) was that there are four lines in the security service, one is for families with children, second is for young people, third is older people and the last line for everyone. When using the mobile security app, the family app includes different mascots and when going through the security line, the children see the mascots appear, and can download games and movies featuring them while waiting for their turn in the security line. For young people, the app presents challenges, such as Instagram competitions to participate in, while they are in line waiting for the security service.	The more pleasurable an activity is and the more voluntary aspects it includes, the more engaging it can become. Group 3 (in workshop 2) presented an idea for gamification of removing any bottles with liquids before entering the security check. The idea was that the security service started with the task of 'playing basketball' with the bottles, which are required to be left behind. There is, for example, a basketball hoop, and by throwing the bottles through the hoop, one may score points, which can be traded for example, for a free refreshment or some other price.	Activities must be attractive and intrinsically rewarding: participation must also be designed as a reward in itself. Group 4 (in workshop 2) designed a security service, for which one can choose a certain visual/thematic style for the gamified security check line, such as medieval. There is, for example, a kind of game in which the players need to arrange their things in different places so that a pickpocket will not take your things. If the player arranges the things in the right ways, s/he points with the game. In the medieval style game, one arrives to the security service and places his/her things in the dragon's mouth and receives prices based on the success in the game.
Rules	Activities need to support participants own goals, pleasure and rewards. Some rules come from action of gamified service design workshop in general. The Group 3 (in workshop 2) designed the following idea: in the beginning, people start the security service by playing by throwing bottles through a basketball hoop to get points. At the end of the security service player who scored points win prices.	Customer experience and engagement can be positively influenced by meaningful use of technology. The second idea of Group 3 (in workshop 2) employs modern water technology walls and floor, music, and sounds of birds, which give the users pleasurable experiences of relaxation, when they go through the security service check, and especially when they need to wait in line,	Game rules have to be designed to foster pleasurable activities that customers like to perform. Group 5 (in workshop 2) designed the idea of 'the five star security service', in which the pleasurable activity is to play the game of speed to be as fast as possible. The players are accumulating points already at the start of their customer journey, when they arrive at the airport. The rules are simple: players try to optimize the size and amount of all bags and goods they travel with. The players can even receive points for the weight of their bag.	Fun and reward increase with well set rules and game mechanics. Group 3 (in workshop 2) designed the idea, which combines music and water elements by using new (AR) technology. There is the game, for example, for children in which you jump on virtual stones without hitting water. If one doesn't hit a stone and go under water one loses points. More points for your security service line experience means bigger rewards for the participating players.
Control	Customers must feel in control over the performed activities. Group 5 (in workshop 2) designed the 'five start security service'. Many want to go through a five star security line, as it is the fastest route, through the security line. (The one star line is the slowest route.) The player gets points when arriving at the airport and when not having the wrong articles in your pockets or suitcase. The more points the players scores means making the way faster through the security check.	Activity demands have to be compatible with customer abilities and wishes. Group 5 (in workshop 1) designed a gamified security service check for families. The main goals of this approach was to raise on information, enjoyment and efficiency. According to the idea, the airport floor has printed steps on it and there are speech bubbles to remind players what to do next, for example, "do remember to open shoe laces because you will need to take shoes off soon". There are also QR-codes, through which more information is given, and mini games for children to entertain them.	Focused activities: the more focused a customer, the more involved and motivated he/she is. The second idea of Group 3 (in workshop 1) was the fast security service game, where players are competing about who is the fastest to go through the security service. This gamified approach motivates players to compete with others. Each day, a winner of this game will received a price. Sometimes one may even win priority seating arrangements on the flight.	Activities need to be designed as learning experiences, prepared through pleasurable actions in gamified security service. The idea of Group 5 (in workshop 1) was that there is also a virtual environment, in which you can practice which things should be taken into consideration at the security check counter. This mini game for families functions both as a learning game, as well as an entertainment game, where the player receives points in his or her airport app.

Objective	Goals can strongly influence user interest, commitment and desire. Group 5 (in workshop 1) designed an idea by seeing the airport like a mobile labyrinth game, which the player starts when arriving at the airport and ends when s/he steps on the aircraft after the security check. 'The Labyrinth game' also helps to reduce queuing time by encouraging families to find the fastest route.	Objectives must be clearly defined and easily understood. Group 4 (in workshop 1) designed different themes for the safety security checkpoint, such as safety with themes (for example, players can go through a Moomin-themed gate etc. and after passing there will be sound effects or even soap bubbles). By pressing a button, the players can have a video made of their journey through the security check, or when they have made their way through. The airport can use these potentially funny videos on terminal screen for the enjoyment of their customers and to show how to move through the gamified security service.	The reasons proposed for doing a task influence customer pleasure. Group 4 (in workshop 1) designed a security service with characters like Moomin involved. The characters help children to learn how to go through the security check service.	Goal achievement is the game design element that most often generates user pleasure. Group 4 (in workshop 1) had an idea, where they designed the airport into a Pokémon GO style of a game, where children look for QR codes and when waiting for the security check the line presents more QR codes. The players gets new challenges to solve and after solving one challenge, there will be others. Playing the game turns the wait into a pleasurable user experience.
Feedback	Feedback must be real time (if the customer uses a mobile phone), frequent and clear. Group 3 (in workshop 1) designed the idea for an interactive floor and mobile application, through which a player can receive useful information about his/her gate number, where the closest restrooms are located, and so on.	A user must always be aware of their action options and the rewards. Group 4 (in workshop 1) presented ideas on that players receive straight feedback when they go through the security check: if they have a problem it gives a normal beep sound, and vice versa, if the customer is okay, a sound appropriate to the theme of the game will go on, for example, communicated with the voice of a cartoon character.	Uncertainty, curiosity and surprise are powerful motivational elements, which feedback will shows with the customers. Group 5 (in workshop 1) designed a mobile labyrinth game in which the player receives feedback when solving challenges at the airport and going through the security system. After the player has finalized the labyrinth game, s/he is motivated to share their diploma with friends and relatives.	Rewards elements are key factors to motivate players. Group 3 (in workshop 1) designed a multidimensional feedback sound on the floor, light on the floor system that operates through the floor and is personalized through a smart phone: It can guide the player to the right gates or nearest restrooms. The floor will recognize the player and can speak even different languages depending on player's needs.
Social interaction	Emotions in a social context are generally more intense and pleasurable. Group 3 (in workshop 1) designed the idea that the airport floor has clouds on it, which light up when stepped on and there could be also sound. The idea is to generate interaction with players, and at the same time connect with an app. The player receives personal information for through the interactive floor and through the app, as the app has all details for specific players. Social interaction happens with other players through the game play and interaction with the floor gives different challenges that the players need to solve.	Certain emotions may arise only through the social interaction. Competition against real users is almost always more engaging than against virtual ones. Group 4 (in workshop 1) had a second design idea, where they designed a Pokémon GO style of a game for the airport. In this game the player user can is competing with others to solve challenges and receives more points, which give rewards, for example, more comfortable seating in the airplane or a free cup of coffee in the cafeteria.	The possibility of embarking on a collective freedom of self-expression and experiencing new situations are strong motivational aspects. Group 4 (in workshop 2) the players pass through the interactive thematic security check gates, and may have a video recorded of this experience, which can be shared with friends and family members. This gives more possibilities for self-expression, for example, by going through the security checkpoint gates in a funny way, for example, by making a somersault.	Social interactions are critical for pleasure and engagement in gamified activities. Group 5 (in workshop 1) designed a mobile labyrinth game, which delivers pleasurable engagement through challenges that help players pass through the security gates. For example, there is a virtual platform on which one can practice how to get through the security control the fastest way, by collecting one's own things on the security check table in an optimal way.
Perception	In gamified experiences, such as the gamified service design workshop students' experience, the focus needs to be on entertainment and pleasure. Students have successfully envisioned, prototyped and narrated their designs of gamifying the airport security service by creating concepts with Comicubes, which students describe as a tool that is easy to use for idea creation, as well as a gameful/playful tool, which can be used for narrating the experience.	Activities should make users feel like they are integrated in gamified environment, or in this case, an airport security service environment. In Group 3 (in workshop 2), the second design idea was that they use modern technology, like water technology for walls and floor to integrate users' interest more in the environment. The water walls make strong instruments and allow a gamified environment by game challenges, in which games and security service are tied together.	Motivation should be stimulated by positive and by the desire to participate in successful and meaningful ways for the customers. Group 6 (in workshop 2) designed an idea for an app in a movie theatre, where one can scan and upload movies from the walls and see them on the smart phone to entertainment oneself. This gives the player positive experiences by making the waiting time in the security control more meaningful.	Context and reason for doing an activity are fundamental to the generation of pleasure. Group 4 (in workshop 1) had the idea of making a similar game as Pokémon GO, which allows a shared, pleasurable gaming experience for players where they have the possibility to play alone or in groups at the airport. The idea follows the idea of a location-based game and is pleasure and entertaining as well as useful for players, as they receive advice through the game.

Designing a Mobile Game to generate Player Data – Lessons learned

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KEYWORDS
Design, Prototyping, Datasets, Mobile Game Design

ABSTRACT

User friendly tools have lowered the costs of high-quality game design to the point where researchers without development experience can release their own games. However, there is no established best-practice as few games have been produced for research purposes. Having developed a mobile game without the guidance of similar projects, we realised the need to share our experience so future researchers have a path to follow. Research into game balancing and system simulation required an experimental case study, which inspired the creation of *"RPGLite"*, a multiplayer mobile game. In creating RPGLite with no development expertise we learned a series of lessons about effective amateur game development for research purposes. In this paper we reflect on the entire development process and present these lessons.

INTRODUCTION

In this paper we detail our experience of creating RPGLite[1], a multiplayer mobile game, developed to provide an experimental dataset to support ongoing research into game balancing (Kavanagh et al. 2019) and system simulation (Wallis and Storer 2018).

RPGLite is an application developed in Unity and distributed on the iOS and Android app stores. It has a server-side REST API, written in the Flask framework, which manages a MongoDB database, for both managing the state of the game and collecting player data for later analysis. Between the public release in April 2020 and the time of writing in July 2020, we have gathered data on over 8,000 completed games for analysis.

The motivation for sharing this experience report was our own frustration at having nothing similar to support us when we embarked on this project. While literature exists pertaining to the engineering of mobile games (Aleem et al. 2016), relationships between academic and industrial game engineering are poorly studied, particularly with regards the use of user telemetry after the game's release (Wallner et al. 2014). In providing reflections upon the successes and failures of our approach as a series of lessons we learned, we hope that this paper can guide other researchers considering a similar project.

[1]RPGLite is available from https://rpglite.app/

LESSON 1: RESIST TEMPTATION

At many points in the development process, we found it difficult to constrain the feature set of the end product. We also fretted over design decisions to a degree of detail that was unimportant. We found that rather than developing a robust data generation platform we were developing for our own enjoyment.

Many ideas came to us during development and resisting all of them would have resulted in a poorer product, however only some were beneficial to the player experience. We spent an equal amount of time developing the ranking system and leaderboard as we did player profile pages. From feedback we know that the leaderboard was a key motivator for many players. The leaderboard page has been visited over three times as often as the profile pages. It is unclear whether the profile pages had any impact on player experience or the amount of data generated. During development it was impossible to know how often a feature would be used in practice. We advise researchers to prioritise systems that are functional requirements or that they know will improve data generation and to keep to a strict time budget for additional features.

Our emotional investment in the project lead to extensive refinement of existing features. Existing design components, such as colour schemes and layouts of minor UI elements, were constantly changed prior to release, even beyond acceptable states. When developing public-facing applications for research, creating original assets is a labourious process, moreover it is rarely necessary. Many free-to-use assets exist and are easily available from sources such as the Unity marketplace. The most effective portion of RPGLite's design were the character artworks we used under a Creative Commons license.

To resist temptation in similar projects, we suggest the following. Firstly, a project should have a plan produced at its inception, which is maintained throughout the development process. Second, we suggest adding to this

plan a "margin"; a block of unallocated time at the end of the project that can be spent on developing new ideas. As development progresses, this margin can be "spent" on new ideas or refinements to existing design elements. This facilitates necessary discussions by framing them within the context of a shared resource.

LESSON 2: EMPLOY AVAILABLE RESEARCH NETWORKS

Advertising is a major cost of app development; new users are expensive. We had no promotional budget, so we sought out opportunities for free publicity from within our research community. There is an appetite for open data and by encouraging people to play our game "for science" our promotions were better received. We anticipated undergraduate students would make up the majority of our users. However, while promotions targeted at undergraduates introduced a large number of users, those users tended to only complete a few games before stopping. This was a significant issue for us as over half of our users failed to successfully complete a single game, and several users installed the app without registering an account. We observed that retention was highest within players who had a vested interest in us or the research itself, or when the game was adopted by users from a social clique.

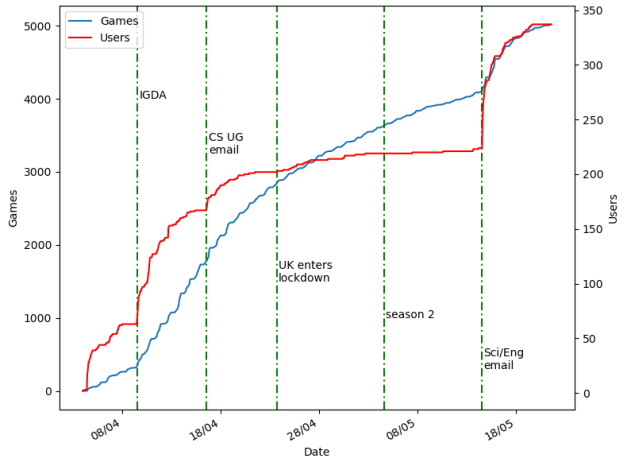

Figure 1: The rate of user acquisition in the weeks following RPGLite's release. Important events are also marked: promotion of the application through the Scottish International Game Developers Association branch, an email to Computing Science undergraduates at Glasgow, the date from which UK citizens were told to stay at home if possible (due to COVID19), the time of a major update to the game and an email to students in Glasgow's Science and Engineering College.

We compared the effect on data generation of events we anticipated would have an effect user acquisition fig. 1. The International Game Developers Association (IGDA) shared an advert about the game. The increase in the speed of game completions accompanying the influx of new users from their involvement shows that those players were valuable data generators. The increase in games following the email to the Science and Engineering college quickly dissipated. We believe this is due to either the lack of a relationship with us as the developers or of interest in games research. We assumed that a large update might increase activity, but found that not to be the case. A single large update changing the configuration of the game, adding seasonal leaderboards and improving existing features had no noticeable effect on the number of games completed.

Many of our university colleagues had been involved in various aspects of application development and deployment, and advised us throughout. For example, a web designer gave advice on UX design and a gamification researcher suggested various incentivisation systems. We also relied heavily on our department's IT services team for support in deploying the server used to manage the game and administrative staff for promoting the app once it had been released. Application development is multifaceted and the support of our peers was important in areas where our skills were insufficient.

Without the extensive use of the research communities we belong to, RPGLite would have been an inferior application. Our research networks supplied skills we lacked and brought a high degree of player retention.

LESSON 3: THE SMALLER THE CLIENT, THE BETTER

The one aspect of RPGLite's implementation that we most regret is the amount of game logic in the client rather than the server. The need for moving logic out of our client became apparent when a player discovered a bug where, after playing enough games, characters that had been unlocked through repeated play would become locked again and could no longer be accessed. Had this bug been in the server, the issue could have been fixed, and a new version deployed in seconds that clients could connect to. With our larger client, this required testing in Unity, testing on-device (to ensure that there weren't platform-specific bugs), and deployment to app stores for approval and distribution. This process took days, even though the bug was trivial to fix.

Large clients risk introducing a duplication of code when paired with a secure server. To validate game logic computed by a client, servers must replicate much of the processing the client previously performed, to verify that a malicious user hasn't supplied corrupted game states. This process requires the implementation of game logic within the server. As a result, a secure server must include game logic regardless of whether the client does. This means spending time, a scarce resource, on duplicated code. This is another reason we recommend

developing a lightweight client, leaving the majority of computation to a larger server.

LESSON 4: TEST EARLY, TEST OFTEN

The best source of feedback and advice we received was from the shared document circulated alongside our two private test releases. We specifically chose friends and colleagues who knew us well enough to be able to have honest discussions on weaker aspects of the application. We were able to implement the majority of the suggestions made, many of which have become central components in the final game. This stage highlighted the importance of push notifications and streamlining the user experience. Specifically, our test users found that they would often forget to check whether they had moves to make. Before testing we had investigated the feasibility of implementing push notifications, but were unsure if they were worth the time to develop. Following testing feedback, we made this a priority.

Figure 2: Evolution of the Barbarian card artwork throughout the design process from initial prototype (*left*), to internal testing version (*centre*) and current version (*right*)

As shown in fig. 2, character cards went through a series of designs. Responding to test feedback that character cards were too complicated, the final designs were significantly simpler. We also received specific advice, such as obscuring the action description of a stunned character to make it clear that they could not act. Having an ongoing dialogue throughout development with invested parties meant that we could rapidly pivot to accommodate their suggestions.

From analysis of our test data we discovered a gap between the data we were collecting and possible useful information we could capture. In particular, we realised we could log user interactions with the application (for example, "a user searched for another player by their username and found they had no free game slots"). This idea was a result of realising that even amongst our dozen test users, there were distinct styles of interacting with the application that might be useful in later analysis.

Testing allowed us to identify areas in both the application and the dataset that were lacking. We would encourage future researchers to get early versions of their applications into the hands of testers multiple times before finalising their system. We structured the format of the feedback we received from testers in our shared document by grouping requested feedback under specific headings and directing them to features in which we lacked confidence. This helped to scaffold the insightful conversations amongst our test users, and we strongly recommend others make an effort to facilitate a similar dialogue.

CONCLUSION

In releasing RPGLite we learned several lessons about the realities of mobile game development within research. We have outlined our key insights and hope that these will be helpful to researchers developing similar tools. To summarise, the lessons that we learned are: to beware of scope creep and lengthy feature refinement; to utilise one's research community for their expertise and engagement; to use a server-centric architecture, permitting rapid bug-fixing and avoiding duplication of code, and; to test as soon as you have a workable build often thereafter.

We hope that these observations are helpful to other researchers developing similar projects. If they are, we encourage them to document the methodologies they follow for building data-generating games for the benefit of others engaged in similar projects, and the lessons they learned doing so.

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TOWARDS THE CREATION OF A CONCEPTUAL FRAMEWORK IN THE CONTEXT OF GAMERS4NATURE TOOLKIT TO GAME DESIGN

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KEYWORDS
Toolkit, Game Design, Digital Games, Game Elements, Conceptual Framework.

ABSTRACT

Encouraging learners to create their own games reveals learning outcomes beyond conventional learning and thinking. Aiming to encourage the active participation of youngsters in the creation of mobile games related with environmental conservation, a Toolkit to Game Design was developed in the context of the Gamers4Nature project. This paper describes a fundamental step in this process, the definition the Gamers4Nature Toolkit to Game Design conceptual framework. The framework emerged from a literature review on game concepts and game design and from discussions, in the format of individual interviews and focus groups sessions held with experts and designers/developers in the game field (N=14). The framework, which approaches game design as a dynamic system, evolving around narrative, goals and outcome, was adopted as the basis for the construction of the game construction cards set, one of the Toolkit's resources. The Toolkit can be considered as a dynamic and useful approach for the development of strategies designed to support game design activities.

INTRODUCTION

Research on the impact of games on human behaviour has, for many years, been focused on the negative aspects of digital games, namely in the promotion of aggressive and violent behaviour (Anderson 2004; Anderson and Bushman 2001), the consequences for self-regulation of playing time (Ogletree and Drake 2007), and the development of addictive behaviour (Griffiths and Davies 2002) and social isolation (Merhi et al2007). Despite this research development in the negative aspects of digital games, there has been a growing research development in the positive impacts of digital games on learning, motivation, knowledge acquisition, skills development and behaviour change (Briot et al. 2011; Connoly et al. 2012; Gee 2008; Jeffrey 2015; Robertson 2012; Vos and Denessen 2011).

Technological development and the emergence of tools created to be used by individuals with little experience in the programming field blurred the line that separates game creators and game players, giving the latter the possibility of designing their own playable resources.

Young people feel motivated to create games similar to those they like to play (Good and Howland 2017). Seeking to capitalize on the interest of the younger public in the area of digital game development, the Gamers4Nature project aims to design and implement strategies able to encourage the active participation of this public in mobile game creation to promote knowledge about environmental preservation and biodiversity conservation.

These strategies include the development of a Toolkit to Game Design – the G4N* Toolkit - where G4N is used as the project's acronym and the asterisk represents the wildcard charactes widely used in code (Beça et al. 2019).

The G4N* Toolkit seeks to support and ease the process of designing games by allowing users with and without experience in game design to manipulate and explore its several elements. One initial and fundamental step of for the G4N* Toolkit development was the establishment of the Toolkit's conceptual framework.

In this paper, the process of defining the G4N* Toolkit's conceptual framework is described. Defining a conceptual framework is considered as a key part of any research design, a way to communicate ideas, identify concepts and the connections between them (Ivey 2015). Usually translated into a visual or written product, conceptual frameworks explain and define the main things to be studied and addressed along the research process: the key concepts, variables, and relationships between them (Bickman and Rog 1998).

To understand the process that underlies the design of a game, and to establish the project's conceptual framework, it was important first to reflect on what a game is and what the fundamental features of games are. The results are presented on "Theoretical Framework" section as well as important considerations about having players involved in game design. "Defining the G4N* Toolkit's conceptual framework: methodological approach" introduces the methodological approach adopted. "Results" presents and discusses the findings and presents the resultant conceptual framework. The paper ends with a final discussion, and a final considerations section where potential directions for future work are presented.

THEORETICAL FRAMEWORK

Present from childhood to throughout most of adult life, in leisure activities and in more structured contexts, games and playing have been part of human nature since ancient times,

playing an important role in the development of the intellectual, physical and social capacities of the individual. As a result of the human desire to play and the human capacity to pretend and represent, games emerge related to activities that take place in the context of a make-believe reality, an emotional place where participants – voluntarily submitted to pre-defined rules – strive to achieve certain goals (Adams 2014). Simultaneously a social activity and a cultural phenomenon (Huizinga 2001), games arise as an experience where uncertainty about the result, and the freedom of action inside what is defined by its rules, keep the player engaged (Callois 1990). Tensions, boundaries, rules, all these dimensions are part of the game and valid only for the time the game takes place: by entering the game, the player enters into the "magic circle", a temporary arena within the real world where conventions, hierarchies and everyday rules are temporarily suspended (Huizinga 2001).

Games evolve within a previously delimited field (limited in a material or imaginary, deliberated or spontaneous way), a temporary world with rules and tension that exist during a specific activity (Huizinga 2001). This relationship between rules and game is established by several authors, as demonstrated by Salen and Zimmerman in the book "Rules of Play" (2004). For the authors, games are systems in which players engage in artificial and structured conflicts, defined by rules.

Games are complex systems, composed by elements (e.g. rules, resources, players, results, uncertainty, involvement, objectives, among other) that relate with each other in order to create a unique experience for the user. In this system, rules play an important role, providing the player with the necessary information to optimize his choices and to know the consequences of his actions (Adams 2014).

Hunicke et al. (2004) present a formal approach to understanding games in their MDA (Mechanics, Dynamics and Aesthetics) Framework – a lens to understand games, where the player experience (aesthetics) emerges through interactions (dynamics) with the game rules (mechanics).

Based on a literature review, Jull (2005) describes games as being a rule-based system with negotiable consequences, where the player works in order to influence the outcome while feeling emotionally involved (Juul 2003). For the author, these game characteristics can be organized in three dimensions: the game as a formal system; the interaction between the player and the game; and what relates to the game and the rest of the world.

Elias et al. (2012) also approach game as a system, reinforcing the importance of playing time, number of players and heuristics as basic rules in game design. For the authors, the uncertainty and perceived randomness of games are important to maintain the attention and interest of the player, and the heuristics (present in the reward and feedback system) are important for the player as they allow him to know whether he is winning or losing, and to know what to do next.

Games as systems is a concept also addressed by Martinho et al. (2014), to whom a game is a system built by participants while playing, by the physical artefacts that may be used in this activity and by the rules that regulate that activity.

Fullerton (2014) describes games as formal systems that involve players in a conflict subject to rules and that results in an unequal outcome. For the author, a game has formal elements (players, objectives, procedures, rules, resources, conflicts, boundaries, outcome) that form the structure of the game and that articulate to create in the player the experience of being in a game; and dramatic elements (challenge, play, premise, characters, story, world building and dramatic arc) that emotionally involve the player and contribute to his the commitment to the game. Furthermore, the author states that games are systems, where the formal elements contribute to a dynamic experience with which players get involved, and where objects interact with each other according to their properties, behaviors and relationships, changing the state of that system.

Macklin and Sharp (2016) mention actions, rules, goals, objects, playspace and players as the basic elements of play design, from which limitless play experiences can emerge.

Players Designing Digital Games

In recent years, digital games have taken over part of the territory filled until then by traditional games, bringing significant changes into the way individuals spend their free time and revealing positive impacts on learning and motivation (Connoly et al. 2012). While being resposible for the design of their own digital games, students acquired scientific concepts and developed technological and digital literacy skills (Huizenga et al. 2017); became more interested in programming and design activities, worked on scientific concepts and became more involved with the addressed subject (Falcão et al. 2018). Digital game design activities also led to more responsibility and better attitude in group work (Falcão et al. 2018) and promoted student's sense of accomplishment and self-confidence, making them more engaged with the coding and implementation process (Papavlasopoulou et al. 2019).

Digital game creation is considered by young people as being highly appealing, as they feel motivated to develop games similar to the ones that are used to play (Good and Howland 2017). It must be stressed, however, that creating a game requires a rich and extensive set of knowledge and skills. Game designers are asked to think about end-users, the interaction between users and the game, to be able to present their ideas, describe design features and reflect on the impact their games have and their relevance, as media, in relation to other media (Salen 2007).

DEFINING THE G4N* TOOLKIT'S CONCEPTUAL FRAMEWORK: METHODOLOGICAL APPROACH

The involvement of students in the creation of their own games may increase the interest toward the addressed theme, allowing for the acquisition of scientific concepts and the development of digital literacy along the design process (Huizenga et al. 2017). Nevertheless, research also points out that low or undeveloped programming skills and a lack of interest in the educational subject (Falcão et al. 2018), as well as a tendency to focus on the storytelling and character development and to ignore the gameplay mechanics and content integration are often identified as obstacles when involving younger audiences in game design activities (Ke 2014; Howland and Good 2015).

Taking these two aspects into consideration, the project Gamers4Nature aims to design and operationalize a set of strategies that encourage the active participation of the youngest audience in game creation, namely mobile games,

while promoting knowledge about environmental preservation and biodiversity conservation.
One of these strategies is the development of the G4N* Toolkit to Game Design, designed to support upper secondary and undergraduate students in the process of developing a game. The G4N* Toolkit comprises a set of resources and tools designed to help in the creation of mobile digital games: a game construction cards set; a rapid game design document; and thematic cards addressing a nature preservation theme.
Prior to the resources' development, and considering the several perspectives on game and game elements addressed in the literature review, there was the need to establish the conceptual framework that would guide the Toolkit's resources development. Participatory Design (Spinuzzi, 2005) was used in the establishment of the conceptual framework, which development and validation process is described in this paper.

RESULTS: G4N* TOOLKIT'S APPROACH TO GAME DESIGN

As addressed in the literature review, game design emerges from the relation between the output of the game design development and the user's experience while playing the game. From the review, three approaches were considered as being more in line with the G4N* Toolkit to Game Design goals: i) Juul's perspective of game as a structure evolving around its formal system, the relation between the player and the game, and the relation between the game and the rest of the world (2003); ii) Hunicke's et al. MDA framework (2004); and iii) Fullerton's playcentric approach to game design (2014). Taking into consideration the project's target audience – upper secondary and undergraduate students who may or may not have experience in creating games – Fullerton's (2014) perspective was considered as being the most adequate, as it presents an extensive description of several game elements (19) and the relation between them.
As this approach would benefit from further validation, experts and developers from the game design field were invited to discuss each element and its relations. It was intended that participants could discuss all game elements without any guidance or constraint. For the discussion around game elements and what composes a game, a set of 19 hexagonal cardboard pieces with 3cm side (Fig. 1), one for each game element, was created.

Figure 1: Hexagonal Cardboard Pieces: Game Elements

Each cardboard piece had on each side the game element's name, and all cardboard pieces had the same color and size; this way, participants could explore and talk about the game elements freely, without being conditioned by any information about the importance, connection of hierarchy of that game element. The hexagonal shape allowed the connection and aggregation of elements, fostering the construction of concepts or idea maps. In order to promote the eventual construction of mind maps, a tray (size: A3) with a honeycomb structure was also distributed to each participant, to be used – if needed – during the discussion. Four individual interviews with game design researchers and a game developer were carried out, and two focus group sessions were held with postgraduate students with expertise in the game design field.

Individual interviews: "What elements compose a game?"

Four individual interviews were conducted with three experts and one game developer: experts were academic researchers from the game design field, and the developer has been working in game development for several years.

Asked to talk about what game elements must be considered when designing a digital game, each participant was invited to explore the cardboard pieces and the board freely, following the think aloud protocol, with no additional information about the meaning of each element or the literature review on which the project was based.
To expert A, the game starts from the premise, a concept that helps to create the game's narrative, which, by turn, helps the premise to evolve. Story helps to define the player and to create and develop the characters, while conflicts can be related with the conflicts players face while playing the game. To this expert, the dramatic arc is related with the story, and the game's procedures are connected with the rules, challenges and behaviors.
Expert B pointed out that all games must have an outcome, a termination condition. Objectives or goals are linked to those conditions, and the mechanics allow the player to achieve the game goals and, at the same time, bound his/her movements inside the game. Games start with a challenge that must be engaging in order to keep the player interested, and play is related with game mechanics and gameplay; procedures emerge as a way to achieve the game's objectives or goals. Boundaries are set by the rules.
Expert C used the cardboard pieces to address the reasons that lead players to play. To the researcher, there are three main players' profiles, structured according to their playing preferences: symbolic or abstractionists, hardcore gamers who try to test the game limits; simulators or creators, who explore the game to see if what they are doing works within the game world; and narrative and story builders, who are driven by the desire to experiment and engage with the story.
The fourth interviewed, the game developer, mentioned that, when designing a game, it is preferable to start from the concept and premise and then establish mechanics and other game dimensions: rules, behaviors, play (as gameplay), challenge, objects (creation of assets), properties, outcome and boundaries.

While talking about which elements they considered essential in the design of mobile games by young students, all experts mentioned rules, goals, play, challenge, boundaries and outcome; three mentioned character, player and procedures; and two mentioned story, premise, world building, resources, dramatic arc and conflict. As for properties, objects, behaviors and relationships, Fullerton's (2014) system elements, it was pointed out that they required deeper knowledge of game design and game dynamics; therefore, these elements should be presented only after all the other elements were mastered.

The experts' perspective towards the importance of each game element is represented in Fig.2, with the most addressed elements being represented by the wider circles.

Figure 2: Elements Essential to Game Design: Experts' Perspective

Focus Groups: "What elements compose a game?"

The 9 ICT postgraduate students that participated in the two different focus group sessions were students from the same Master's degree course and were well acquainted with the process of game design.

During the two focus groups sessions, participants were invited to identify which elements were essential to design a game. From the 9 participants, 6 mentioned story; 5 mentioned rules, premise and challenge; 4 mentioned boundaries, dramatic arc and character; 3 mentioned goals, outcome, procedures and world building; 2 participants mentioned resources and conflict, and 1 player mentioned play. In line with the expert's opinion, they also considered objects, behaviors, properties and relationships as elements that required deeper knowledge of game design and dynamics, and therefore should be introduced only in a second stage of the game development process. Elements of the first focus group suggested "feeling" as a possible element to add to the Toolkit to Game Design.

When talking about the games they considered as being essential when designing a digital game, focus group's participants mentioned history and premise as the most referred elements, followed by challenge and character and rules, resources, universe and dramatic. The postgraduate students' perspective towards the importance of each game element is represented in Fig.3, with the most addressed elements being represented by the wider circles.

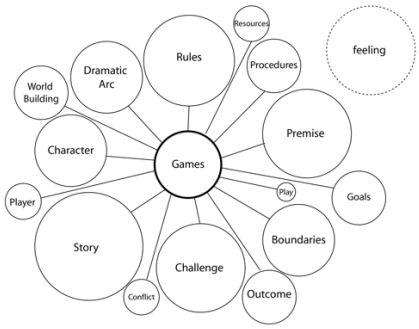

Figure 3: Elements Essential to Game Design: Postgraduate Students' Perspective

FINAL DISCUSSION

Along the individual interviews and the focus group sessions, it was possible to identify the elements participants considered essential for the design of a digital game, and also to understand the relations that, according to participants, could be established between the different game elements. By using the hexagonal pieces, participants were able to explore ideas, articulate thinking, establish relationships of dependence or symbiosis between game elements, which resulted in the construction of different structures capable of translating the various perspectives of what could be the design of a game: a) a process centred on challenge; b) an object built from the premise; and c) even a dynamic resource that is built from what keeps the player engaged. Asked to identify which elements were considered as being essential in the design of a game, all experts mentioned challenge and rules, while objectives, outcome, player and procedures were mentioned by three participants. In the focus group sessions held with former Master's students, history and premise are the elements most mentioned, followed by challenge and character and rules, resources, universe and dramatic arc.

The properties, objects, behaviours and relationships (system elements), were considered by both respondents and focus group participants as elements that would require a deeper knowledge of game design and dynamics, and therefore they should be presented to the target audience at a later stage, when they already had a mastery of the other elements.

From the analysis of participants' inputs, a conceptual framework (based in Fullerton's (2014) work) of the G4N* Toolkit to Game Design emerged. The framework, approaches game design as a dynamic system evolving around premise, goals and outcome (Fig. 4).

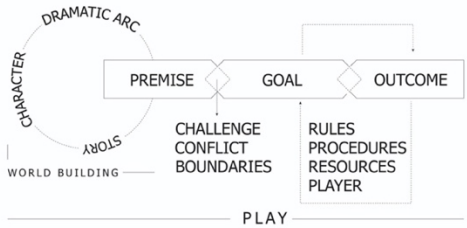

Figure 4: G4N* Conceptual Framework to Game Design (based in Fullerton, 2014)

In this framework, the relation between the premise and goals define the challenge, the conflict and settle the game's boundaries. Goals are strongly related with the game's outcome; in this relation, rules, procedures, resources and the player have a preponderant role. Play becomes the result of the player's experience while playing the game. As for properties, objects, behaviours and relationships, they were considered as elements that required a deeper knowledge about games and therefore were not included in this framework. It is also important to mention that, as the Gamers4Nature project's is closely related with achieving a specific goal – environmental education through creation of games – it implies a strong component of narrative and eventually storytelling. The possibility that this might have led participants to guide their thoughts following a narrative to outcome path, not starting from mechanics or gameplay, should be taken into consideration.

FINAL CONSIDERATIONS

In this paper, we described the process of defining the Toolkit's conceptual framework, which emerged from the literature review described in this paper and from the inputs of experts and designers/developers from the game field. The framework approaches game design as a dynamic system that evolves around premise, goals and outcome. The results presented in this paper made it possible to expect that the G4N* Toolkit to Game Design conceptual framework could be adopted in the development of artefacts designed to engage students in technological-learning activities related with game creation, in different education disciplines and fields. In fact, the research team of G4N has already adopted this conceptual framework as the basis for the construction of the game construction cards set, one of the G4N* Toolkit's resources, which was already used along several game design sessions, held with upper-secondary and undergraduate students. During these sessions, participants worked on the game's rules and procedures, defined the number and the role of the player, designed and integrated resources; defined the story, the characters and the dramatic arc, while working on the conflict and challenge that keep the player engaged. As a result of this process, 32 playable prototypes of digital games emerged.

ACKNOWLEDGEMENTS

This work is part of the Gamers4Nature project, PTDC/COM-OUT/31047/2017, that has the financial support of FCT - Foundation for Science and Technology (Portugal)/MCTES – Ministry of Science, Technology and Higher Education and FEDER under the PT2020 agreement.

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AI in Game Design

HOW TO MAKE A HORROR GAME SCARY: A CASE STUDY

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KEYWORDS
Horror games, game AI, immersion, suspense.

ABSTRACT

Nowadays, horror is a relatively popular game genre. Successful horror games like *Man of Medan, Blair Witch, Walking Dead* and *Resident Evil 2* demonstrate that game designers are able to make players feel scared and captivated at the same time. It is interesting from both psychological and technological perspective how this effect can be achieved, and how player emotions change during interaction with the game. In order to learn individual instruments that contribute to the overall atmosphere of the game, we set up a simple horror-themed game based on a freely available Unity project — *John Lemon's Haunted Jaunt*. Our goal is to add, modify and remove specific game elements and study their impact on user perception of the game. The present paper discusses our ongoing experiments and preliminary findings.

INTRODUCTION

Horror is clearly a negative emotion, and yet horror books, films, and video games enjoy a wide and loyal following. Why do people enjoy horror entertainment? There is no clear and definite answer to this question. A large number of research works are dedicated to the phenomenon of a horror genre, and different explanations have been proposed. For example, Zillmann's excitation transfer theory argues that our enjoyment is caused by the feeling of suspense, followed by resolution [1]. It has also been suggested that enjoyment can be associated with the portrayal of destruction, with excitement, and unpredictability [2]. Furthermore, researchers observe that the very experience of emotional arousal is attractive on its own [3].

While most studies in this area are seemingly devoted to horror films, horror video games also attract the attention of researchers. Being inherently interactive and immersive, video games often rely on techniques that can be notably different from the instruments used in horror books or movies. There are extensive essays of the history of the horror game genre, as well as discussion of the elements implemented in successful horror games [4, 5].

Our primary goal is to explore how such elements translate into immediate user experiences, and whether the users subjectively perceive the game as more or less scary and/or exciting as a result of modifying specific game components. While this work is still at an early stage, we were able to trace how gradual introduction of certain game elements has turned our test project into a real albeit very simple horror game, as confirmed by independent testers.

FEATURES OF THE TESTBED GAME

Our starting point is a very simple escape game called *John Lemon's Haunted Jaunt* [6] initially created as an educational project for beginner Unity developers. In this game, the player needs to control a cat who has to hide and eventually escape from the ghosts haunting an old mansion. Technically it can be classified as a horror game, but the overall style is so adorable that it looks more like a game for kids (see Fig. 1). Therefore, this game can serve as an appropriate setting for gradual introduction of more "horrifying" elements.

Figure 1: John Lemon's Haunted Jaunt

Following observations found in the literature, we decided to focus on the following aspects of the game for now: 1) positioning the camera; 2) altering the enemy AI system; 3) introducing sudden changes in the game environment with brightness and audio. Sixteen test subjects volunteered to help us in testing the game. This group consists of five females and eleven males with age between 18-30. Seven test subjects played horror games before, while others never tried.

IMPLEMENTATION DETAILS

Change of Player's Vision

John Lemon's Haunted Jaunt is originally a third-person game. The camera faces a fixed direction and is placed far away from the player character, which makes ghosts easily noticeable. Such choice of camera positioning has a notable effect on horror experience. A fixed camera for horror games has an advantageous capability to force the player to experience certain horror plots. However, it also has certain issues like non-camera-relative controls, which could be confusing when the player has to escape certain danger quickly [7]. To evaluate the impact of a fixed-angle camera, we have changed the camera from a third-person to a first-person view. We also added free camera control, which enabled the player to gather more information from the

environment and have more control over the game in general. Furthermore, first-person view makes the game experience more vivid and real (see Fig. 2).

All of our test subjects prefer the first-person view rather than a fixed-angle camera, since it provides a more immersive experience. Five testers think a third-person view with a player-controllable camera can be effective for creating a horror atmosphere as well, like in Dead Space and Resident Evil games, where the player is able to see character surroundings, which also can be horrifying. For our game, however, they still agree that the first-person view is more suitable for creating a horror-like atmosphere for the player.

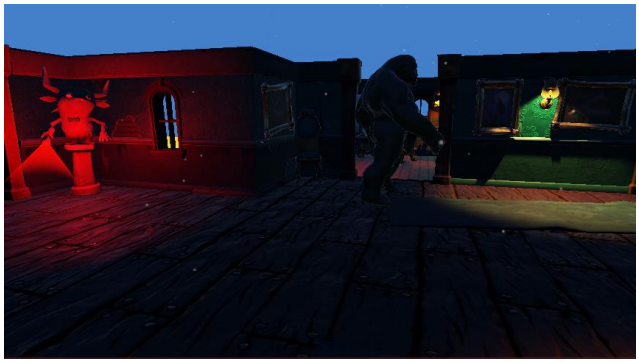

Figure 2: First-Person View in *John Lemon's Haunted Jaunt*

AI-Controlled Enemy Characters

AI-controlled characters play an important role in horror games. We added two new enemy ghost types in addition to two types originally built-in into John Lemon's Haunted Jaunt.

The simplest type stands still and checks the player's presence with a flashlight. If such a ghost notices the player, the game ends immediately. We placed three of them in different areas. Another type of a ghost just walks in a predefined route until the player is nearby. The player has to find ways to avoid them, or else the game will be ended. We also placed three such ghosts in different paths. The third type can sense the player's location. It will find the player character and follow it everywhere. We included just one ghost of this third type. We believe that in horror games harmless yet troublesome obstacles can also make players panic and mad. Unlike other AIs, the third ghost type is harmless but annoying. It will find and follow the player character to hinder its movements, providing a somewhat traffic jam-like experience. The last (fourth) enemy type will hang around randomly in the house. When the player is too close, this enemy will chase it. If the player keeps distance in a specific range, this enemy will move around the player slowly until the player gets further away, and then the enemy will get back to walk, or the player gets closer to the enemy and trigger chase. There is also just one ghost of this type in the game. If the player cannot escape it, the game will end (see Fig. 3).

According to the testers' reports, the first and the second ghost types are commonly considered to be cute rather than scary. However, since these types catch the player most frequently, they make it harder to the player to escape from the puzzle. Ten of the testers think the third type of ghost is scary because they did not know this ghost cannot kill them, so they try to avoid it. Since this ghost is always moving towards the player character, the testers feel they have to move all the time. After they realize this ghost cannot kill them, they just consider it annoying. Finally, all of the testers agree that the fourth enemy type — the zombie lady — is scary because of her appearance and animation. The behavior of the zombie lady is also one of the reasons they get scared.

Figure 3: AI-Controlled Enemy Characters

Sudden Changes in Game Environment

Whenever people watch horror movies or play horror games, they feel unsafe when the environment is being dramatically changed. Thus, they feel the need to escape as soon as possible. Grip observes that good horror games actually offer scarce terrifying moments, mostly providing the atmosphere of suspense and anticipation of horror. He offers a "roller coaster" analogy: the actual ride (and especially the scariest moments) do not last long; the whole experience is built largely on the anticipation of the ride, on emotional expectation [9].

In our game, we have currently implemented a trigger at the door of the bathroom. Once the player gets into the bathroom, the room's walls will change to the walls with arms and eyes, the floor will be bloody and red. The shower ghost in the bathtub will become the third type of ghost to start to chase the player. Besides, a loud screaming sound and a hell-like sound effect are played. Generally, people will be frightened by loud sounds when they are in a dramatically changing environment, so we believe they will panic when facing this situation. When the player leaves the bathroom, all the above-mentioned effects disappear (see Fig. 4). We also made several jump scares in the game: once the player activated the trigger, there would be a red giant monster jump out and scream for seconds. During jump scare activation, player vision is blocked by a black scene (see Fig. 5).

Jump scares do play an important role in horror games, and all of our testers think the jump scares are the scariest elements in the game because they appear unexpectedly. Some of our testers mentioned that the black scene during jump scare activation also makes them feel panic and anxious.

Bathroom location changes are not that scary: eight testers perceive them chill rather than horrifying. They do not understand what to do when they are facing this situation, but after getting used to new conditions, they do not feel afraid anymore. One of our testers missed the bathroom location completely. The rest of the testers were frightened by the sudden change in the bathroom, and were impressed by the wall arms and sound effects.

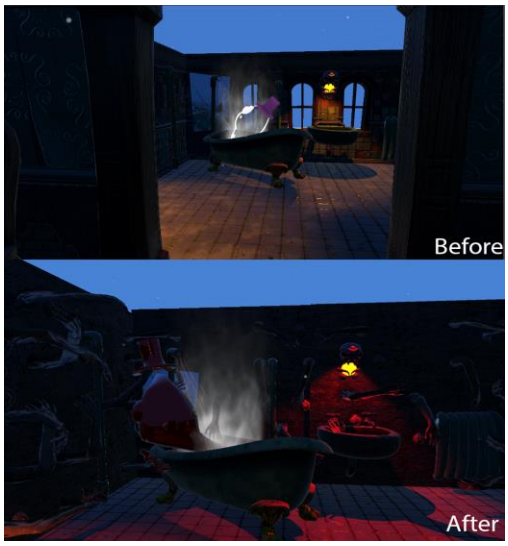

Figure 4: Effect of a Trigger in the Restroom Location


Figure 5: Example of a Jump Scare

DISCUSSION

It is known from past studies which elements can be used to create a horror-like atmosphere in a computer game. While it is clear that one cannot add or remove them in a straightforward, mechanical manner, it is still interesting to analyze the relative contribution of individual elements and their perceptions by the gamers. We believe that one possible approach for this kind of a work would be to create a game world where such elements can be easily introduced, and to study actual user reactions.

In the current work we were relying on user interviews. While providing a certain degree of reliability, they can hardly serve as an objective measurement of players' emotional responses.

Our next goal is to employ a more objective method of analyzing player reactions. Two possible options include breath sound detection and heartbeat rate measurement. Since breath and heartbeat are directly affected by our emotional state, it should be possible to identify measurements corresponding to strong emotions like fear.

CONCLUSION

In this paper, we show how individual elements can help to build up a complete horror game experience. We have changed the camera to a first-person view and implemented designated AI-controlled enemies to chase players and make them panic. Finally, we added a trigger causing a dramatic change in the in-game environment to frighten the player. We believe the obtained results are promising, given that the test subjects think the current version of the project can be considered a real horror game.

In our current experiments "horrific" elements are treated as independent, though one may argue that in successful horror games they all work in synergy to build the right atmosphere. Also, we recognize that there are numerous factors affecting user perception of "terrifying" game aspects, of their recognition as "cool" or "annoying". For example, our current implementation of the "Sudden Changes" element is probably too straightforward, and should be elaborated in subsequent revisions of the game project.

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EVALUATING CLUSTERING METHODS UNDERPINNING CONTENT GENERATION IN GAMES USING GANs

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KEYWORDS
Artificial Intelligence, Clustering, Computational creativity, Generative Adversarial Networks, Image processing

ABSTRACT

In recent years there has been a push for more customisation options in games, along with a desire for greater realism. While graphics have been steadily improving year over year, the current customisation options remain limited, however thanks to developments in research surrounding generative artificial intelligence the combination of both of these desires may be made possible through the use of the latest Generative Adversarial Networks. The aim of this project is to implement and compare four different clustering methods for conent generation. These methods will be used to generate classification labels from gameplay images which will then be given as input to a generative network to create photorealistic equivalents. It will then be determined which method is most suitable for this task by comparing their initial classification performance and the results from the photorealistic images they are used to generate. In order to compare classification performance, the Dice coefficient was calculated for each classification image generated, using a ground truth image to represent perfect segmentation. It was found that good classification performance does not necessarily lead to superior GauGAN output images, and overall the best performing method for this task was Region-Growing due to the spatial consideration in its approach.

INTRODUCTION

Customizing and sharing experiences is a fundamental part of how we enjoy games– even before video games were a mainstream form of entertainment, tabletop games such as Dungeons and Dragons thrived by allowing players to make the game their own with custom campaigns, characters, and enemies to be shared among a group of friends. Even now these aspects retain the popularity of more traditional games, while also making their way into modern video games in the form of fan-made modifications (mods).

At the same time video games have evolved to allow for aspects such as these, there has also been a push for higher realism in every aspect of gameplay – from mechanics to sound design, this theme has been persistent as a sign that increased realism makes games more immersive and enjoyable for certain player demographics. Part of this trend has seen the graphics of games gradually tend towards photorealism within some genres, as people want to see a real life equivalent of what they are experiencing in- game.

These ideas of customization and an increased desire for realism forms the basis of this work which converst stills of games using different unsupervised learning clustering methods into segmentation maps describing the class of every object present on a per-pixel basis. This level of detail is required for input to a Generative Adversarial Network (GAN) in order to produce a photorealistic image with the same objects and context provided by the game. These clustering methods will then be compared against each other in terms of pure clustering performance along with their applicability to this specific context, with a final recommendation on which method is likely to give the best results based on results gathered.

METHOD

The method employed can be split into two main elements – image processing and GauGAN translation as in the diagm below Fig 1.

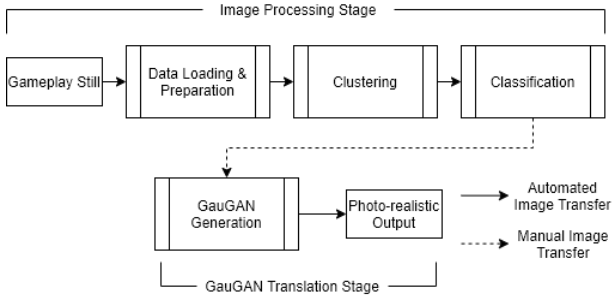

Figure 1 – Stages of the methodology

Clustering Methods

The implementation of the clustering methods forms the most crucial part of the application as it is here that the accuracy of the data that the classifier must work with is determined, and therefore the accuracy of the application results overall. Each of the four methods implemented were selected for their different core approaches to segmentation in a hope to draw out different strengths and weaknesses potentially making them more applicable for different scenarios and contexts. The 4 clustering methods used were K-Means algorithm (ref), Mean-Shift (ref), Region-Growing (ref) and Simple Linear Iterative Clustering (SLIC) (Achanta, R. et al., 2010). Colour comparisons within each clusterinbg method was done with CieLab (LAB) colour space (Luo, 2015) and the Delta E formulae was used to quanitify colour difference.

Classification and GauGAN

Classification forms the final stage of this application where an attempt is made to determine the objects and features present in a segmentation map on a pixel-by-pixel basis. The first step in this process is loading in the data describing the target classes and their corresponding features – in this case class information has three components loaded: the average colour of every texture in game, the colour of the related classes in the GauGAN application, and the name of these classes from a text file. The texture and label information are stored as two separate image files, with the relation between each being defined as their position in the images themselves (figure 2).

Figure 2 - Classification labelling data

Testing and Evaluation

The four clustering methods implemented will be tested and evaluated . The first and most important area of comparison is how well these methods classify a given image, using the Sørensen–Dice coefficient (Sørensen–Dice coefficient, 2020).

RESULTS

Figure 3 shows the diustribution of Dice scores across classes (sky, sand, stone, water, wood). The sky and water classes are more accurately classified. The most variance appears in the stone, grass and brick classes.

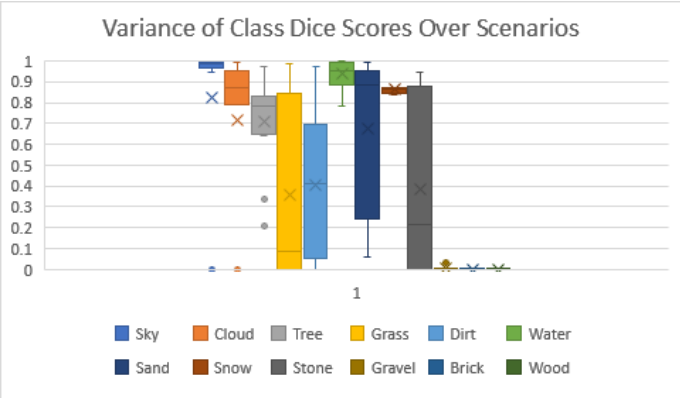

Figure 3 Performance of classification scores across classes and scenarios.

The visual result for scenario 1 Forest is presented in Figures 5 - 9 showing the game source image, clustering and labelling result based on KMeans, Mean-shift, Region-growing and SLIC, and GauGAN output of that clustering and classification.

CONCLUSION

The primary goal of combining unsupervised learning and Generative Adversarial Networks for the purpose of computational creativity in games has been demonstrated. The clustering methods display varying results across different criteria that make the methods applicable to different use cases, and as it stands Mean-Shift appears to be the most reliable method in terms of pure clustering performance. As demonstrated however this does not necessarily carry over to desirable GauGAN results due to issues of noise, and as such the local, spatially based methods of Region-Growing and SLIC are more suitable for this specific task. Of these two methods, Region-Growing is recommended as the overall best solution for clustering due to its high classification performance when compared with all other methods. With the further work suggested however this recommendation may be subject to change as there are options to resolve each method's shortcomings – in this regard any method may become performant enough to justify its use.

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FUTURE RESEARCH

While the current implementation of this project serves well as a proof of concept, further work would be required to realise it as a commercially viable application. Part of the limitation comes down to the unreliable classification performance which would need to be addressed by the improvements discussed above, or to implement a different method of segmentation which overcomes the shortcomings of unsupervised learning. Fortunately, this task may be trivial in a games application when developing the game itself since perfect segmentation performance could be achieved by building the functionality directly into the game's graphics pipeline, which would work by simply changing the material of every object to a solid colour of its intended label and disabling any additional lighting and effects. Without this type of access to a game's source code, machine learning methods, such as those discussed in this paper, can serve as a good alternative for more limited application. The GauGAN model used for this project is also limited in that it can only generate images of landscapes from the datasets it has been trained on, as has been discussed from the results gathered. It would likely then be beneficial to train a bespoke model for games application, particularly if the intended use case is a fiction or fantasy setting as many of the labels that would be identified in these will not have real-life equivalents.

Figure 4 Scenario 1 – K-Means

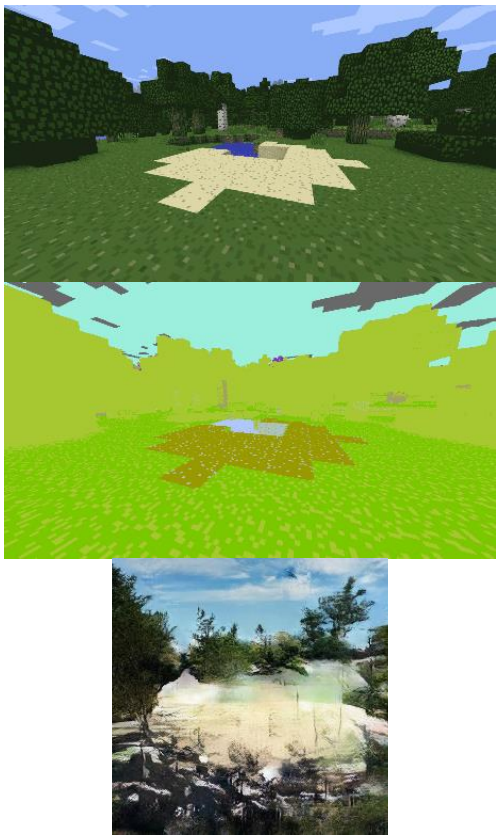

Figure 5 Scenario 1 – Mean-Shift

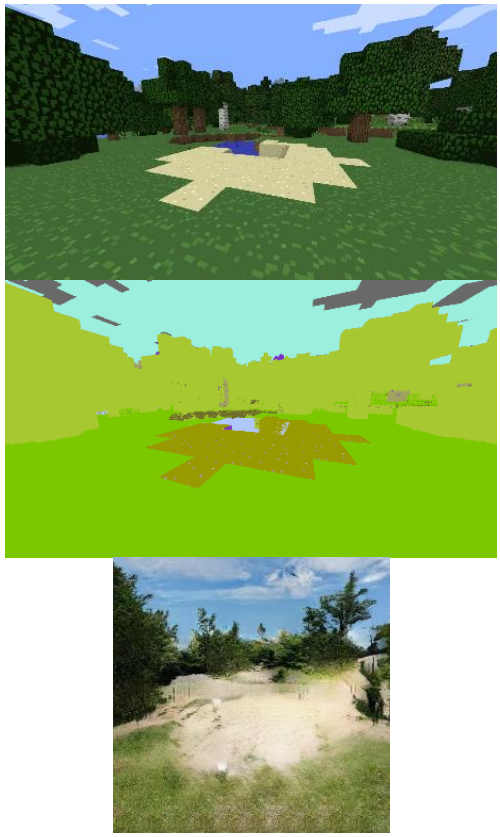

Figure 6 Scenario 1 – Region-Growing

Figure 7 Scenario 1 – SLIC

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Game Mechanics

MULTI-MODAL STUDY OF THE EFFECT OF INFORMATION COMPLEXITY IN A CRISIS MANAGEMENT GAME

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KEYWORDS

Game-based training, information complexity, serious games, multi-modal player modelling, crisis management

ABSTRACT

In this paper, we study the effect of information complexity on player in-game behaviour and physiological responses during a dilemma-based crisis management game. We run a user study, where players attempt to solve a crisis scenario while their in-game and physiological activity is being monitored through game logs and wearable physiological sensors. Results show that information complexity has noticeable effects on players' decision making and physiological responses, while moderate correlation was found between specific in-game- and physiology-based behavioural features. This study is focused on exploring behavioural patterns correlated to various levels of information complexity. Our findings can be applied in future studies aiming at designing personalised crisis management training scenarios.

INTRODUCTION

The use of digital games as training tools has been steadily increasing in popularity over the last decades. Complex and highly stressful tasks such as crisis management, require a significant amount of resources for the proper training and education of expert staff. Digital games enable the simulation of such tasks, providing an alternative and cost-efficient solution.

Furthermore, the introduction of game-based training techniques has enabled multiple data collection channels during gameplay. Such modalities include in-game action logging (Bakkes et al., 2014), peripheral and wearable sensor data (Healey and Picard, 2005), and trainee- or trainer-generated feedback (Sabourin and Lester, 2013). Several multi-modal approaches have been presented in studies that involve player modelling (Pedersen et al., 2010), affect recognition (Kapoor and Picard, 2005) and crisis management training (Mackinnon et al., 2013). It has been shown that multi-modality increases the robustness of player behavioural monitoring (Holmgård et al., 2015).

We employ the Mayor's Game (van de Ven et al., 2014), which enables the simulation of text-based, dilemma solving crisis management scenarios. We have designed three variants of a crisis scenario, which involve low, medium and high information complexity. We run a user study, where participants attempt to "solve" a crisis scenario which has a pre-defined information complexity level. For the remainder of this paper, we define information complexity as the total amount of information that is made available to a player as in-game text, through non-player characters (NPCs). In the Mayor's Game, information is presented to players through discrete messages, each presenting a new perspective to an already described problem which needs to be solved.

The main motivation behind this study is the detection of behavioural patterns, with respect to specific information complexity levels. We expect information complexity to have an observable impact on (1) players' approach towards solving the crisis scenario, and (2) players' (perceived) stress levels during gameplay. To that end, we track player in-game actions to analyse their decision making processes, while we use physiological sensors and post-game questionnaires to retrieve objective and subjective measurements of player affect respectively. In the long term, the results of this study will be leveraged in order to implement personalised crisis management scenarios.

RELATED WORK

The detection, modelling, prediction and expression of human player characteristics which are manifested through cognitive, affective and behavioural patterns in games is often referred to as player modelling (Yannakakis et al., 2013). Multi-modal player modelling involves multiple sources, through which descriptive information about player behaviour is extracted. Methods of multi-modal player modelling have been applied in entertainment games (Pedersen et al., 2010), detection of player affect (Martínez and Yannakakis, 2011) and even diagnosis of PTSD symptoms (Holmgård et al., 2015). Yannakakis et. al. have conducted a thorough study on the methods and principles of player modelling (Yannakakis et al., 2013).

Any computing that relates to, arises from, or influences user emotions is called affective computing (Picard

et al., 1995). Over the last decades, scientists have been developing new methods and devices to monitor and interpret humans' affective state. Such devices include wearable physiological sensors, which have been previously used for tasks such as user emotion recognition (Haag et al., 2004), entertainment modelling (Mandryk et al., 2006) and stress detection (Healey and Picard, 2005). Gaming and affective computing have also been combined in recent studies (Toups et al., 2006), where skin conductance and heart rate were used as descriptors of player affective state during gameplay. In particular, player experience analysis through affective signals has been conducted using shooter games (Nacke et al., 2011). In similar fashion, we leverage wearable physiological sensors in order to extract descriptive features of the affect of information complexity in players' physiological responses.

Regarding crisis management training, several key cognitive characteristics (also referred at as "soft skills" (Di Loreto et al., 2012)) of crisis managers have been identified, and require to be trained on in order to maintain experts' preparedness at a sufficient level (Stolk et al., 2001). Such soft skills have been investigated in previous studies and include teamwork & collaboration (Sagun et al., 2009), strategic planning (Turoff et al., 2005), leadership (Wallace and Suedfeld, 1988), stress resilience (Janka et al., 2015) and information complexity processing (Svensson et al., 1997). Crisis management training sessions have also been implemented in a large-scale real-life exercise (Helsloot, 2005), where team coordination played a major role in the effectiveness of multi-level decision making.

We believe each of the aforementioned soft skills need to be studied in isolation, in order to yield valid results. It has been shown that the outcomes of crises are likely to be linked to responders' personality traits (Wallace and Suedfeld, 1988). Recently, Steinrucke et al. (Steinrücke et al., 2019) studied the effect of time pressure as a stressor on players' analytical skills using the Mayor's Game. Similarly, this study identifies information complexity as a core characteristic of crises, and leverages the Mayor's Game to study player decision making under various levels of it.

A review on collaborative management games has been conducted by Di Loreto et. al. (Di Loreto et al., 2012). The authors define crisis management as "the anticipation of foreseeable events and minimisation of unexpected events during a crisis". Furthermore, they point out the importance of the use of predictive models within the context of crisis management games, in order to implement realistic and effective training scenarios. In the process of implementing such predictive models, a key step is to analyse player behaviour and extract descriptive features to interpret it. The current study focuses on the latter two topics, by collecting behavioural data through multiple modalities and analysing its correlation to training scenario-related variables.

Figure 1: A screenshot of the Mayor's Game. In the bottom half of the screen, players are provided with the scenario's texts, while in the top half, five advisors provide additional information when an information bubble appears on top of their avatars.

A key contribution to the field of crisis management training is Pandora (Bacon et al., 2013). It provides a complete training environment, which includes multi-modal player modelling through physiological sensors, trainee self-reports and expert observation of trainee performance. Furthermore, training scenarios are adaptable, based on trainees' real-time affective state assessment. In our study we aim to extract information on player affective state through physiological sensors. Similarly to Pandora, we aim to employ the extracted data in order to interpret players' in-game and physiological behaviour, and ultimately provide crisis management experts with personalised crisis management training scenarios.

METHODOLOGY

In order to study patterns in player decision making under various levels of information complexity in a crisis management game, we ran a user study using the Mayor's Game (van de Ven et al., 2014).

Mayor's Game

The Mayor's Game is a text-based, dilemma-solving digital game, originally designed to assess leadership skills of town mayors in the Netherlands. During a Mayor's Game scenario, players become the mayor of a fictional town which is undergoing a crisis. The crisis is initially described to the player by a short text, and unfolds through a sequence of dilemmas which have to be addressed in order for the scenario to end. Regardless of the players' answers to the dilemmas, each scenario has a pre-defined ending, meaning that every player will have to answer the same questions and reach the exact same outcome. Dilemmas are "yes or no" type of questions, and are designed in such a way where there is no right or wrong answer; each answer represents a different ap-

Table 1: Setup of our experiment's crisis scenario. For each of the eight dilemmas provided, additional information were either neutral (=), suggesting a "yes" answer (+), or suggesting a "no" answer (-). Advice was always given in the form of a two to one majority suggesting a "yes" or a "no" answer.

	Information ID					
Dilemma ID	1	2	3	4	5	Advice
1	=	=	=	-	+	+
2	=	=	=	+	-	-
3	=	=	=	+	-	+
4	=	=	=	+	-	+
5	=	=	=	-	+	-
6	=	=	=	+	-	+
7	=	=	=	+	-	-
8	=	=	=	-	+	-

proach towards solving the crisis.

During the game, players are also able to interact with a number of advisors (see Figure 1). These advisors represent various institutions such as the police and fire department, and provide additional information on the players' demand. They can also provide advice in the shape of a "thumbs up" or "thumbs down", which indicates what their suggested answer is for the current dilemma. Both additional information and advice are optional and require players to explicitly click on the advisors to request them. Moreover, depending on the crisis scenario's design, additional information and advice may not always be available.

Crisis scenario

The crisis scenario used in this experiment, discusses a train accident in the outskirts of a fictional town. A tanker train carrying hazardous toxic chemicals collided with a truck on a road crossing, which caused the derailing of a tanker car which is leaking toxic gasses. The scenario consists of eight dilemmas and the player is accompanied by five advisors, namely the communication & press advisor, the public health services advisor, the fire dept. advisor, the legal advisor and the police dept. advisor (see Figure 1).

The scenario starts with a short description of the crisis, followed by the appearance of the first dilemma. A total of eight dilemmas appear sequentially, in 15 second intervals. Each dilemma is accompanied by a short description, and five pieces of (optional) additional information. For each dilemma, all of the advisors are visible to the player, but whether or not they provide the additional information pieces depends on the experimental condition. Additional pieces of information are designed to arrive in 15 second intervals, and are indicated by an "information" text box above the advisors' avatars (see Figure 1). Incoming additional information does not interrupt gameplay. The scenario has a maximum playtime of 20 minutes, after which it automatically ends. Participants were instructed to answer each dilemma as soon as they believe they have read enough information to make a confident decision.

Table 2: First dilemma encountered in the current scenario. Experimental conditions 0, 1 and 2 provide information pieces 1, 1–3 and 1–5 respectively.

Dilemma question	Are you allowing civilians to assist with the evacuation?
Dilemma description	Because of the potential explosion hazard, the CoPI and ROT plan to evacuate the surrounding area within a radius of 300 meters around the burning truck.
Information 1	A daycare centre lies within the evacuation radius.
Information 2	It is expected that there will also be parents who want to pick up the children themselves.
Information 3	An emergency ordinance is being prepared. The police are sent to the nursery to assist with the evacuation, because every child care provider is able to attend to at most four children.
Information 4	Evacuating is our job. We cannot bear the responsibility that parents must take risks to help us with the evacuation.
Information 5	The parents might become emotional if we try to stop them. It is better to let them help with the evacuation. Many hands make light work.

Experimental conditions

Three experimental conditions were designed: Low, medium and high information complexity. These experimental conditions will be referred to as condition 0 (low), condition 1 (medium) and condition 2 (high).

In condition 0, players were provided with only one piece of additional information from the advisors. In similar fashion, in conditions 1 and 2 players were provided with three and five pieces of additional information respectively. Table 1 illustrates the distribution of additional information. For each dilemma, the first three pieces of additional information were designed to be neutral, meaning that the information did not bias the player towards a positive or negative answer. However, the fourth and fifth pieces of additional information would suggest either a negative or a positive answer. Regardless of experimental condition, for each dilemma, only three advisors would respond with advice in the shape of a "thumbs up" or "thumbs down". There was always a two to one majority towards a positive or negative answer to the specific dilemma (see last column of Table 1). An example dilemma is illustrated in Table 2.

Data collection

97 participants (29 male) were voluntarily recruited from Tilburg University's student participant pool, with an average age of 21.55 years ($sd = 3.37$ years). Due to sensor recording failure, 18 out of 97 participants were excluded from the dataset. This resulted in 81 valid participants (25 male), out of which 26 were allocated to condition 0, 25 allocated to condition 1, and 30 allocated to condition 2. Before playing the Mayor's Game crisis scenario, participants were given a presentation describing the goals of the study and the mechanics of the game.

In order to collect physiological sensor data, Shimmer3 GSR+ (Burns et al., 2010) sensors were used. These sensors are equipped with a Photoplethysmography (PPG) and Galvanic Skin Response (GSR) sensor to measure heart rate (HR) and skin conductance (SC) respectively. Sensor sampling rate was set at 20 Hz. For every participant, a two minute baseline measurement (resting state) of physiological activity was collected. Baseline data collection enables the comparison of physiological data between participants. Along with physiological data, in-game activity is logged by the game engine and provided in XML format. Lastly, post-game questionnaires were submitted by the participants, providing scoring of their experiences in the valence-arousal-dominance scale (Russell, 1980).

From the collected in-game and physiological data, several features were extracted. These features have been described in detail previously in (Mavromoustakos-Blom et al., 2018). The raw PPG signal has been processed using the HEARTPY (van Gent et al., 2019) python library, while the raw GSR signal has been processed using the BIOSPPY (Carreiras et al., 2015) python library.

RESULTS

In this section, we present the results acquired from experimentation. We divide results in three categories; in-game behaviour related, player affect related, and a correlation test between the two modalities.

In-game behaviour

Regarding in-game behaviour, we explore how information complexity affects participants' interactions with the Mayor's Game in three major aspects of the game:

1. Participant answers:

   Figure 2 illustrates the percentage of "yes" answers given by all participants per dilemma, in each experimental condition. Our first observation is that in four out of eight dilemmas, participants in different experimental conditions have shifted from a majority in "yes" answers to a majority in "no" answers and vice-versa. More specifically, in dilemmas 1,2,4 and 7 the majority of answers has shifted along with the complexity of provided information.

   Furthermore, looking at Table 3, we observe the total number of participants (per dilemma) that requested advice from the advisors, in each experimental condition. In parentheses we indicate the number of participants that followed the advice (answered according to the advice majority). A Kruskal-Wallis statistical test showed no statistical significance in the number of participants that followed the given advice across experimental conditions ($s = 0.91, p = 0.63$). In all conditions, most participants tended to follow the majority of the advisors' suggestions.

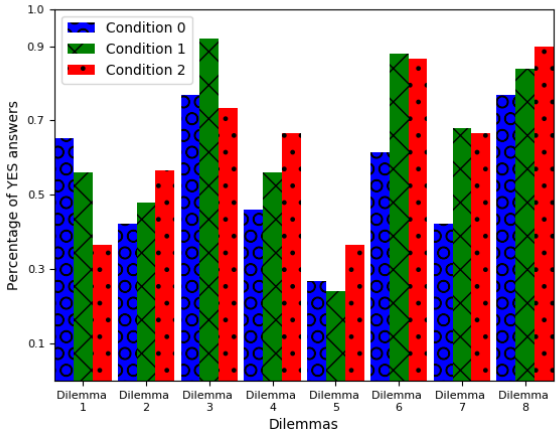

Figure 2: Percentage of participants that gave "yes" answers per dilemma, for each experimental condition.

2. Additional information read:

   In conditions 0, 1 and 2 participants had (optional) access to one, three and five pieces of additional information from the advisors respectively. We expected participants in different conditions would interact differently with the advisors' additional information.

   Indeed, looking at Figure 3, we observe that participants in condition 1 read 100% of the provided additional information by average, while in condition 2 they consulted less additional information than in the other two conditions. A Kruskal-Wallis significance test has shown a significant difference in the number of additional information read in condition 2. ($s = 7.77, p < 0.05$), . By average, participants took 56.9, 97.0 and 92.4 seconds to answer each dilemma in conditions 0, 1 and 2 respectively. This means, that even though participants had access to the fourth and fifth additional information in condition 2, most of them chose to proceed to the answer without consulting those.

Table 3: Total number of participants that requested advice (yes or no) per dilemma, for each experimental condition. In paretheses, the total number of participants that followed the given advice.

		Dilemma ID							
		1	2	3	4	5	6	7	8
Condition	0	13(11)	11(8)	14(8)	13(6)	14(10)	20(12)	16(9)	14(6)
	1	9(5)	12(10)	11(10)	12(9)	10(9)	18(17)	12(5)	11(3)
	2	9(4)	10(7)	9(6)	5(4)	11(9)	11(11)	13(7)	11(2)

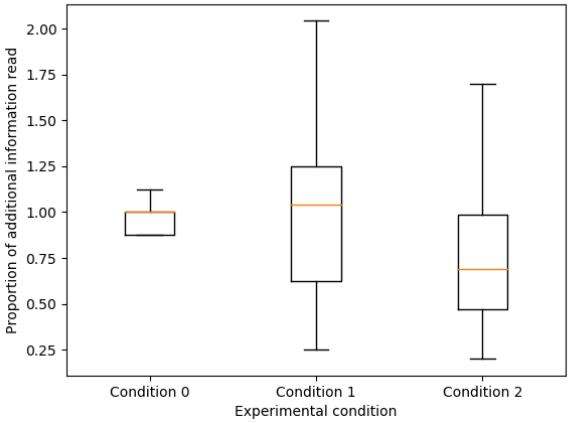

Figure 3: Percentage (out of total number available) of additional information read per dilemma, for each experimental condition. Values greater than 1 mean that additional information pieces were re-visited and re-read by participants.

3. Advice requested:

   Given that participants in different conditions had access to a different number of additional information pieces, we expected information complexity to affect the number of participants that requested advice from the advisors. Table 3 illustrates the total number of participants that requested advice per dilemma, in each experimental condition. We observe a tendency of participants in condition 0 to ask for advice more often, given the low information complexity. A Kruskal-Wallis significance test has shown a significant difference in number of times advice was requested across all experimental conditions ($s = 16.0, p < 0.001$).

Player affect

Player affect was analysed through two separate modalities, namely post-game questionnaires and physiological sensor data. From post-game questionnaire answers, we analyse participants' scores on three variables: valence, arousal, and dominance. Each variable was scored on a scale from 1 (low) to 9 (high). Looking at Table 4, we observe no statistical significance across experimental conditions for these three variables. They were similarly scored by participants across the three experimental conditions.

Table 4: Player affect related features across conditions, described by mean and standard deviation, and tested for statistical significance through a Kruskal-Wallis test (significant difference found in condition 1).

Feature	Condition	μ	σ^2	s	p
valence	0	5.8	1.4		
	1	6.0	1.2	1.0	0.58
	2	5.6	1.4		
arousal	0	4.0	1.6		
	1	3.8	1.4	0.48	0.78
	2	3.9	2.0		
dominance	0	5.6	1.3		
	1	5.9	1.5	2.3	0.30
	2	5.1	1.8		
diffSC	0	2.7	2.3		
	1	9.1	7.8	11.4	< 0.01
	2	3.5	3.5		
shiftSC	0	1.2	2.4		
	1	8.3	7.9	16.3	< 0.001
	2	1.5	4.0		

Regarding physiological sensor features, we ran statistical tests for $avgHR$ & $avgSC$ (average HR & SC), $diffHR$ & $diffSC$ (subtraction of maximum minus minimum HR & SC), $shiftHR$ & $shiftSC$ (subtraction of last minus initial value of HR & SC) and $tsMaxHR$, $tsMinHR$, $tsMaxSC$ & $tsMinSC$ (timestamps of maximum/minimum HR & SC). $diffSC$ and $shiftSC$ were the only features that showed statistical significance across different experimental conditions, and are included in Table 4. While participants in conditions 0 (low information complexity) and 2 (high information complexity) showed relatively stable physiological responses (low standard deviation), participants in condition 1 (medium information complexity) showed significantly more variation in their physiological responses, as described by these two features.

Cross-modal correlation

We investigated correlation between features that belong to different modalities. Alongside looking for the effect that information complexity has on each modality separately, we would like to observe whether the effects

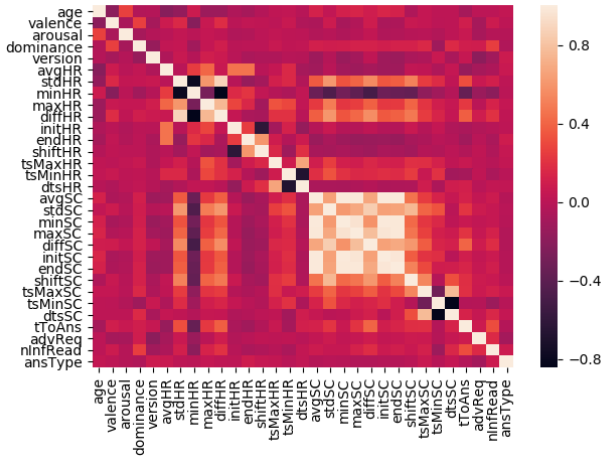

Figure 4: Correlation matrix of in-game, physiological sensor and questionnaire-related features. Each measurement is the average value across all dilemmas.

are shared across two or more modalities. We collected in-game and physiological sensor features during each dilemma answered by the participants along with their questionnaire scores, and created a correlation matrix of these features (see Figure 4).

Looking at Figure 4, we observe correlation between various physiological sensor-related features. Moreover, there is a moderate ($coeff > 0.3$ or < -0.3) linear correlation between the in-game feature $tToAns$ (time required to answer dilemma) with the physiological sensor features $minHR$ (minimum value of HR, $coeff = 0.36$), $diffHR$ (difference between minimum and maximum value of HR, $coeff = 0.37$), $diffSC$ (difference between minimum and maximum value of SC, $coeff = 0.40$). It is important to point out that time required to answer dilemma was measured as a percentage of total game time, to normalise measurements across participants.

DISCUSSION

In this section, we discuss the results obtained through experimentation. We identify how information complexity has affected both players' in-game behaviour and affective state, while indicating how these findings can be employed to supplement crisis management training through the Mayor's Game.

In-game behaviour

Table 3 and Figure 3 illustrate how differences in information complexity cause a shift in players' decision making processes. As Table 3 shows, the lack of additional information during gameplay, encouraged players to consult the advisors significantly more (condition 0) than in the other two conditions.

One may argue that this is the expected behaviour, however, Figure 3 shows that an increase in information complexity is not necessarily followed by an increase in the amount of information read by the participants. Participants in condition 2 read approximately 75% of the additional information provided, showing that in most cases, 75% of the information provided is enough for them to reach a final decision with confidence. In real-life crises, neglection of incoming information can lead to communication gaps, which may harm the efficiency of crisis management (Palttala et al., 2012). However, through a crisis simulation game, after identifying the amount of information deemed necessary for efficient decision making, the next step would be to indicate how information could be structured and communicated so that all involved parties are equally regarded. Towards that goal, we ultimately aim to design adaptive crisis management training scenarios, where the structure and source of incoming information will be based on the players' current information processing performance.

Moreover, Figure 2 illustrates how participants' average answer to each dilemma may shift across the three experimental conditions. Not only can information complexity affect the dominant answer type (dilemmas 1,2,4 and 7), but the average participant answer in condition 1 tends to follow the condition with dominant majority in each dilemma. This leads us to the conclusion that even if there is no right or wrong answer to a dilemma, various levels of information complexity have a significant effect on crisis responders' approach towards answering it. Such inconsistency in decision making can also be a major cause of sub-optimal crisis management response. From the above observations and in the context of this study, we conclude that condition 1 incorporates a level of information complexity that leads to confident decision making; participants in condition 0 consult their advisors to retrieve more information, while participants in condition 2 avoid consulting them.

Player affect

Regarding participants' affective state, no significant difference was found in post-game questionnaire scores regarding the valence-arousal-dominance model across different experimental conditions. This finding can be explained by the low-fidelity nature of the Mayor's Game. A text based game with a "static" non-playing character (NPC) setup does not seem to have a strong effect on player emotions, as would be expected in a real-life crisis.

However, we expect physiological sensor measurements to enable a more fine-grained analysis of player affect. In fact, Table 4 indicates that two skin conductance-related features, namely $diffSC$ and $shiftSC$, differed significantly across experimental conditions. More specifically, participants in condition 1 have significantly higher average measurement in both variables, meaning that that

the difference between the minimum & maximum and initial & final SC measurement was significantly higher. From this observation, we may assume that the level of information complexity in condition 1 caused a distinguishable, yet ubiquitus physiological response from the players. While we cannot conclude whether this response derives from experienced stress, excitement, uncertainty or any other aspect of human cognition, we believe this result is worthy of further investigation. Identifying the source of this subtle effect, may be employed towards increasing the fidelity of virtual crisis management training scenarios. Moreover, the moderate correlation between $diffSC$ and the average time taken to answer dilemmas (see Figure 4), indicates that there is a relationship between players' playstyle and their physiological responses.

Condition 1

By assessing the aforementioned results and observations, we identify condition 1 as a salient condition. Participants in condition 1 show a difference in playstyle, which includes not only the patterns in which they process information before answering dilemmas, but also participants' answers themselves. In condition 1, participants consulted 100% of the additional information provided by the involved advisors. This pattern was not observed in condition 2, despite more information pieces being available to the players. In a real-life crisis scenario, uniform decision making and coordination of communication are needed (Palttala et al., 2012). To that end, we claim that participants in condition 1 were the highest performing by average, in terms of additional information processing. However, this does not mean that participants in other groups underperformed; an increase in information complexity (condition 2) may cause higher uncertainty, which the participants seem to avoid. Furthermore, physiological sensor data has shown that condition 1 causes a significant increase in skin conductance-related values, indicating that information complexity can have an effect on player physiology. Lastly, since a moderate linear correlation between in-game and physiological behaviour was observed, we believe that a multi-modal approach should be preferred in the context of this study.

Limitations

As this study's results show, information complexity has affected players' playstyle more than their physiological responses. In an attempt to extract player subjective scorings of affect through the valence-arousal-dominance module, we observe no significant differences across experimental conditions. The low fidelity nature of the Mayor's Game seems to have a mild impact on player affective state, regardless of experimental condition. That being said, we acknowledge that crisis management training scenarios through the Mayor's Game should mostly focus on player decision making and information processing instead of providing a realistic, immersive crisis management experience.
Lastly, with this study's participant pool consisting of university students, we recognise that results may vary when actual crisis responders are put under experimentation. We expect experienced experts to have developed specific decision making skills, probably decreasing the observed variety across experimental conditions. However, experts may relate to the scenario's texts more intimately, which could have noticeable effects on their physiological & affective responses.

Conclusion

In this paper, we presented a multi-modal study of player decision making under various levels of information complexity. Our goal was to determine whether, and to what extent information complexity can affect not only player playstyle, but also their physiological responses during gameplay.
Using the Mayor's Game, we ran an experiment in three separate conditions: low, medium and high information complexity. During gameplay, we collected game-generated logs to monitor player in-game behaviour, while at the same time measured players' physiological responses through wearable physiological sensors. Moreover, we requested players' objective affect scoring through post-game questionnaires, using the valence-arousal-dominance model. We ran statistical analyses on the collected dataset, to identify patterns of player decision making that correlate to the level of information complexity presented to them.
Results show that players did not perceive the three conditions differently in terms of experienced affect, as shown from the analysis of the questionnaires. However, we have identified that under the medium information complexity condition, participants' in-game and physiological behaviour significantly varies with respect to the other two conditions. Players in the medium information complexity condition tend to read 100% of the game's provided information pieces, whereas participants in the high information complexity condition tend to read less information, albeit more is available to them. Furthermore, participants in the medium information complexity condition show significantly higher variance in specific skin conductance-related features, indicating a higher impact in player's physiological responses, with respect to the other two conditions. Lastly, moderate correlation was found between heart rate- and skin conductance-related features and players' in-game actions.
Our long-term aim is to provide crisis management experts with an adaptive, personalised crisis management training environment. Our main focus in future studies is to drive crisis responders towards uniformly dis-

tributed information processing, while maintaining consistency in their decision making.

ACKNOWLEDGEMENT

This study is conducted within the Data2Game project, partially funded by the Netherlands Research Organisation (NWO).

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FROM LEARNING MECHANICS TO TABLETOP MECHANISMS: MODDING *STEAM* BOARD GAME TO BE A SERIOUS GAME

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KEYWORDS
Post-digital, Serious Games, Board Games, Simulation

ABSTRACT

Board games are thriving in the post-digital era. Digitalization is present in almost all dimensions of contemporary life and it is expected to be even more prevalent in the future. However, a growing number of players are choosing to play analog games, mainly influenced by modern board games and hobby game designs. These games are different from mass-market games and show that analog platforms still have much to offer in terms of gaming innovation. These new designs have not yet been adequately studied by the serious game research field, and the filling of this research gap can provide new solutions for learning and simulation games of all types. This paper proposes a new framework, relating learning mechanics to the tabletop mechanisms (LM-TM) of the modern board game designs. The case study of the adapted version of *Steam* board game, tested during a lecture with MBA students, is explained as an example of the application of the LM-TM framework. This case study proved to be useful to unravel future development paths in this field of research.

INTRODUCTION

This paper intends to establish a connection between learning mechanics (LM) and game mechanics (GM) present in a modern board game. This approach is relevant in the serious games field of research because these analog games tend to be ignored, in an epoch of digital dominance in gaming (Dörner et al. 2016; Michael and Chen 2006). However, some authors consider we are living in a post-digital age (Cramer 2015), as a new form of hybrid expression appears. Board gaming seems to be a growing trend, and the analog games are prospering in societies dominated by digital technologies (Rogerson and Gibbs 2018; Sousa and Bernardo 2019). The study of serious games should acknowledge this trend, taking advantage of physical dimensions that promote socialization and physical learning dimensions. Therefore, the systematization of these new possibilities is urgent.
The paper is composed of three main parts. The first part introduces modern board games. The second part focuses on the game mechanics and mechanisms, highlighting the differences between analog games and digital games. The third part describes the proposed framework and presents its application in a case study using *Steam* (Wallace 2009).

MODERN BOARD GAMES

According to some authors, we are living a golden age of board gaming (Arnaudo 2018; Booth 2015; Donovan 2018), even though this can still be a niche activity. As Woods (2012) highlighted, many of the new games are still considered hobby games and not mass-market products. Furthermore, several market studies refer to the board game market as a market growing above the two digits, with thousands of new games released every year. Conferences and pubblications related to these modern board games are also becoming more common (Sousa and Bernardo 2019).
The new board game products, described as analog games (Torner et al. 2014), are a manifestation of the post-digital movement (Cramer 2015). But these games do not oppose digital innovations, although they provide alternative ways to rediscover and experiment with the pleasures of human interaction. As Woods (2012) proved, face-to-face social interaction in modern board games is the most appreciated feature of these games, followed by the strategic play and the intellectual challenge. Digital communication tools and social media enable the development of these board game communities. The paradigmatic case of the *Board Game Geek* (BGG) website (www.boardgamegeek.com) is the main database for getting information about these games (Rogerson and Gibbs 2018). But many other websites, blogs vblogs, and podcasts, as well as many other apps help to organize the community of players. This culture of tabletop gaming also spread to TV shows, as *The Big Bang Theory* and *Stranger Things*. This proliferation enables knowledge sharing about new games. It enlarges the community, motivating the organization of events and meetings where games are played both in small gatherings, in local stores and board game cafes, and huge conventions like *Essen Spiel* or *Gen Con* (Donovan 2017; Rogerson and Gibbs 2018).
As Kosa and Sprock (2019) shown, people playing these games are mostly males (81.16%), with an average age of 39.12 years (SD=11.91). The interest for modern board gaming is a recent trend, as 54% started to play these games in the last 15 years only, highlighting that 26.2% of the players came to the hobby only since 2014. These recent data follow the same tendency as the one gathered by Woods (2012) 10 years ago, although the percentage of women increased, more than 10% in total.
This growing interest in modern analog and hobby tabletop/board games is evident. But not all the board games are the same, and the abundance of designations can be misleading. Sousa and Bernardo (2019) have classified them and have highlighted the features that distinguish modern

board games (MBG), mostly related to their innovative mechanics when compared to mass-market games.

FROM GAME MECHANICS TO TABLETOP MECHANISMS

In the hobby community, the mechanics of MBG are, apparently, clear. However, when doing a literature review, it is evident that concepts are not that clear. What is a game mechanic and how are the MBG mechanics different from general game mechanics? Should we use mechanics or mechanisms as designations?

Almost totally centered in digital games, authors like Schell (2019) say that mechanics are the procedures and rules of the game, describing the goals, how players can and cannot achieve them, providing feedback from play. Adams (2014), thinking mainly in digital games, says that mechanics are what determines how the game operates. Sicart (2008) relates the game mechanics to the ways players can interact with the game system. Lundgren and Bjork (2003) state that they are part of the game system. Järvinen (2008) says that mechanics cannot exist without a rule system because mechanics are a particular set of rules.

Adams and Dormans (2012) alert that the relationship between rules and mechanics in analog games is different from digital games because, in digital games, players do not need to know the rules before playing, while, in analog games, knowing the rules a priori is mandatory. The authors say that mechanics are related to rules of play, but mechanics are more concrete in general action-driven, at least as players perceived them (Kritz et al. 2017). The mechanics in board games can be implemented mostly by the game components, but players need to play an active role to make the game system to function. Analog games induce a higher degree of collaboration and player involvement for the game to work (Xu et al. 2011; Zagal et al. 2006) because they lack the automation existing in digital games. Nevertheless, many scholars do not distinguish between the mechanics of digital, analog, and even sports games (Adams and Dormans, 2012), which might be confusing when trying to implement games on different platforms because of the systems and dynamics in digital and analog games are not the same.

Järvinen (2008) refers to the semantic confusion about mechanics and mechanisms in game studies, concluding they are the same, being the process or techniques players can use to achieve game goals. Järvinen (2008) also states that game mechanics, especially in board games, are related to the game components, providing pleasure and helping to establish the narratives and the systems of meaning, assisting the learning of the game. In this work, we consider game mechanics and mechanisms to represent the same concept.

Some authors describe game mechanics as a form of learning methods. Gee (2003) states that mastering a game is learning, which is a lot about mastering their mechanics. Cook (2006) says the mechanics are rule-based systems and simulations that facilitate and encourage the players to explore and learn in the game environment. Plass et al. (2011) follow the same approach, stating that the mechanics enforce the players' behaviors and actions, directly facilitating the players understanding of the game system and enabling learning, which leads to direct relations between learning mechanics and game mechanics.

If we consider that serious games are the games created or adapted with a defined objective in mind (learning and/or simulation), maintaining the fun of the play (Dörner et al. 2016; Michael and Chen 2006; Winn 2009), it is mandatory to analyze their game mechanics according to their objectives. For a learning mechanic to help players to learn in a serious game, it needs to be implemented in a game system as a game mechanic, relating to the activity of playing, bounded by the rules of the learning theories (Plass et al. 2011).

When searching for MBG mechanics literature, difficulties establishing a connection with the previous definitions arise. Among MBG, eurogames are one sub-type, being responsible for the creation of the most innovative board game mechanics in the last 40 years, avoiding the randomness and enabling meaningful decisions from players (Sousa and Bernardo, 2019). Woods (2012) departed from Järvien (2008), and from the forty identified mechanics, conclude that only twenty-five were appreciated by more than 50% of eurogame players, related mostly to strategy, avoiding direct conflict and randomness. The most appreciated mechanics, by more than 80% of the players, were: trading, variable player powers, action points, tile placement, area control, hand management, variable phase order. However, more recent work from Engelstein and Shalev (2019) promises to systematize the notion of mechanics for analog games or mechanisms for the tabletop game design. They group the defined mechanisms in a repository for consultation, mainly for designer's use. The three-letter code represents the thematic group, and the numbers represent the different manifestations of that type of mechanism (see Table 1).

Table 1: Tabletop mechanisms according to Engelstein and Shalev (2019)

Description /Code	***Mechanisms***
Game Structure (STR)	1 - Competitive games; 2 - Cooperative games; 3 - Team-based games ; 4 - Solo games; 5 - Semi-cooperative games; 6 - Single loser games; 7 - Traitor games; 8 - Scenario/mission/campaign games; 9 - Score-and-reset games; 10 - Legacy games
Turn order and Structure Terminology (TRN)	1 - Fixed Turn Order; 2 - Stat Turn Order; 3 - Bid Turn Order; 4 - Progressive Turn Order; 5 – Claim Turn Order; 6 - Pass Turn Order; 7 - Real-Time; 8 - Punctuated Real-Time; 9 - Simultaneous Action Selection; 10 - Role Order; 11 - Random Turn Order; 12 - Action Timer; ; 13 - Time Track; 14 - Passed Action Token; 15 - Interleaved vs. Sequential Phases; 16 - Lose a Turn; 17 - Interrupts
Actions (ACT)	1 - Action Points; 2 - Action Drafting; 3 - Action Retrieval; 4 - Action/Event; 5 - Command Cards; 6 - Action Queue; 7 – Shared Action Queue; 8 – Follow; 9 - Order Counters; 10 - Rondel; ; 11 - Action Selection Restriction ; 12 - Variable Player Powers; 13 - Once-Per-Game Abilities; 14 - Advantage Token; 15 - Gating and Unlocking; 16 - Tech Tree/Tech Tracks/Tracak Bonuses; ; 17 – Events; 18 - Narrative Choice
Resolution (RES)	1 - High Number; 2 – Stat Check; 3 - Critical Hits and Failures; 4 - Ratio/Combat Results Table; 5 - Die Icons; 6 - Card Play; 7 - Rock, Paper, Scissors; 8 - Prisioner's Dilemma; 9 - Alternate Removel; 10 - Physical Action; 11 - Static Capture; 12 – Enclosure;

Description /Code	*Mechanisms*
	13 – Minimap; 14 - Force Commitment; 15 – Voting; 16 - Player Judge; 17 - Targeted Clues; 18 - Tie-breakers; 19 - Dice Selection; 20 - Action Speed; 21 - Rerolling and Locking; 22 - Kill Steal
Game End and Victory (VIC)	1 - Victory Points from Game State; 2 - Victory Points from Player Actions; ; 3 - Temporary and Permanent Victory Points; 4 - Victory Points as Resource; 5 - Hidden and Explosed Victory Points; 6 - End-Game Bonuses; 7 - Race; 8 - Player Elimination; 9 - Fixed Number Rounds; 10 - Exhausting Resources; 11 - Completing Targets; 12 - Fixed Number Events; 13 - Elapsed Real Time; 14 - Connections; 15 - Circuit Breaker/Sudden Death; 16 - Finale; 17 - King of the Hill; 18 - Catch the Leader; 19 - Tug of War; 20 - Highest Lowest
Uncertainty (UNC)	1 - Betting and Bluffing; 2 - Push-your-luck; 3 - Memory; 4 - Hidden Roles; 5 - Roles with Asymmetric Information;6 - Communication Limits; 7 - Unknown Information; 8 - Hidden Information; 9 - Probability Management; 10 - Variable Setup; 11 - Hidden Control
Economics (ECO)	1 – Exchanging; 2 – Trading; 3 – Market; 4 - Delayed Purchase; 5 – Income; 6 - Automatic Resource Growth; 7 – Loans; 8 - Always Available Purchases; 9 - I Cut, You Choose; 10 – Discounts; 11 – Upgrades; 12 - Random Production; 13 – Investment; 14 – Ownership; 15 – Contracts; 16 – Bribery; 17 - Increase Value of Unchosen Resources; 18 – Negotiation; 19 - Alliances
Auctions (AUC)	1 - Open Auction; 2 - English Auction; 3 - Turn Order Until Pass Auction; 4 - Sealed-Bid Auction; 5 - Sealed Bid With Cancellation; 6 - Constrained Bidding; 7 - Once-Around Auction; 8 - Dutch Auction; 9 - Secon-Bid Auction; 10 - Selection Order Bid; 11 - Multiple-Lot Auction; 12- Closed-Economy Auction; 13 - Reverse Auction; 14 - Dexterity Auction; 15 - Fixed-Placement Auction; 16 - Dutch Priority Auction
Worker Placement (WPL)	1 - Standard Worker Placement; 2 - Workers of Differing Types; 3 - Acquiring and Losing Workers; 4 - Workers-As-Dice; 5 - Adding and Blocking Buildings; 6 - Single Workers; 7 - Building Actions and Rewards; 8 - Turn Order and Resolution Order
Movement (MOV)	1 - Tessellation; 2 - Roll and Move; 3 - Pattern Movement; 4 - Movement Points; 5 - Resource to Move; 6 – Mesurement; 7 - Different Dice; 8 - Drift; ; 9 – Impulse; 10 - Programmed Movement; 11 - Relative position; 12 – Mancala; 13 – Chaining; 14 – Bias; 15 - Moving Multiple Units; 16 - Map Adition; 17 - Map Reduction; 18 - Map Deformation; 19 - Move Through Deck; 20 - Movement Template; 21 - Pieces as Map; 22 - Multiple Maps; 23 – Shortcuts; 24 - Hidden Movement
Area Control (ARC)	1 - Absolute Control; 2 - Area Majority/Influence ; 3 - Troop Types; 4 - Territories and Regions; 5 - Area Parameters; 6 - Force Projection; 7 - Zone of Control; 8 - Line of Sight
Set Collection (SET)	1 - Set Variation; 2 - Tile-Laying; 3 - Grid Coverage; 4 - Networking Building; 5 - Combo Abilities
Card Mechanisms (CAR)	1 - Trick Taking; 2 - Ladder Climbing; 3 - Melding and Splaying; 4 - Card Draw, Limits and Deck Exaustion; 5 - Deck Building; 6 - Drafting

This paper proposes adapting the Learning Mechanics Game Mechanics LM-GM (Arnab et al. 2015) model, mainly related to digital games, to the mechanisms of MBG as defined by Engelstein and Shalev (2019), and making use of the defined codification.

LM-TM RESEARCH MODEL TESTING

To establish the connection between mechanics some references to previous inspirational works and researches must be considered. Arnab et al. (2015) argue that learning must be defined at a higher level, through goals, rules, and other components with pedagogical value. Arnab et al. (2015) also claim that although some well-established frameworks for pedagogic games exist, there is a lack of knowledge about how the game components relate to learning in a game system. So, the authors go beyond the Game Object Model (GOM) framework (Amory 2007) and establish the LN-GM framework, arguing that serious games need a new and more adapted approach. Arnab et al. (2015) defend that serious games produce intrinsic learning dynamics, being their mechanics the best way to address them because these mechanics correspond to the way players interact with the game system. To establish this, the authors identified learning mechanics and game mechanics from a literature review, from the main authors in the field. When comparing the main game mechanics, it is possible to realize that they do not fit into the mechanics typically related to MBG. To address this gap we propose the crossing between the Learning Mechanics (LM) and the Game Mechanics (GM) developed by Arnab et al. (2015) and Tabletop Mechanisms (TM) identified by Engelstein and Shalev (2019) (see Figure 1). We adopted the spatial and graphic organization of Arnab et al. (2015) framework.

	Learning Mechanics Game Mechanics **Tabletop Mechanisms**	
Instructional Behavioral Momentum ***Rules explanation**** **ACT**	Guidance Role Play **ACT**	
Demonstration Cooperation ***Rules explanation****/ **STR**	Participation Collaboration ***Rules explanation****/ ***STR***	Action/Task - **ACT**
Generalization/ Discrimination Selecting/Collecting ***Rules explanation**** ***Rules consultation**** **ACT**	Observation Tokens ***Game Components****	Feedback Goods/Information **TRN/VIC/RES**
	Question/Answer Question/Answers/ Cascading Information ***Rules Explanation**** ***Rules Consultation**** **RES**	- Cut Scenes/Story ***Game Components*** **/RES/ACT**
Explore - **ACT/MOV**	Identity Question Answers **RES**	Discover Communal Discovery **RES/MOV**
	Plan Strategy/Planning Ressource Management **ECO/ACT/MOV**	Objectify Pareto Optimal **ACT/ECO/WPC/MOV/ARC/SET**
Hypothesis Capture/eliminate **ACT**	Experimentation Tiles/Grids ***Game components****	Experimentation Infinite Gameplay **VIC**
Repetition Game turns **TRN**	Repetition Capture/eliminate **ACT/ECO/WPC/MOV/ARC/SET**	Repetition (*progress*) Levels **VIC**
- Time Pressure **TRN/VIC**	Reflect/Discuss Pavlov Interactions **RES/TRN**	Analyse Feedback **RES/VIC**
	Imitation Protegé Effects	Shadowing Metagame

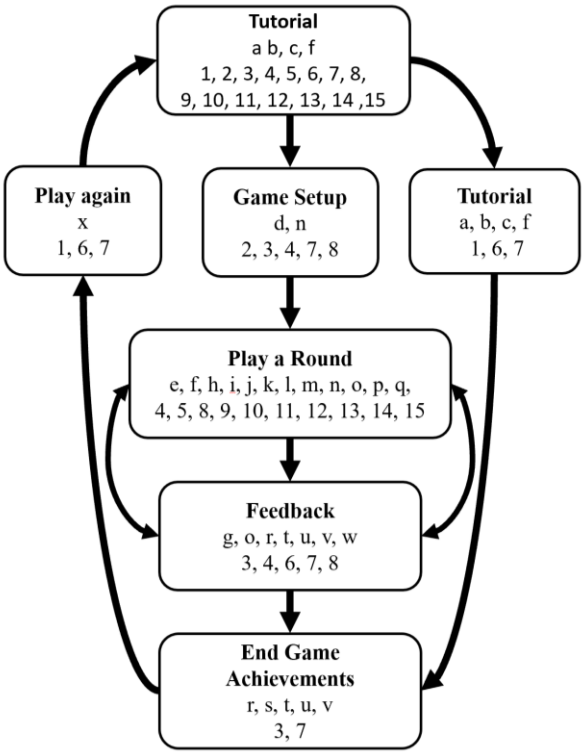
	RES/TRN	UNC
Simulation Design/Editing **TRN/ACT/RES**	Simulation Simulate/Response **RES/VIC**	Modeling Movement **ACT/ECO/WPC/MOV/ARC/SET**
Tutorial Tutorial ***Rules Explanation**** ***Rules Consultation****	Assesment Assesment **RES/VIC**	
	Competition Competition **TRN/VIC**	
Motivation Urgent Optimism **TRN/RES/VIC**	Ownership Ownership **TRN/VIC**	Accountability Rewards **RES/VIC**
	Responsability Status **TRN/RES/VIC**	- Vitality **TRN/RES/VIC**

Figure 1: Crossing relations among LM, GM and TM

Having as a starting point the defined crossing relations among LM-GM-TM (see Figure 1), it is necessary to take into account the particularities of MBG flows. Including the game materiality of components and the need for a continuous tutorial, represented by the rules explanation and rules consultation during each game (* in Figure 1). Figure 2 depicts a proposed flowchart representing the Learning Mechanics and Tabletop Mechanisms (LM-TM) model. Sato and de Hann (2016) proved that it is best to explain an analog game while it progresses, avoiding to overwhelm players with rules and mechanisms, although the initial explanation is essential. The way players learn to play an analog game is different from the way they learn to play a digital game, mostly because of the way players interact with the game system. Duarte and Battaiola (2017), considering these differences, proposed an alternative remodeling of the Mechanics, Dynamics, and Aesthetics (MDA) model, arguing that players do not always interact first with the aesthetics in analog games, but with all the game dimensions at the same time, including the mechanics.

These limitations and unique features of analog games involve the need to have a facilitator continuously explaining the rules and the basics of the game, pointing out to the game structure and the objectives/victory conditions. This guidance is transferred to the LM-TM model by the bypass "Tutorial" (see Figure 2). The importance of the facilitator also is manifested during the "Feedback" phase and in the "End Game Achievement". It may even occur when deciding to "Play again" in the final stage, rebooting the model (see Figure 2). There is a loop between the "Play a Round Phase" and the "Feedback" because in games with multiple turns the two phases occur several times. And in games with no defined turns, they happen all at the same time.

The "Feedback" phase, "The End Game Achievement" and the "Play Again" are related to the debriefing process that occurs naturally after an MBG play (Masuda and de Haan 2015). But this is utterly more important in a serious game approach, considering the need to deconstruct and explain to the player the metaphors, relations, and consequences of their decisions and interactions during gameplay (Crookall 2010). The rules explanations and tutorials in a serious game approach need to be related to the debriefing process from the start to empower the player after continuous plays.



a) Instructional	1) Rules Explanation/Consultation*
b) Tutorial	2) Game components*
c) Demonstration/Guidance	3) STR (Game Structure)
d) Participation	4) TRN (Turn order and Structure Terminology)
e) Generalization /Discrimination	5) ACT (Actions)
f) Observation	6) RES (Resolution)
g) Feedback	7) VIC (Game End and Victory)
h)Explore/Discover	8) UNC (Uncertainty)
i) Plan	9) ECO (Economy)
j) Hypothesis	10) AUC (Auctions)
k) Experimentation	11) WPL (Worker Placement)
l) Analyse	12) MOV (Movement)
m) Action/ Task	13) ARC (Area Control)
n) Modeling/simulation	14) SET (Set Collection)
o) Reflect/Discuss	15) CAR (Card Mechanisms)
p) Imitation	
q) Shadowing	
r) Assessment	
s) Competition	
t) Motivation	
u) Ownership	
v) Accountability	
w) Responsibility	
x) Repetition	

Figure 2: LM-TM model for board games

Applying the LM-TM Model to *Steam* board game

To test the LM-TM model *Steam* (Wallace 2009) board game was used as a case study. The game was adapted and modified to be played as a serious game by MBA Students from the *Faculty of Economics of the University of Coimbra*, in the Logistics course. The main objective was that the students could understand the concept of the shortest path problem in a transportation network, and how these paths are related to the efficiency of the network itself. The game experiment occurred for two hours, with two game-tables playing two different copies of the same game (GTI & GTII). Twelve students played the game, nine men and three women, with ages between 30 and 50. After the gameplay, the game facilitator conducted a debriefing with the active participation of the students, analyzing the human behaviors and game results.

The game suffered considerable simplifications to be played rapidly after fifteen minutes of rules explanation. The setup consisted of adding four random cubes to every city in the Rhine and Ruhr region base map from the original *Steam* game, dividing the land units in a hexagonal grid. Like in *Steam* standard game, players needed to transport cubes available in a city to another city with a color that matched the color of the cube. The cargo cubes could only travel from one city to another through a railroad. When a cargo cube reached its destination, it was removed from the game, and the corresponding player kept it for the endgame scoring.

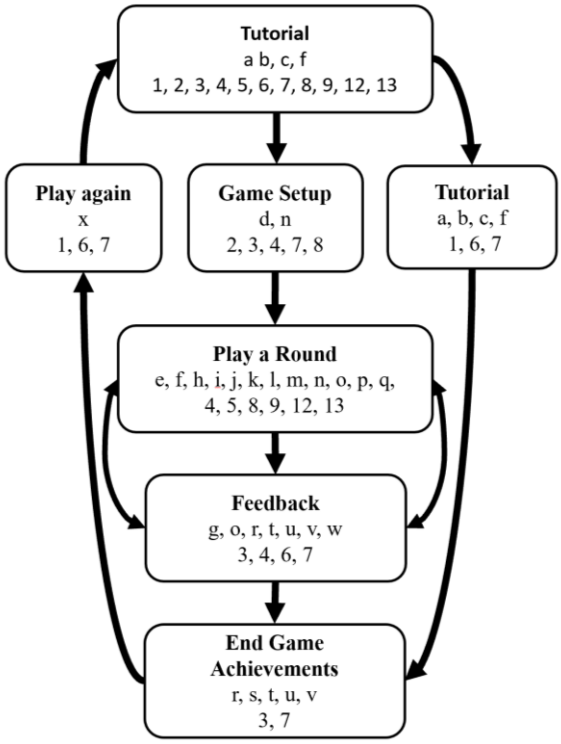
The sequence of playing in clockwise turns was adapted instead of doing an auction to determine the play order. It was defined that the game would end after seven rounds. Players had three action points to construct new railroad lines, paying the costs as in the original game, considering a coin for each connection in the hexagonal tile, one more for crossing a river, and two more for crossing a mountain. The cost of the railroad construction was recorded using staking coins of the game, as debts. Then, in each turn, after doing their construction phase, players could move at most two-colored cargo cubes from one city to another of the same color. They could transport the cargo cube along a railroad, no matter the distance. If the transportation required the use of railroad infrastructures belonging to other players, then both would win a cargo cube from the general supply, with the same ten money units value.

Applying the LM-TM model for the modified version of Steam allowed us to build an example with fewer game mechanisms. Removing, for example, the auctions for turn order (ACU-01), the variable Start Turn Order (TRN-02), the advantage tokens (ACT-14), the income (EC0-05), loans with multiplied impact (ECO-07), the upgrades of the machinery to achieve greater distances (ECO-11) the map addition of the new cities and new cubes (MOV-16).

From the original game, it was kept:

- Competitive game mode (STR-01),
- Turn order (TRN-01);
- Actions points to construct the railways (ACT-01);
- Prisoner's dilemma during railways sharing (RES-08);
- Physical action of removing the moved cubes (RES-10);
- Victory points result from the money spent and money earned through cube transportation (VIC-01);
- A predefined number of rounds (VIC-09);
- The cubes when transported were removed from the game as an exhausted resource (VIC-10);
- A variable setup disposing of the colored cubes in the cities (UNC-10);
- Ownership of the railways and the cubes contributed to determining the final scoring (ECO-14);
- Players could establish alliances when using their railways to transport the cargo cubes (ECO-19);
- The cubes should be moved to be scored (MOV-05);
- The railways' paths must be chained to travel along with multiples cities (MOV-13);
- Map addition of the railway tiles (MOV-16);
- Railways can create shortcuts (MOV-23);
- The railways' tiles represent zones of control (ARC-07).

Considering the modified version of *Steam* the LM-TM model adapted to this case is shown in Figure 3:



a) Instructional	1) Rules Explanation/Consultation*
b) Tutorial	2) Game components*
c) Demonstration/Guidance	3) STR-01
d) Participation	4) TRN-01
e) Generalization/Discrimination	5) ACT-01
f) Observation	6) RES-08 / RES-10
g) Feedback	7) VIC-01 / VIC-09 / VIC-10
h)Explore/Discover	8) UNC-10
i) Plan	9) ECO-14 / ECO-19
j) Hypothesis	12) MOV-05 / MOV-13 / MOV-16 / MOV-23
k) Experimentation	13) ARC-07
l) Analyse	
m) Action/ Task	
n) Modeling/simulation	

o) Reflect/Discuss
p) Imitation
q) Shadowing
r) Assessment
s) Competition
t) Motivation
u) Ownership
v) Accountability
w) Responsibility
x) Repetition

Figure 3: LM-TM model for moddified version of *Steam*

Although the original LM-GM model is flexible to use, it can be confusing to establish direct relations between mechanics when there are many of them activated at the same time, and even more when thinking without concrete gaming activities. To make the proposed LM-TM model clearer, the direct relations identified between learning mechanics established by Arnab et. (2015) and the tabletop mechanisms from Engelstein and Shalev (2019), identified in the case study for the modified version of Steam, are shown in Table II.

Table 2: Direct relations between TM and the LM (references in Figure 3)

Game Activity	***TM***	***LM***
Reading the rule book or be taught by another player or the facilitator.	1), 2)	a), b), c), f)
Participating in a competitive game.	3)	d), t), r), s), t), u), v), w), x)
Waiting for the turn to play, while analyzing and planning the next move.	4)	i), e), f), j), l), o), p)
Tile placement of the railway tracks and paying the price according to the location.	5)	h), i), j), k), m), n)
Choosing which cubes to move and which railways to use, discussing with opponents.	6), 9)	l), m), n), o)
Counting the victory points resulting from the balance of the money spent and the cubes gathered, analyzing other players' scores.	7)	g), o), r), s). t), u), v), w)
Uncertainty or deliberate setup of the game, to play differently each time.	8)	d), n)
Building a network of railways with the minimum cost to transport the maximum number of cargo cubes along with the gameplay, considering that other players can build in desirable places first or transport the desirable cubes also first.	12), 13)	e). f), i), j), k), l), o), p), q)

Steam **board game case study: data gathering**

Before and after the game, two inquiries (pretest and posttest) were done. The pretest recorded the players' previous experiences with games, game habits, and the perceptions of the games as possible learning and simulation tools. The posttest recorded the gameplay and the players' experiences. These inquiries were done following Mayer et al. (2014) framework, with a special focus on the participants' experiences during gameplay, the achievement of the serious objectives defined for the games, and the perception participants had about future game usages and analog games in particular. They consisted of "yes" or "no" questions and five-point Likert scale questionnaires, done in a way that allows the comparison of results. In Tables 3 and 4, the mean average (μ) results, and the standard deviation (SD) are presented for the 12 players.

Table 3: Inquiries after playing the game

Question	***Mean Average (μ) (1-5)***	***Standard deviation (SD)***
How fun was the game?	4.33	0.75
Motivation during gameplay?	4.58	0.64
How difficult was the game?	3.08	1.11
How challenging was the game?	4.25	0.60
How was your anxiety level during the game?	2.25	0.83
How well did you adapt to the game?	3.92	0.76
Were you surprised by the game session?	3.64	0.64
How was the level of empathy among players?	4.17	0.69
How was your level of frustration during gameplay?	1.92	1.04
How motivated were you?	4.58	0.64
Have you tested skills and knowledge during gameplay?	4.25	0.71
Can games be applied in other serious situations?	4.75	0.43
The game fulfilled its serious purpose?	4.58	0.49
Would you play this game just for fun?	4.58	0.64
Can analog games be better than digital games in general?	4.67	0.62

When asked about their game habits, seven students said they played once or less per month, and only two played every day. This shows that the game habits are, in general, low, which can explain some of the results later presented, like the low preference for digital games (μ=3.92) when comparing to analog games (μ=4.25). Only one student knew some MBG, and all the others said they have never heard of them despite several popular games were presented as examples (i.e. *Catan, Ticket to Ride, Codenames, Carcassonne, Azul*). Even though the results suggest students prefer analog games, they ignored MBG. This data is presented in Table 3.
In the inquiries field for voluntary observation, only one player shared his testimonial: "*enriching experience and suitable for many real training sessions*".
Although the game habits among students were low, they perceived games as fun activities (μ=4,17) even before playing the game (see Table 3), and after playing the game they improved that perception (μ=4.33, see Table IV). The motivation levels also increased after playing the game, from μ=4.50 before the game to μ=4.58 after the game (see Table 3 and Table 4, respectively).
According to BGG, *Steam* board game presents a complexity of μ=3.46 (on a scale that goes from 1 to 5, as the Likert scale adopted), which is considered a medium-heavy game. With the adopted simplification of the mechanics, it was expected that new players would feel the game more accessible. Students considered the game slightly difficult

(μ=3,08, SD=1,11). This value is relevant because players were new to the game, did not know MBD, and had low game habits. Although students felt a lower complexity than the one recorded in BGG, they were not considered easy.
According to Table 4, students considered that the game was helpful to test their knowledge and skill (μ=4.25, SD=0.71), and, departing from this example, that other games approaches could be adopted for different serious applications (μ=4.75, SD=0.43). They feel that the played game accomplished the objective of simulating the shortest path effect in a transportation network (μ=4.58, SD=0.49). Students assumed they would play the game just for the fun of it (μ=4.58, SD=0.64), and have even considered that analog games could be more suitable than digital games as serious games tools for learning and training purposes (μ=4.67, SD=0.62).
In the Game-Table I (GTI) players scored worse than in Game-Table II (GTII). By observation of the behavior and the development of the final railway network, it was notorious that GTI players were playing deliberately to block other players from making direct railways to the desirable cities. That did not happen in GTII, where the average scoring was 50% higher than in GTI.

DISCUSSION

Identifying game mechanics and mechanisms can lead to misleading and vague definitions. Considering established mechanisms as starting points, like the ones by Engelstein and Shalev (2019), can help develop serious games, although a list of this kind is an ongoing work that will never be complete as game innovations never stop evolving.
It is necessary to consider some assumptions to be able to compare learning mechanics to game mechanics and tabletop mechanisms. This work intents to contribute to this field of study, helping to produce and evaluate new serious games inspired by MBG designs. As seen before, the mechanics or mechanisms are what distinguishes MBG from mass-market board games, which makes it mandatory to consider the relations between them and their learning mechanics.
The LM-TM proposed framework starts from the LM-GM, considering the distinctive features of MBG, highlighting the need for a constant tutorial about the game mechanisms, but also taking into account the importance of the game materialism and components in the process of playing and learning the games. It was clear that a single tabletop mechanism can activate several learning mechanics at the same time. While board games depend almost totally on their mechanics/mechanisms to function as games, this dependence can transform them into powerful learning and simulating tools for serious games. Starting to play a board game implies plenty of learning skills. Although the use of many game mechanics/mechanisms can help to create a deep simulation and a more engaging game experience, it increases the complexity of play. Complex games are difficult to play quickly by new players (Sousa 2020). Therefore the game complexity tends to accentuate the need for a facilitator to explain and accompany the gameplay. In the case of a serious game approach, it is mandatory to do the debriefing part, since it plays an important role.
In the *Steam* case study, it was clear that even players with low playing habits, and without knowing how to play any MBG, can enjoy them. Reducing some of the original complexity allowed players to understand the game with low levels of anxiety (μ=2.25, SD=0.83) while keeping high challenges (μ=4,25, SD=0,60). The posttest proved to be consistent with the hypothesis that these games and their mechanics can be adapted to produce new serious games approaches, perceived by participants as ways to address serious content and provide engaging activities.
Players considered that they were able to test skills and knowledge during gameplay and that the game accomplished the predefined main objectives. Because the final scoring was positive, considering the debts and the cargo transported through the network composed by the railways they constructed, players proved to understand the game concepts and objectives. In every game-table, the shortest paths between all cities were established, considering all the private railways' lines, although in GTI players deliberative constructed railways to block other players. Taking this into account, the game allowed players to play a competitive game while accomplishing the learning objectives. However, the serious objectives can easily be undermined just for the fun of the gameplay. We can also conclude that when players were really targeting the creation of shortest paths, and not deliberately blocking one another, they were able to achieve efficient results in their final personal scoring. The emergent blocking was also useful for the debriefing process, as it generated an example of inefficiency, easily understood by students. The results from the two game-tables were compared. The higher score in GTII demonstrated that in this kind of eurogames, even in competitive ones, collaboration can be efficient and improve game results.
The importance players gave to analog games over digital games, when applied as serious games, can be explained by their low gaming habits and due to some bias because the posttest was done just after playing an analog game with positive feedback.

CONCLUSION

Besides their growing popularity, modern board games are still far from being well-known. This opens new research possibilities for serious games and game studies in general, considering the design innovation and novelty they represent, and the lack of studies done with them (Sousa and Bernardo 2019). Game mechanics/mechanisms can relate to learning mechanics, and these associations can help to develop serious game approaches, with adapted or new games. The LM-TM framework provides some guidance to establish these relations for analog games.
Learning more about board game unique mechanisms also promises to be useful for the development of new digital and hybrid games for the post-digital era, in a time were the analog dimension has value for itself.

GAPS AND FUTURE RESEARCH

The LM-TM framework should be tested with more MBG intended to be used as serious games, comparing them to the mechanisms of mass-market board games. This extensive

testing would be useful to support the relations of the different tabletop mechanics/mechanisms to the different learning mechanics and player profiles.

The effect of playing just for fun, not following the game's serious objectives, can undermine their serious dimension. New strategies to avoid this must be developed, especially when using games that were not meant to be serious games.

There is a clear need to deepen the methodologies to relate the direct effect of each game mechanism/mechanic to the learning mechanics and to record the player's behavior. The inquires could be reformulated along with a deeper statistic analysis to evaluate the experience results.

The frameworks for the debriefing process should be improved, considering the unique features of analog and MBG. Applying *Steam* board game with more students would be recommended, adding control groups, reducing and augmenting the complexity of the game mechanisms. Measuring the players' knowledge about the game objectives, before and after the games, should be included in future applications of this framework.

Including control groups of players with more deep gaming habits should be relevant, especially to understand how the natives of digital gaming can benefit from MBG approaches to serious games.

ACKNOWLEDGEMENTS

The authors would like to thank "Fundação para a Ciência e a Tecnologia" (FCT), the Portuguese funding agency, that supported this research under the grant PD/BD/146491/2019. To professor António Pais Antunes for supervising the associated Ph.D.

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Game - Player Interaction

EXPLORING PEAK-END EFFECTS IN PLAYER AFFECT THROUGH HEARTHSTONE

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KEYWORDS
Peak-end theory, player emotions, affective games, facial expression analysis

ABSTRACT

Peak-end theory suggests that when remembering an experience, people tend to focus on the moments of highest emotional variance and the last moments of the experience. In this paper, we study whether peak-end effects occur in gaming experiences, by comparing real-time to retrospective measurements of player affect. We ran an experiment where each of 26 participants played two games of Hearthstone while their affective state was monitored in real time through self-reporting and facial expression recognition. Additionally, participants submitted a retrospective report on their emotions 24 hours after the experiment took place. Strong correlation was found between the self-reported peak-end and retrospective emotion values, while no correlation was found between the retrospective self-reports and player facial expressions. The results of this study validate that the peak-end rule can be leveraged in order to identify players' retrospective emotions towards a game experience.

INTRODUCTION

The vast variety in video game players' personalities makes it impossible to guarantee that a game will be considered entertaining by every single player. People perceive in-game experiences in a unique way, leading to different individual responses (Kosinski et al. 2018). In the last decade, technological advances have enabled the obtaining of player feedback through consumer-level devices capable of monitoring player behaviour in real-time. A review by Peake et al. (2018) describes more than 100 devices able to measure humans' physiological, motor and cognitive functions.

One of the most popular biofeedback methods in affective computing research is facial expression recognition (Cohn et al. 2007). Players' facial expressions may provide accurate indicators of their affective state, translated into six basic universal emotion expressions (happiness, anger, fear, disgust, sadness and surprise) (Ekman and Friesen 1978). However, the search for a satisfactory experience goes beyond the sheer measurement of different emotions during a task. Gent et al. (2013) state that retrospective hedonic evaluations play a major role when people decide whether they are willing to repeat a certain experience or not.

Among the several tools that psychology has developed to try to understand what leads to a positive or negative retrospective memory, there is the peak-end rule (Kahneman et al. 1993). The peak-end rule states that people's judgement of an experience is highly associated with the emotions they felt at its peak and at its end (Kahneman et al. 1993; Do et al. 2008). Although the peak-end rule has been validated in different areas of science, its application in the gaming domain is still scarce (Gutwin et al. 2016).

In this paper, we use Hearthstone, an online collectible card game (Blizzard Entertainment 2013), to observe correlation between real-time player emotions and the retrospective hedonic memory of players' experiences. We run an experiment where player affective state is monitored during gameplay through self-reports and facial expression analysis. After 24 hours, players submitted a retrospective assessment of their emotions during the games played. Our main contribution is a multi-modal study of the applicability of the peak-end rule in online gaming scenarios.

RELATED WORK

In this section, we describe relevant studies conducted in the fields of facial expression analysis and human memory. Moreover, we describe the peak-end rule and its effect on retrospective memory.

Facial Expression Analysis

Facial expression analysis can be used to infer emotions, intentions and other internal indicators (Zhang et al. 2015). Although there is vast literature about recognizing emotions from facial expressions, it was Ekman and Friesen (1978) who defined the standard and most broadly accepted method of recognizing emotions by introducing the Facial Action Coding System (FACS)(Cohn et al. 2007). FACS defines 44 specific facial muscle movements (Action Units) that can be activated either individually or in combination, resulting in more than 7000 different facial expressions (Tian et al. 2001).

Ekman and Friesen (1978) define six basic emotions, namely happiness, sadness, anger, fear, disgust and surprise. These emotions can be identified through facial expressions, using the FACS. Multiple approaches have been presented (Amini et al. 2015; Ekman and Friesen 1982; Scherer et al. 2019; Zhang et al. 2015), each using a different mapping of facial Action Units (AUs) to specific emotions. It is important to note that the FACS is a descriptive system, excluding the subjectivity factor that is often connected to emotion expressions.

Facial expression analysis has been previously employed in game-related studies, including player experience assessment (Tan et al. 2014), avatar control (Zhan et al. 2008) or dynamic game difficulty adjustment (Blom et al. 2020). Compared to other biofeedback methods, facial expression analysis provides a cost-efficient non-intrusive solution, as it can be applied through any consumer level webcam. Furthermore, open source state-of-the-art software such as OpenFace (Baltrusaitis et al. 2018) can provide accurate detection of facial AUs in real-time. In the present paper, we employ OpenFace in order to detect player facial expressions during gaming experiences. The extracted facial expressions will be mapped to Ekman and Friesen's six basic emotions, and tested for correlation with peak-end effects of players' retrospective memory.

Memory Bias

The success of a video game highly depends on how much people are willing to repeat the experience that the game offers. A determinant factor in making this decision, is players' retrospective hedonic memory of an experience. In other words, how they remember they felt during the experience (Ariely and Carmon 2000).

Scientific studies point out a difference between how people feel during an experience and how people remember they felt during that experience. Due to memory limitations, the human brain is not able to recall everything that it has experienced in detail. Therefore, the brain selects to record certain features of a specific experience, and based on those, it reconstructs the retrospective summary of the experience (Geng et al. 2013). As this process does not take every event of an experience into consideration, the selection of such features may be biased. The result is that the actual experience and the retrospective memory of it may not be exactly similar (Kahneman 2000).

The Peak-End Rule

The Peak-End rule was first proposed by Kahneman et al. (1993). His hypothesis was that because of memory bias towards emotional factors, people are unable to accurately judge their own experiences in retrospect. This hypothesis was validated through a user study, where between two painful experiences, participants showed preference towards the one that lasted longer but was slightly less painful towards the end. Kahneman et al. proposed that participants' retrospective evaluation of the experience was not a time continuum, but a collection of moments. The selection of those moments to construct a retrospective evaluation were biased towards those with an emotional peak and the emotions perceived at the end of the experiment, regardless of the duration of the experience. The base of this theory is that situations that evoke high emotional valence are more remembered than situations that evoke low emotional valence (Kahneman et al. 1997; Kensinger 2009).

In the context of video games, studies regarding the Peak-End rule are scarce, even though players' retrospective affective memory of a game experience is a determinant factor in player retention. In addition, games provide highly immersive experiences and usually generate more intense momentary emotions than daily tasks (Gutwin et al. 2016).

Gutwin et al. (2016) explored this domain by testing for Peak-End effects in three games where in-game difficulty was manipulated to induce positive, negative and neutral peak-end effects. The results showed positive correlation between players' recollection of in-game challenge and peak-end effects. Furthermore, in one of the games, peak-end effects were also correlated to players' higher perception of interest, fun and desire to play the game again. In this study, we aim to further investigate the applicability of the peak-end rule, as we expand into the domain of online games played in a home environment.

METHODOLOGY

The goal of this study is to explore whether the peak-end rule can be applied to online games, played in a home environment. To that end, we ran an experiment where player affective state was monitored during gameplay through self-reports and facial expression analysis. Peak-end scores of player emotions were tested for correlation against retrospective emotion scores submitted by the participants.

Experimental Setup

During the experiment, participants played two online (non-competitive) games of Hearthstone against random opponents. We chose to use Hearthstone for three main reasons: (1) It is a widely popular game, which facilitates obtaining participants; (2) the average duration of a game of Hearthstone is approximately 10 to 15 minutes, which is enough time to collect an adequate amount of data for player emotion analysis; (3) most important, the game is played in turns, which provides researchers with enough idle game time during which participants may provide self-reports. Brief interruptions should not interfere with the participants' game immersion and consequently, their enjoyment of the experience (Brown and Cairns 2004).

This study was originally designed to take place in a University laboratory space, under controlled lighting, recording and computer hardware conditions. Due to the COVID-19 pandemic, social distancing regulations made physical data collection impossible. For that reason, this experiment was run remotely, using participants' home computers and peripheral devices. Even though the remote experimental setup deviates from our initial planning, we believe that it closely resembles a real-life gaming situation. In that sense, we expect recordings of players' facial expressions to be more spontaneous at home than in a lab environment. However, external distractions and uncontrolled lighting conditions may cause noise in the recorded data.

In this experiment, we attempt to validate the peak-end rule through two separate methods: we extract scores on player emotions through facial expression analysis and real-time self reports. Both input channels are tested for correlation with retrospective self-reports of emotions submitted by the players 24 hours after the experiment took place.

Figure 1: Snapshot of the Hearthstone Game. Each Player Uses a Deck of 30 Cards and Aims to Win by Reducing their Opponents' Health Points to 0

Data Collection

Participants were recruited by Convenience and Snowball Sampling during the months of April and May of 2020. A total of 26 (7 female) players participated in this experiment (mean age 24.8 years, sd=5.21). All participants had played Hearthstone at least once before.

Hearthstone is a single player online game, where one's goal is to bring their opponent's health points to 0 using a deck of 30 cards (see Figure 1). The game is played in alternating turns, each of which lasts a maximum of 75 seconds (Blizzard Entertainment 2013). Players have the option to end their turn prematurely, by pressing an "end turn" button. In this study, no game-related data was collected as it falls out of the scope of this research.

OpenFace was used in order to analyze player facial expressions (see Figure 2). OpenFace is an open-source, state-of-the-art facial behavior analysis tool that is capable of detecting facial landmark location, eye gaze, head pose and facial action unit estimations in real-time (Baltrusaitis et al. 2018).

Prior to participating in the experiment, participants received an email containing a consent form and an explanation of the experimental procedures. They were prompted with a link to an online video call with the experimenters which they joined after initiating Hearthstone on their computers. Through screen sharing, participants provided visual access to the Hearthstone game window and their webcam footage. Both the participant's face and game window were recorded throughout the experiment.

Participants played two games of hearthstone each. For every game, starting at the second turn and every three turns after that (including the last turn of the game), participants were signalized to answer the following question: "How would you rate your feelings this moment concerning this experience, on a scale from -5 (extremely unpleasant) to 5 (extremely pleasant), 0 being neutral?".

The question was adopted from Kahneman et al. (1997), aiming to obtain the maximum amount of information with the minimum amount of questions.

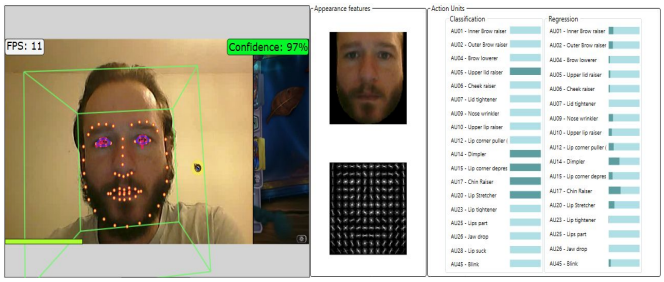

Figure 2: Snapshot of the OpenFace Software. On the Left, the Player's Webcam Recording with Facial Landmark Annotations. On the Right, Real-Time Estimations of Action Unit Intensity

This method was used in order to minimize gameplay disruption. The experimenters also avoided speaking with the participants during the games, doing so only to say the word "rate", which was the signal for participants to answer the previously described question. The three turn interval between participant ratings assured the collection of data alternating between the participant turn and the opponent's turn. Furthermore, it decreased the predictability as to when the assessment would be made, which could decrease the players' level of immersion (Brown and Cairns 2004).

An intermission of a few minutes was made between the two games and was used to ask participants to report on demographic questions (age, experience in Hearthstone). This intermission was intentionally designed to create a perception of finalizing one task (game 1) before starting game 2.

Regarding retrospective affective memory, 24 hours after the experiment took place, participants were contacted to answer the following question: "How would you rate your feelings at this moment concerning the experience of game 1, in a scale from -5 (extremely unpleasant) to 5 (extremely pleasant), 0 being neutral?" The same question applied for game 2. Participants were not informed about the content of the experiment's questions beforehand, to avoid influencing their answer.

Data Processing

From player self-report ratings collected during gameplay, two variables were extracted: (1) *Average emotion* was measured as the arithmetical average of all the ratings participants gave during the experiment. (2) *Peak-end emotion* was measured as the arithmetical average between the rating with the highest absolute value (peak) and the last rating given (end). The last rating was excluded from the peak value calculation. In cases of two peaks of similar absolute value but opposite sign (e.g. -4 and 4), the peak of opposite sign to the end rating was selected as *peak emotion*.

From the collected facial expression footage, per-frame AU intensity estimations were extracted using OpenFace. These intensity estimations are calculated in a continuous scale from 0 (no activation) to 5 (strong activation). OpenFace also provides a per-frame estimation confidence interval, and frames with a confidence value below 80% were discarded from the dataset. From AU intensity estimations, six basic

Table 1: Action Unit Configurations for Calculation of Basic Emotions, Based on Different Studies. Basic Emotions are Derived as the Aggregation of the Mentioned Action Unit Values

Basic Emotion	Action Units per study			
	Ekman and Friesen (1982)	Zhang et al. (2015)	Amini et al. (2015)	Scherer et al. (2019)
Happiness	6,12	6,12	6,12,25	6,7,12,25
Sadness	1,4,15	1,4,15,17	1,4,15	1,4,15,45
Anger	4,5,7,23	4,5,17,23	5,7,9,10,15,17	4,5
Fear	1,2,4,5,7,20,26	1,4,10,20,26	1,2,4,5,20,26	1,4,5,25,26
Disgust	9,15	4,10,17	9,15	4,7,9,10,17,20

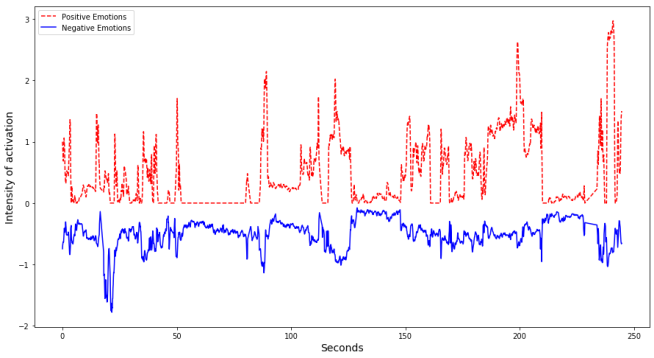

Figure 3: Time Series of One Participant's Activation of Average Positive and Negative Emotions During Gameplay

emotion intensity values were extracted, as defined by Ekman and Friesen (1978). To perform this transformation, four different mappings were used (see Table 1). Subsequently, the extracted emotions were divided into positive (happiness) and negative (sadness, anger, fear, and disgust) emotions. Surprise was discarded from the dataset, as we considered it to be a neutral emotion, yielding little information about player valence. The above methods resulted in a new facial emotion scale, from -5 (highly negative emotions) to +5 (highly positive emotions). Figure 3 illustrates a player's per-frame emotion estimations throughout the course of one game after the calculation of average positive and negative emotions.

In order to translate per-frame facial emotion estimations into per-game descriptors of overall player emotional state, the exact assessment moments (submitting ratings to the experimenters) were annotated. Around these moments, eight different time window configurations were applied. For each time window configuration, three emotion calculation methods were used. The above calculations resulted in a total of *3 x 8* overall emotion variables, for each moment of assessment. A summary of the different configurations used is shown in Table 2. The different configurations used aim to explore (1) whether different time intervals influence the assessment of player emotions and (2) whether negative emotions should be calculated individually or as a group.

Every per-game emotion value calculated through facial expression analysis was tested for correlation against the retrospective emotion value submitted by the players.

Table 2: Description of Per-game Emotion Calculation Parameters

Parameter	Configuration
Time window	1 second before assessment 1 second before and after assessment 3 seconds before assessment 3 seconds before and after assessment 10 seconds before assessment 30 seconds before assessment period between consecutive assessments peak-end values for entire game
Emotion calculation	Average positive & negative emotions Maximum mean value of 5 basic emotions Maximum absolute value of 5 basic emotions

RESULTS

In this section, we present the results obtained from experimentation, divided in two parts: results regarding player self-reports, and results regarding player facial expressions.

Results of the Self-Reported Assessment

Participants' submitted self-reports during the matches played were used to calculate the *average emotion* and the *peak-end emotion* variables. A statistical Shapiro test indicated that the collected data was not normally distributed, therefore the nonparametric spearman test was used to measure correlation between the retrospective affective memory and the extracted emotion variables. The spearman correlation between the retrospective affective memory and the *average emotion* was 0.725 ($p<0.01$, moderate correlation), and the spearman correlation between the retrospective affective memory and the *peak-end emotion* was 0.866 ($p<0.01$, strong correlation).

In order to test whether the correlation scores between *average* and *peak-end emotion* differ significantly, spearman rho scores were transformed to z-scores, using Fisher's ρ to z transformation. The *average emotion* z-score was 0.919 and the *peak-end emotion* z-score was 1.319. The Fisher coefficients comparison formula produced a z value of 1.98,

which exceeds the critical value of 1.96 ($p<0.05$). Therefore, we identify that the *peak-end emotion*'s correlation is statistically superior to the *average emotion*'s correlation.

Results of the Facial Expression Analysis Assessment

We explore whether player emotions, as estimated through facial expressions, validate the peak-end rule. Our approach is to test for correlation between the extracted facial expression recognition variables and the self-reported retrospective affective memory variable. We used 4 different mappings of facial AUs into emotions, with 24 possible configurations.
None of the extracted per-game emotion values showed correlation with the retrospective player emotion rating. While real-time player emotion reports validate the peak-end rule, the same conclusion cannot be drawn for players' emotions extracted through analysing their facial expressions.

DISCUSSION

In this section, we discuss the results obtained, while we also point out the limitations and future studies that derive from the present study.

Self-reports

Regarding real-time player self reports, results showed correlation between both peak-end and average emotion ratings and the retrospective evaluations submitted 24 hours after the experience. Moreover, we found that the peak-end emotions' correlation to the retrospective reports was significantly superior to the average emotions' correlation to the retrospective reports.
The above findings are aligned with Kahneman's peak-end rule, which states that when remembering an experience, people tend to focus on the moment of highest emotional variance and the last moment of the experience. Furthermore, they also validate Geng et al. (2013): a characteristic of the peak-end rule is that it can be applied for a short period after the experience; in the case of this study, 24 hours after the experiment took place.
From the above observations, we may conclude that the results of this study validate the applicability of the peak-end rule in the discussed context. In other words, in online Hearthstone sessions, players tend to keep memory of the peak and end emotions they felt during gameplay. As the retrospective hedonic memory of an experience is a determinant factor for people to decide if they want to repeat an experience or not (Ariely and Carmon 2000), these findings can be used to improve the adherence to a game, which is crucial to its success.

Facial Expression Analysis

Additional to player self-reports, player facial expressions were monitored and analysed in order to to identify their emotions during gameplay. A combination of 4 different configurations of facial AUs (Amini et al. 2015; Ekman and Friesen 1982; Scherer et al. 2019; Zhang et al. 2015) were tested using 3 different emotion extraction procedures and 8 different time window settings. None of the combinations showed significant correlation to the retrospective emotion self-reports. In the context of this study and through the facial expression analysis methods selected, player facial expressions failed to validate the peak-end rule.
An underlying reason why this result is observed might be the experimental setup. Due to the COVID-19 pandemic, data collection was performed using participants' hardware, in their home environment. This may have caused noise in the collected facial expression data, mainly due to sharp changes in lighting conditions, face occlusion, poor hardware performance or external distractions. A more robust dataset would have been collected if participants played the games in a University laboratory space, where the experimental conditions could be controlled.
Furthermore, studies have shown that players' intrinsic emotions do not always comply with their facial expressions (Blom et al. 2020). We have observed instances where participants would smile when feeling frustrated, leading to negative emotions being falsely identified as positive. In order to obtain more accurate results, facial expressions should be mapped into more descriptive emotions, e.g. "happy smile" vs. "frustrated smile".

Limitations and Future Work

Certain limitations can be applied to this study. Following Geng et al. (2013), this study was conducted by getting the retrospective affective memory of participants 24 hours after the experiment. As a consequence, the obtained results are limited to this time specific interval. In future studies, it would be insightful to verify whether the results obtained hold true for various (larger) time intervals.
Lastly, the relatively small sample size (26 participants and 52 games played) and the use of a specific online game harms the generalizability of the results presented to the entirety of the online game industry. However, since most online card games are played in a turn-based fashion, we believe that the results of this study may still apply in other online card games. To generalise these results over other game genres, separate studies need to be conducted.

CONCLUSION

In this study, we present an experiment where participants play two games of Hearthstone while ratings of their emotions are retrieved in real-time, through self-reports and facial expression analysis. 24 hours after the experiment took place, participants submitted a retrospective self-report rating their emotions during gameplay. Our main goal is to test the applicability of the peak-end rule (Kahneman et al. 1997) in the context of online card games played from a home environment. To that end, we ran correlation tests between real-time player emotions (extracted through self-reports and facial expression analysis) and retrospective player emotion ratings.
Results indicate that our calculations of peak-end player emotions extracted through player self-reports are strongly

correlated to the retrospective player emotion ratings. However, no correlation was found between peak-end player emotions extracted through facial expressions and the retrospective player emotion ratings.

Through the above results, we validate the applicability of the peak-end rule in the context of this study. It seems that in retrospect, players keep memory of the peak and end emotions felt during the game experience. In future studies, we aim to increase the generalisability of these results into other game genres, while at the same time, developing robust algorithms to accurately recognize player emotions through players' facial expressions.

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BIOGRAPHY

AGNER PITON, was born in Brazil, where he graduated in business administration and worked 10 years in the field. After realizing he wanted a career where he could have more impact in people's lives, he started to learn Neuroscience and became a master's student in Cognitive Science and Artificial Intelligence at Tilburg University.

PLAYER MODELING FOR ROLE-PLAYING GAMES

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KEYWORDS
Player Modeling, Interactive Storytelling, Role-playing Games, Decision Tree, Player Models, Machine Learning, TESV: Skyrim

ABSTRACT
In many popular role-playing games, player modeling features are poor, despite the fact that their use can enhance the player experience regarding its content and narrative. In this work, we present a Player Modeling architecture to incorporate in Role-Playing Games that uses a classifier to analyze player interactions with the virtual world, associating them with a player profile. We designed an association between those profiles and types of quests to generate a tailored experience that provides better enjoyment and immersion for the player. The architecture was implemented in a well known commercial game (TESV:Skyrim) and validated through both a controlled study and the player community.

INTRODUCTION

Player modeling (PM) is the creation, study and use of computational models of players in games (Yannakakis et al. 2013). The primary goal of player modeling is to understand how the interaction with a game is experienced by individual players. Player profiles can be created through several methods and can have a large variety of applications in video games, such as adapting the game difficulty, creating personalized content and believable agents, play-testing analysis and monetization of free-to-play games (Yannakakis et al. 2013). The use of player modeling in video games can make for a more rich and diversified experience as much of the game content can be created or adapted to the player preferences.

In the case of Role Playing Games (RPGs), an important component of the content is connected with the narrative. Incorporating and balancing player's actions in the world with the dramatic structure to form a coherent and engaging narrative is the subject of Interactive Storytelling (IS) (Cavazza and Young 2016). Today there are some commercial systems that make use of some IS techniques, such as the *Radiant AI* system in Bethesda's The Elder Scrolls V: Skyrim. This system allows the game engine to create dynamic reactions both from the virtual world and the Non-player Characters (NPCs) to the player actions.

Various techniques for generating stories and missions have been proposed in the literature and its advantages discussed (Freiknecht and Effelsberg 2017). Nevertheless, the use of IS techniques in commercial games is still timid. Proposed techniques have been implemented on academic environments but not on commercial systems. There is an enormous potential for applying IS techniques to create enjoyable stories in order to differentiate a video game from the competition, but it is mostly untapped. Two main reasons contribute to this state of affairs: the first one is the authoring problem - designing and implementing a comprehensible IS system has been traditionally costly, as the main techniques used (branching story and/or dialogues) involve predicting and taking care of all possible player options (Wiltshire 2017). Procedural content generation could be a solution to this problem, but it can lead to the loss of authoring control (Smith 2015) and to shallow experiences (the "one mile wide and an inch deep" syndrome, plaguing some recent *Procedural content generation* (PCG) heavy games), which is the second reason. The authors believe that it is possible to obtain a good player experience which is not too costly to implement by applying Artificial Intelligence (AI) techniques to detect player preferences in order to change some aspects of the game. That would be a solution to the problems indicated above.

We present and validate an architecture that uses knowledge about the player state and actions in a RPG to create personalized content during run time. The system analyses the player actions and classifies the player in a archetype, generating and offering quests to the player in an immersive way. That architecture was implemented in a commercial game (TESV: Skyrim) and tested with hundreds of users, wielding very good results.

The contributions of this work are four-fold: (1) the proposed architecture, (2) a mapping between Bartle's player types and types of quests they find more enjoyable, (3) the TESV: Skyrim implementation which was

distributed as a mod and (4) the tests' results, which validate our approach and show that Bartle's classification is relevant for single player role-playing games.

STATE OF THE ART

Interactive Storytelling

In IS, the storyline is not predetermined and the narrative and its evolution can be influenced and changed by the user interactions (Kelso et al. 1993). IS in RPGs can be achieved through several approaches. A simple yet largely used technique is to build a direct acyclic graph, also called *branching story graph* where each node contains a point in the story where the player has to make a decision (e.g. plot point) and the arcs represent the paths that the player can follow in the story.

More sophisticated implementations try to maximize the expected enjoyment of the player through several methods, such as creating player profiles (Nelson and Mateas 2008) and trying to match the player with a predefined profile, using previous players feedback to create more appealing stories (Sharma et al. 2007) or using probabilities that predict which story branch the player is more likely to follow (Yu and Riedl 2015).

Drama Managers

In order to keep the narrative coherent and to apply the changes made by the user to the story, a Drama Manager (DM) is often used. A DM is a background agent that monitors an interactive experience and intervenes in order to shape the global experience so that it reflects the user's actions or choices, keeping the expressive goals by the author at the same time.

The video game TESV:Skyrim makes use of a DM - *Radiant AI* - to make the virtual world more alive and the agents more believable. This system is capable of creating dynamic NPC reactions to changes in the virtual world made by the player. Its objective is to create an immersive and non-linear narrative and thus a believable and unpredictable experience for the player.

Player Modeling

Player Modeling, from a general perspective, is the study of player profile and play data, detecting patterns in its interactions with the virtual world, to create a statistical model.

The information is obtained through an analysis of players cognitive, affective and behavioral patterns in order to create a *model* that expresses their personality, intentions and characteristics (Drachen et al. 2009). This model is then used to create an adapted experience that the player is more likely to enjoy and be interested in (see Figure 1).

Player Modeling has a variety of applications. The first and more important is to adapt the game experience to the player. This includes the narrative, mechanics, levels, difficulty, etc. The system captures and analyses

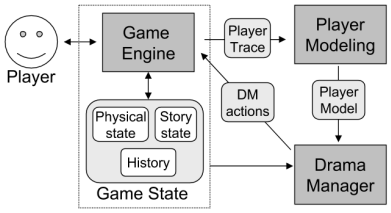

Figure 1: Player Modeling .Adapted from (Sharma et al. 2010).

in-game data and telemetry provided by the player to decide what content should maximize its enjoyment.

Another application is the creation of personalized game content. Some games use PCG (Togelius et al. 2011). This content can also include story segments or NPCs behavior and is sometimes the result of search based algorithms that try to adjust accordingly to player preferences or expected enjoyment.

Some systems make use of human user models to change the behavior of the agents present in the game to make them feel more "natural" or less robotic, thus creating believable agents (Togelius et al. 2011).

Player Type Classifications

In order to map player behavior, psychological traits and cognitive states to a model, player classifications are often used. One of the earliest documented division of RPG player types was formulated by Glenn Blacow (Blacow 1980). The author considered that there were four aspects of adventure gaming - *Power Gaming, Role-Playing, Wargaming* and *Story Telling* - and that the interaction of those four elements created the feeling of any given adventure. Other authors then gave their contributions to this topic, for instance Robin D. Laws (Laws 2002) proposed another RPG player type classification that divided players into seven archetypes, and the more recent a more recent player classification, that covers all game genres and has some psychological and physiological foundations, have been postulated by video game industry consultant *International Hobo - BrainHex*(Nacke et al. 2014). For this work, we choose the use the simpler and classical classification done by Richard Bartle.

Bartle in (Bartle 1996) postulated four different player archetypes for Multi-user Dungeons (MUDs). This classification, which was designed with a multi-player structure in mind, can also be applied to single-player games and separates players according to their preferred actions within the game. The archetypes are *Explorers, Killers, Achievers* and *Socializers*. (see Figure 2).

A concern that can be raised is that a classification based on multiplayer player types is not adaptable for a single player RPG. In fact, this classification is relevant also for single-player games, as referred already in online discussions (Megan 2018, Wikipedia 2008), and as our own tests prove.

For example, a Socializer player prefers single-player

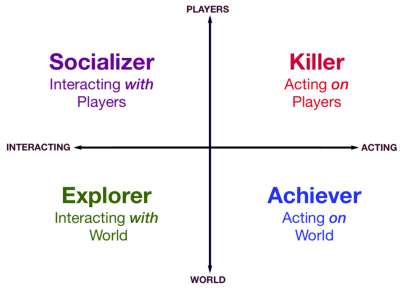

Figure 2: Bartle player taxonomy chart interaction.

quests where he has to interact and/or develop relationships with NPCs.

Quest Types

There has been an increasingly interest in classifying RPG quests and missions, according to their content, structure or quest-giver motivations. This is specially helpful when trying to build quest generation frameworks, procedural content generation and PM implementations.

Quests are often grouped and categorized according to some of their properties. One video game classification consisting on three basic quest types was proposed by Aarseth (Aarseth 2003). The author postulated that video game quests can be divided into three main groups: *time-oriented, place-oriented* and *objective-oriented*.

Doran et al. (Doran and Parberry 2010), describe common RPG quests structures. In their work they make an analysis on the most common objectives in RPGs and propose a quest classification model based on seven NPC motivations: Knowledge, Spirit, Comfort, Reputation, Serenity, Protection, Conquest, Wealth, Potential, Ability and Equipment.

Another analysis on Massively Multi-player Online RPGs (MMORPG) quest types is provided by Dickey et al. from the player actions perspective and quest structure (Dickey 2007). While the classification was built taking into account multi-player video games, it can be adjusted to the single-player component as well. The authors divided the quests into six groups: *Bounty, FedEx, Messenger, Collection, Escort* and *Goodwill*.

Procedural Content Generation

A recent general survey of PCG for games is given in (Freiknecht and Effelsberg 2017). Regarding quest generation, Dormans and Bakkes (Dormans and Bakkes 2011) proposed generative grammars to produce adaptable play experiences, in what regards space adaptation, mission adaptation and difficulty scaling. More recently, Machado et al.(Machado et al. 2017), extending (Doran and Parberry 2010), described Witcher 3 quests using also a grammar, that can be used for Procedural quest generation.

Discussion

By using existing classifications for abstract video game concepts such as quests and player types - and creating a correlation between them - it is possible to procedurally create more meaningful content for the player.

Machine Learning algorithms have been successfully implemented in video games for a large variety of purposes, such as player classification, level generation, agent believability and difficulty level adjustment. It is possible for a game engine to extract a player type from the player interactions with the game using a trained classifier. Such a system can be implemented in RPGs with a Drama Manager, as proposed below.

SOLUTION ARCHITECTURE

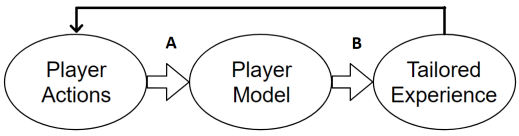

Figure 3: General solution concept.

Overview

The proposed solution consists of several components which sequentially interact with each other. To obtain a Player Model from the Player Actions, the main components proposed are a Player Classifier Module and a Class Manager. The generation of tailored experiences needs a Content Manager and an Integration Module. These components interact with each other and other game elements to function properly.

During the solution evaluation phase, the second part of the general concept was validated (transition B in Figure 3) using a controlled experiment. The solution as a whole was validated through a game modification (mod) release to the online TESV:Skyrim player community and an online survey.

Quest Types/Player Type Association

Since - to the authors' knowledge - there was no documented correlation between player types and quest types in the literature, we propose here a link between several quest types (as provided by Dickey (Dickey 2007)) and the player archetypes from Richard Bartle (Bartle 1996) - which is described in Table 1. This relation maps the relative interest level from a player type to several quest types and was inferred by the authors through a careful analysis of the quest types (Dickey 2007) and player archetypes (Bartle 1996) descriptions.

The authors believe this association to be an essential contribution, because it acts as the link between game content (e.g. game quests in this particular case) and player archetypes. Without this proposed link there

would be no trivial way to pair a functional model of human personality to a game mission structure or content. One of the results of the tests that were done (see Section) is the validation of this association. Below is the idea of each quest type:
In the **bounty quests**, the player character (PC) is somehow notified that there is a bounty on a creature, animal or enemy NPC, and a great rewards awaits him, should he complete the bounty. The **escort quests** require the PC to escort an NPC to another town of the player choosing. In the *messenger quests*, an NPC asks the PC for help to deliver a message to another NPC in some part of the game world. The **FedEx quest** type is similar to the messenger one but requires the player to deliver, fetch or trade items with the NPCs. Finally, the collect quests require the player character to collect a certain number of items. The difference between **peaceful and aggressive collection quests** reside in the fact that the aggressive one requires the player to kill creatures or enemy NPCs to get the items, while the items asked in a peaceful quest type can be obtained in the game world without fighting.

Table 1: Quest type preference. The number of plus signs represent the level of interest in a quest type from a particular player type, as proposed by the authors.

Quest Type/ Player Type	Killer	Socializer	Explorer	Achiever
Bounty	++			+++
Escort	+	+++		
Messenger		++	+	
FedEx			++	++
Collect Peacefully		+	+++	
Collect Aggressively	+++			+

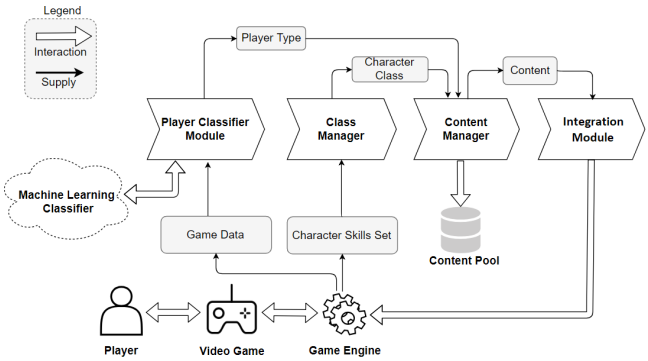

Figure 4: Proposed player modeling solution architecture.

System Description - External Entities

Player

The players interact with the game engine and express their thoughts, psychological traits, game style preference, intentions, etc (Bjork and Holopainen 2004). They are the ones who generate the data to the Player Classifier Module and the Class Manager, using their avatar to interact with the virtual world. They also validate the personalized content, by either accepting or rejecting it.

Game Engine

The game engine stores the current state of the game, receives the player physical input and orchestrates all other game components to deliver the player some sort of feedback, be it visual, auditory or physical. The game engine is, in reality, the component that the player is interacting with through an abstractions such as the video game itself and the character controlled by the player.

Character Skills Set

Character skills are a mean for character personalization. Generally speaking, the different types of skill progression in RPGs can be divided into three types: player-defined, game-defined and mixed.

On the first type, once the player character has reached an experience threshold, i.e. evolved a level, the game will ask the player to assign skill and perk points to different character skills or across a skill tree. In the game-defined type, the game engine is in full control of the skills and perks developed by the player character and will assign them according to a certain criteria - e.g. the most used skills by the character. On the mixed type, the game engine will either assign the skills or the perks automatically and will let the player choose the remaining one.

The character skill set provides a second layer of personalization over the chosen content, e.g. class-related quest and dialogue. A large majority of RPGs have character classes that are defined by some attributes and uses them as guidelines for a number of features. experience boost, class-specific skills, class-limited content, NPC dialogue, etc. Most RPGs will force the player to choose a class during character creation or throughout the game, offering the possibility of changing them later on or not.

Player Type

In Section *State of the Art* the authors addressed several player type classifications. Player classification is one of the foundations of this system, since a player type is what the ML algorithm will try to obtain to select the personalized content. The player classification model divides players into groups according to some psychological traits, interactions with the different game elements and so on. The player characteristics used to classify a player into in a class and the number of classes vary from model to model. One player type from the selected player classification will be retrieved from the Player Classifier Module and inputed in the Content Manager, allowing it to choose from a large set of content, to maximize player enjoyment.

System Description - System Components

Player Classifier Module

The Player Classifier Module is a subsystem that periodically queries the game engine for actions, events and interactions that involved the player and interacts with a ML algorithm to identify the player type that better fits a profile, according to the data obtained from the game engine. Finally, it outputs the obtained player type from that interaction with the ML algorithm to the Content Manager.

Machine Learning Classifier

The ML classifier is the entity responsible for choosing the appropriate player type, according to the features given by the Player Classifier Module. The inputed values correspond to the feature values being tested in the ML instance and the output is the chosen label after classification. It is important to note that a set of relevant features must be defined *a priori*, when choosing the ML algorithm and that it must be trained using a labeled set.

Class Manager

The Class Manager acts as a second classifier to further personalize the content selection. The character class can either be obtained automatically or inferred using the player character skills, depending if the game engine have predefined classes or not. The chosen character class is sent to the Content Manager in the end of the execution of this module.

Content Manager

This unit receives the player type from the Player Classifier module and the character class or classes from the Class Manager module and selects fitting content to present to the player. To do this, the module queries the Content Pool on available content, using as criteria the inputed values. The delivered content can come in many forms, inclusively a sequence of instructions, e.g. change difficulty setting, send enemies to attack the player character, or start a certain quest. Ultimately it depends only on implementation and available content. The chosen content is sent to the Integration Module at the end of the execution of this unit.

Content Pool

The Content Pool is a repository of the content that can be selected by the Content Manager - an identification of game features that can be used as personalized content to generate and present the player.

In order to create a tailored experience, some custom content has to be created or reused from the game to be selected by the Content Manager. It is also necessary to identify which content is suitable for which player type, e.g. a player who prefers action and a challenge may be more interested in an higher difficulty setting or a quest where it have to defeat several difficult enemies.

Integration Module

The Integration Module is an entity that receives the content selected by the Content Manager and provides instructions to the game engine on how, when and where to present the content to the player without breaking the normal game flow. Let us suppose that the Content Manager selected a quest to present to the player. The Integration Module will instruct the game engine on how to get the player to be notified of this quest. The module could perhaps instruct the game engine to put an NPC at the end of the next dungeon that the player character enters in and engage him in conversation, giving details about the quest.

IMPLEMENTATION IN TESV:SKYRIM

The objective of the implementation was to validate the proposed architecture by creating a proof of concept in a commercial video game. The chosen platform was TESV:Skyrim because of the easy to use and well documented developer tools provided by the game publisher, large player base, active game community and the versatility of the game engine itself.

As for the machine learning algorithm, a decision tree was chosen for being more efficient, faster and easier to implement in the Creation Engine when compared to classifiers such as Neural Networks or others. The proposed player modeling architecture was implemented using Bethesda's *Creation Kit* and Waikato Environment for Knowledge Analysis (Weka) tools.

As the player navigates through the world of TESV:Skyrim and interacts with it, the game keeps track of a collection of data and statistics on the player and the virtual world (e.g. Dungeons Cleared, Creatures Killed, Items Crafted, etc). A total of 16 features that the engine keeps records of were chosen to represent the player profile and form the *attributes* used by the ML algorithm.

As described above, the classification by Richard Bartle (Bartle 1996) was the one chosen for the proof of concept. Bartle's 4 classes compose the *labels* in the ML algorithm. When implementing such a system in a production environment, where one has the capacity to train the model with a great number of players, a more discriminating player classification could also be used.

Regarding the training data set used to create the classifier, it was generated by 25 different players. Each element was obtained through a controlled play session that culminated with a Bartle player type self classification. The objective of the experience was to map player actions (attributes) to a player type (label). The authors acknowledge that 25 elements is a rather small sample for a training set, but arguably enough for a proof of concept, developed in an academic environment. In a commercial videogame scenario the training data

set would have to be significantly bigger. The decision tree was implemented in the *Creation Engine* using its own scripting language - *Papyrus*. The function containing the tree runs every two hours and will always select a label - player type - in the end. The implemented ML entity is composed of a decision tree (DT) created through the C4.5 algorithm (Quinlan 2014). Its purpose is to predict a player type, given a set of attributes as input.

In the proof of concept, three classes were designed: the Mage, the Hunter and the Blacksmith. Each class is a representation of a group of several skills. The objective was to create three classes that grouped most of the skills and represented a "theme" for the quests proposed to the player. This function computes three class weights and decide the player class that corresponds to the highest class weight.

The quest templates that represent the personalized content were created focusing on each of the available player classes and types. A total of 18 quest templates were created, six for each player class available and were adapted from the work by Dickey (Dickey 2007). As part of the data collection, the skills of the player character are analysed and a prototypical class derived from the three described above. When the algorithm runs, it will look for the class that was assigned to the player and the selected Quest Type (e.g. Messenger) will have a *theme* related to the assigned class.

There is also a random factor that is used when selecting the quest. For each player type-class combination, there is a distribution of 50%, 35% and 15% between the three quest types that the player is more likely to enjoy, according to Table 1. This is a correlation proposed by the authors for the purpose of this work and is based on the quest types description provided by Dickey (Dickey 2007) and the quest objectives. The quest is then presented to the player in an immersive way, provided by an integration component developed by the authors.

All the quest templates were created specifically for the purpose of this work. Each character class has a quest template for each one of the six quest types. These quest templates were created using the interface provided by *Creation Kit* and *Papyrus* scripting. The way that quests relate with a class is through their plot and objectives, e.g. a quest belonging to the hunter class will have the player using its hunting skills and helping other hunters.

SOLUTION EVALUATION

The proposed architecture was evaluated both quantitatively and qualitatively. The authors evaluated transition B in Figure 3 using a controlled test and the system as a whole (including the online ML classification subsystem) by launching a game *Mod* and surveying the user satisfaction.

Player Model ⇒ Tailored Experience Evaluation

A test was conducted with 30 subjects to validate the *Player Model ⇒ Tailored Experience* transition from the proposed model given by Table 1. The idea of this test was to make the players play with two different save files where the classifier had already run - one where the classifier assigned the player type equal to the one the player self-evaluated as and other with a different one - and understand if the difference in content was noticeable by the subjects and which session they preferred. All the save files contained a player character that was equal in skills levels and equipment. The only difference was the variable under study.

The conducted test followed the following protocol: First the participants were asked to take the Bartle test (Erwin and Downey 1999). The result of this test provided the player class that the authors define as the "correct" one, i.e. the player type that the player identified as. Then a save file is chosen for the player. This could be the "correct" or "incorrect" version, i.e. the save file that contains a character with the same player type that the participant obtained in the Bartle test or another one. The participants are then asked to play the game freely for one hour, filling the corresponding part of a questionnaire in relevance to how they felt during and after the gaming experience. Another save file is loaded. If the "correct" version was selected in the first play session, another version - as the authors define as an "incorrect" one is now loaded. The subjects are asked to play again for one hour and to fill the corresponding part of the questionnaire in relevance to how they felt during and after this last gaming experience.

The results obtained validated the association made between the Player Model and the Tailored Experience. The results cover all the areas assessed by the Game Experience Questionnaire (GEQ) test (IJsselsteijn et al. 2013). However, the ones that the authors were more interested in were Immersion, Flow, Positive Effect during gameplay and Positive Experience post-gameplay.

The statistic metrics used are the *mean*, *median* and *standard deviation* of scores obtain from the participants in the different GEQ areas. Due to the nature of the tests (i.e. repeated measures), it was also possible to perform a Wilcoxon signed-rank test (Wilcoxon et al. 1970) to understand the levels of significance between the results provided by the two classifications, given by a *p-value*. A side-by-side comparison allows us to draw some conclusions that can be seen in Table 2.

The analysis of the results shows that the participants preferred the quests chosen according to the "correct" player classification over another one. Looking at the Table 2 the mean values for the Competence, Immersion, Flow, Positive Effect and Positive Experience areas for the correct player classification are statistically significantly higher ($p < 0.05$) than its counterparts. Moreover, the values in the areas of Annoyance, Neg-

	Incorrect Quests for Player Type			Correct Quests for Player Type			
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Significance (p-value)
Competence	2.427	2.500	0.737	**3.027**	3.000	0.475	0.0001
Immersion	2.461	2.333	0.655	**2.989**	3.000	0.501	0.001
Flow	1.927	2.000	0.870	2.167	2.100	0.840	0.193
Annoyance	0.622	0.667	0.516	**0.111**	0.000	0.307	0.00004
Challenge	1.413	1.400	0.407	1.240	1.200	0.438	0.084
Negative Effect	0.858	0.750	0.579	**0.305**	0.250	0.357	0.0001
Positive Effect	2.560	2.700	0.711	**3.180**	3.200	0.462	0.0001
Positive Exp.	1.967	2.000	0.863	**2.772**	2.917	0.561	0.0001
Negative Exp.	0.360	0.200	0.412	**0.139**	0.000	0.196	0.022

Table 2: Comparison of the questionnaire answers per GEQ area.

ative Effect and Negative experience are significantly lower.

Community Mod Feedback and Survey Results

To validate the work as a whole (including the classifier module) with the TESV:Skyrim player community, the "Your Own Skyrim" game modification was published in the *NexusMods* website and the *Steam* game platform. On both *NexusMods* and *Steam Workshop* the "Your Own Skyrim" mod exceeded expectations, with over 26 thousand mod downloads as of the end of March 2020 and a high level of interest on the issues addressed by this work. It was in the top 10 most popular Skyrim Mods of the week and top 10 trending Skyrim mods, reaching the 16th place in the most popular mods of that month. On *Steam Workshop* it was in the top 10 Skyrim Mods of the week, reaching the first place during the second week and top Skyrim mods of the month with a five star rating.

A total of 825 people answered the questionnaire provided in the mod description. The questionnaire contained 9 questions that aimed to assess the opinion of those who downloaded the mod, regarding the mod itself and PM systems in modern RPGs. The results show a great interest in this type of PM applications as discussed in the Conclusions section.

CONCLUSIONS

We presented and validated an architecture that uses knowledge about the player state and actions in a RPG to create personalized content during run time. The system analyses the player actions and classifies the player in a archetype, presenting quests - which have some dynamic elements (e.g. objectives, locations, quest givers) generated during run time with the game AI system, *Radiant AI* - to the player in an immersive way.

TESV: Skyrim was the chosen platform to develop a solution implementation because of its open-world role-playing nature, its unquestionable success and popularity, and the accessibility to game modification tools. Richard Bartle's player classification was the one used for this particular implementation but other player models can also be used in a commercial scenario.

As for the player type assignment algorithm, a decision tree was used, which was generated using a training set generated by 25 players. Of course, if this system is implemented during development of a commercial game, a larger dataset should be used to train the classifier as well as a more advanced classifier. The choice of a decision tree here had to do with the speed at run time. The developed solution was tested by 30 players in a controlled setting and also released to the public as a game modification which was subject of appreciation by the game community. From the results of the tests conducted with the testing group, it can be concluded that Bartle's classification model together with the proposed quest type mapping is appropriate and that there was a significant increase in player enjoyment and immersion when the players were assigned quests that our model predicted to be preferred, according to their self-tests. This validates one of the main contributions of this work - the proposed mapping between player types and quest types.

The game community shows a high approval rate, with 74,4% agreeing that presented content was determined by their in-game actions and 71,6% concurring that it matched their preferences an play style. Furthermore, it is also possible to conclude that there is a high demand for player modeling systems in modern role-playing video games, with an impressive 94,6% of the respondents agreeing that PM components should be more frequent in RPGs.

The authors managed to develop a solid PM architecture based on a valid classification model and using a ML technique that can be replicated in commercial game versions. The promising outcome of the conducted tests on the final solution allows us to support the hypothesis that this type of systems should be invested on during game development by the video game industry in order to create more immersive and believable virtual worlds, maximize enjoyment and create an overall better experience for the players.

Acknowledgements

This work was partially supported by national funds through

FCT, Fundação para a Ciência e a Tecnologia, under project UIDB/50021/2020 and Project SLICE PTDC/CCI-COM/30787/2017.

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Real World Gamification

GAMIFIED DOLL-DRAMAS: PROVOCATIONS, PLAYBOR AND PARTICIPATORY PLAY PRACTICES IN THE AGE OF iTV

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KEYWORDS
Adult toy play, Doll-dramas, Gamification, Interactive television, Participatory viewership, Playbor

ABSTRACT

This work-in-progress paper presents a study on mature toy players and their gamified activities related to production of serial narratives of toy characters shared on social media platforms, Facebook and Instagram. Our research builds on two case studies of doll-dramas, or visually and socially shared toy stories, demonstrating how Barbie dolls are employed as characters in serial and interactive storytelling targeted to adult audiences. The focus of the paper is in investigating the gamified dimensions of interaction between mature players participating in the creation and consumption of doll-dramas. We ask how the creators of doll-dramas as the authoring players and hosts invite others to join in their game: to participate in the cultivation of the provocative storylines through persuasion strategies recognized from gamification. Our goal is to investigate how the relationships between acts of playbor, game-like player persuasion strategies, and active viewership of doll-dramas develop to participatory play practices and experiences familiar from the consumption of Interactive TV (iTV).

INTRODUCTION

The audiovisual material of today's media landscape often follows the certain typical conventions of television drama and narrative. It often evokes controversial feelings and reactions. The consumer gets irritated, shocked, furious, hyped, and confused on a daily basis. (Tuomi 2016, n.p.) Different media notions that arouse feelings of disgust, even hatred gather huge attention among their audiences. Television and the ways to consume it, to enjoy it and to take part in it have been changing during the last years. Multiplatform phenomena have spread television consumption to several different devices and environments. Moreover, television content has changed over the years to become more and more activating - especially with the premise that viewers need to be "attracted". The phenomenon of *provocative television production* simply refers to content that is in some way disturbing the common values, norms, and even morality. (Norris et al. 2010; Dant 2012; Tuomi 2016, n.p.)

The other area of interest for our study—gaming—has become more pervasive in society in the last few decades. In fact, media culture has become sort of a game itself. People are more and more aware of the artificial nature of it and they tend to 'play' with its different meanings and signs. Consequently, today's TV has become an important agent in active and social gaming experiences.

In this paper, to draw parallels between Interactive TV (iTV) and doll-dramas—or visually, socially shared and serial toy narratives—we focus on key persuasion strategies recognized from games and their respective cultures: *parasociality* (the following of game-hosts), *participation* (the interactive consumption of content), and *playbor* (the active creation of playful content for others to spectate and consume), explained in more detail the following:

First, viewers develop kind of relationships with the hosts, called parasocial affairs, which arise when a viewer comes to know a media figure/person and starts to spend time with him/her in his/her imagination (Mustonen, 2001). This relationship is important for understanding the creation and consumption of doll-dramas, as their authoring players act both as content creators as well as game-hosts, who provide viewers or players with content created through play.

Second, the boundary between active and passive viewership has blurred. A user can be active in many ways, on various platforms, without breaking the link to a TV. Audience involvement has thus widened to include "passive" ways of using a broadcast platform, "active" uses of Web platforms, and in-between phenomena such as voting via mobile devices and participating in online meetings (Tuomi & Bachmayer 2011, 55–56).

Third, audiences are nowadays actively creating content and taking part in several ways and on several platforms, and active audience practices that take place in and via social media. (Harrington et al. 2012) Once shared on social media, doll-dramas turn into interactive entertainment delivered through *playbor*. By a definition introduced by Kücklich (2005), playbor refers to gamification. In fact, Rey (2015) states that "gamification is the production of (one form of) playbor. Therefore, understanding playbor is key to understanding the gamification of production" (Rey 2015, 286).

RESEARCH METHOD AND DATA

Our two case studies introduce the examples of the dolls of Silky Street and Ellie from Finland and their stories told by their adult owners, who we here address as *players* of the toys.

Both of the doll-dramas are played out with Barbie and Ken dolls adventuring either in a specifically staged setting, or actual physical locations in public space. Their dramatic stories resembling docusoaps are then shared through social media platforms on blogs, Facebook and Instagram on profiles or accounts dedicated especially for this purpose.

The data of our study constitutes of two in-depth personal interviews (conducted in January and April 2019), participatory observation of doll-dramas, photographed field notes, and a content analysis of images and episodes posted by *Silky Street* (Facebook) and *Ellie from Finland* (Instagram). The rationale for choosing these particular cases is in regard to their representativeness of the phenomenon under scrutiny, their representation and (public) accessibility on two different popular social media channels, and their different volumes of followers (100+ for Silky Street, over 25K for Ellie).

In the study, we seek to answer the following research questions: First, how can the doll-dramas of the 21st century produced as playbor be understood as a form of participatory or interactive and provocative television? And second, in which ways do the doll-dramas under scrutiny employ strategies familiar from the context of gamification?

FINDINGS

Silky Street

The serial drama Silky Street created with fashiondolls started in spring 2012 at the bdollBarbie forum by a female toy player based in Southern Finland. From episode 80 onwards the story moved to a blog. The series follows contemporary life, is produced in real time and is interactive.

Many characters (played by Barbie/Ken dolls) and happenings featured in the series are based on media 'reality', meaning that their associated storylines are heavily inspired by contemporary TV personalities and docusoap-style of storytelling. Because of its provocative content, the series is rated R18+. (Silky Street blog, also, see Figures 1-3.).

Silky Street invites its Facebook page followers (some 120 followers to this date, May 2020) to join in the storytelling and competitions through mechanics and audience participation familiar from game-play. Competitions and voting familiar from interactive television formats take place regularly. As stated in the introduction to the doll-drama, one can become "part of the plot with your own dolls through a [personal] meeting [with the host and her dolls] or you can send pictures of your dolls" to the content creator or 'host'. By commenting, one can propose "what you would like there to happen in the series."

Figures 1-3: Playbor of Silky Street: a doll-drama with provocative content for adult consumption.

Ellie from Finland

The Instagram account for Ellie from Finland was created in 2016. In an interview with the 'host' of this toy story, it was revealed that the doll-drama evolved organically, as Ellie Aino Aalto (a made-to-move Barbie doll) was creatively experimented and photoplayed with by her owner. The photoplay (or doll/toy photographs) were the shared on the Instagram account featuring snapshots, stories and lines from Ellie's life in a city in South-Western Finland (Interview materials, 2019).

Ellie has 25,2 K followers (May, 2020). The narrative of Ellie has included romantic relationships to male dolls, in which the viewers have been encouraged to take part in the development of the plot. For example, the host of Ellie from Finland invites the Instagram followers to view a 'game' of love between characters of the popular, Finnish doll drama. In an Instagram post inserted into a photograph of male doll characters Damon and Ben (rivals in the doll-drama related to Ellie.from.Finland), the host of the site states: "You have voted. Let's start the game." Additionally, there is another clear reference made to gaming, describing the dynamics of the doll characters: "The game begins Damon and Ben/One loves and the other wants control." (see Figure 4.)

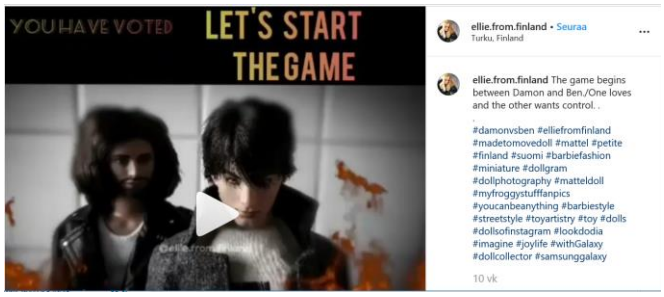

Figure 4: "Let's Start the Game", an Instagram post by Ellie from Finland inviting to game-like interaction.

DISCUSSION

Our firsthand analysis of the two case studies revealed how the creators of doll-dramas invite their viewers to join in the game by participating in voting and competitions. Due to the process of accepting this invitation to take part in the

gamified storytelling, the interaction evolves into many directions. Simultaneously, the viewers develop into players of the game, whose actions may be categorized as follows:

- *Solitary play dimension*: In consumption, parasocial, imaginary relations are developed with both the (human) creators, authoring players or 'hosts' and the (doll) characters of the doll-dramas.

- *Social play dimension*: By active participation, viewers and spectators of doll-dramas as fellow content creators become co-players through participation in gamified activities.

In the light of the preliminary findings of our work-in-progress study, the creation, sharing and consumption of contemporary doll-dramas operate by complex systems of interaction and participation. The creators of doll-dramas as the authoring players and hosts invite the audience to join in their game: to participate in the cultivation of the storylines through persuasion strategies recognized from iTV and *gamification*: parasociality, participation and playbor.

To clarify further, the creation and sharing of the toy stories can be seen as *invitations to play*, whose creators aim to persuade the viewers and consumers of the doll-dramas to participate in the 'games' around the narratives as co-players, for example, by co-creating content by voting for preferred storylines, character appearances, etc. Moreover, the gamified play patterns of these doll-dramas imply communication through narrative development and sharing of content produced through play—conceptualized here as *playbor*.

CONCLUSIONS

We propose that the serial toy stories produced and socially shared by adults may be considered doll-dramas of the present, which represent playbor and carry remarkable similarities to provocative and interactive TV narratives of today in terms of their themes, content, narrative strategies and the ways they invite viewers, spectators and consumers as audiences to become actively co-playing participators through gamification. According to our preliminary findings, the relationship between creators and viewers/players is *dialogical*.

Furthermore, as the two case studies demonstrate, the *invitations to play propose game-like strategies* in persuading viewers to participate as co-players (through narrative development and actual competitions organized to the viewers). Therefore, it is possible to argue contemporary doll-dramas to be situated as a phenomenon that overlaps the areas of gaming, social media, as well as dolls as 'construction' toys, avatars and providers of 21st century adult amusement (see Figure 5.).

This is to say that toy play of the present is largely inspired by the wider media landscape and productions, including provocative characters and storylines, as well as game-like interaction. Furthermore, character toys, such as fashiondolls in their many manifestations, provide ample material for construction, even re-construction and re-playing of media productions in many ways.

Visual and social storytelling play a significant role in the content creation, in which (human) media personalities intermix with their toyish counterparts. Sometimes, it is also possible to identify avatarial relationships occur with the toys of the doll-dramas, meaning close resemblance between the players and the playthings.

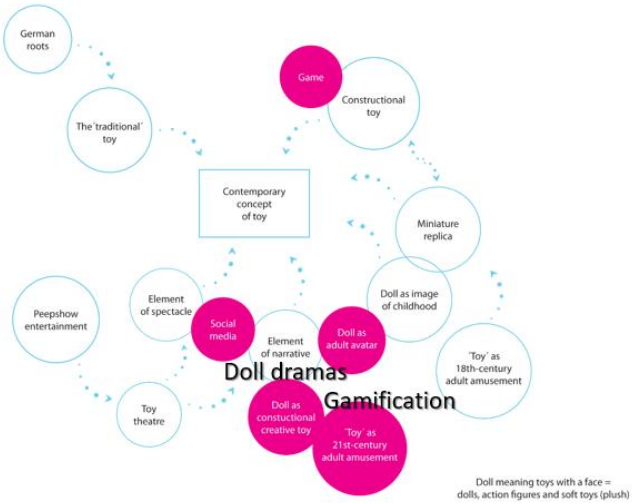

Figure 5: Situating Doll-Dramas and Gamification in the Current Concept of Toy Play (based on Heljakka 2013, 464).

FUTURE WORK

"Playing is what people do when they create culture", claims play scholar Brian Sutton-Smith (in Smith & Vollstedt, 1985). The future stages of our research will focus more on the question, whether invitations to play, such as the interactive doll-dramas as instances of playbor of the present demonstrate that *gaming* is what people do/promote when they create interactive and *participatory* culture.

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BIOGRAPHIES

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A GAMIFIED APP TO PROMOTE SENIOR CYCLO-TOURISM: A PILOT STUDY

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KEYWORDS
Active Ageing, Gamification, Motivation, Cyclo-tourism, Jizo.

ABSTRACT

Over the past few years, there has been a growing interest in the use of Information and Communication Technologies addressed to an ageing population. Since senior citizens are becoming better consumers of digitally mediated products, there has been an increasingly need to meet their demands and preferences, while fostering active ageing. However, even if a boom is observed in this field, there is a lack of information and products that address cycling, senior tourism and its impact into their well-being. The aim of this research is to report on how gamification can motivate and change senior citizens' behaviours, whereas a wide selection of methods, including focus groups, eye-tracking and interviews, were used. A total of 46 participants aged 55 years and over, with different nationalities were involved in a development method research. Based on the literature review, related work and the insights from each method, a cyclo-tourism digital app entitled Jizo was co-designed. The results recommend a set of gamification techniques and elements that can motivate senior citizens to cyclo-tourism, being essential integrative parts of an app in this context. The game elements that were highlighted were: social relationships, progression, challenges, competition, feedback and rewards. These data support the view on the potential of gamification to motivate active ageing and sustainable cyclo-tourism.

INTRODUCTION

A substantial quantity of literature (*e.g.* Webb, 2008; Groot and Fagerström, 2010; Derboven et al., 2012) has shown particular interest in combining indoors and outdoors physical exercise with digital games, in order to engage senior citizen's communities with digital platforms. Indeed, this may happen due to the notable problem of sedentarism, especially in older age groups that are growing exponentially, leading to an increased risk of mortality, mobility and health deficiencies (Rezende et al., 2014). Moreover, physical exercise and the use of Information and Communication Technologies are suggested to have a great potential to overcome this problem, as demonstrated in E-Health studies (*e.g.* Tse et al., 2008; Silveira et al., 2013; Toril et al., 2014).

Even though health-related concerns often arise in the group of senior citizens (Nyman et al., 2018), a decline in physical exercise and a rise of chronic diseases are likely to affect their routines (Angulo et al., 2016). Consequently, the need to re-invent strategies for sustainable active aging and healthier lifestyles has evolved and been brought to public debate and social policies (Costa and Grist, 2017). Physical exercise has also been suggested to significantly contribute to individual's wellbeing, since it is a strong gene modulator that affects structural and functional changes in brain plasticity, having positive physiological and cognitive effects (Mandolesi et al., 2018).

Senior citizens tend to be an exposed group at risk of social and digital marginalization (Marsili and Capacci, 2014). In fact, the current gap between senior citizens and younger groups on the usage and dependency of digital platforms to perform daily tasks may enlarge owing to the lack of concern with the usability, accessibility and context of use in virtual environments (Zheng et al., 2013). Perceptual and cognitive changes (*e.g.* farsightedness, need of glasses, hearing aids, memory challenges) need to be taken into consideration when assessing the context of use of ICT (Information and Communication Technologies), since they are likely to have a major effect on the success of an app, digital game or other digital platforms (Pak and McLaughlin, 2010). Furthermore, it is also important to acknowledge that differences in the usage of technology may also be dependent on such aspects as income disparities, perception of actual need to use digital platforms and products being too difficult to learn to use (Fisk et al., 2009; Olson et al., 2010).

Tourism has become one of the most forceful worldwide activities (*i.e.* social, cultural and economic), with sharper economic developments while connecting people (Rastegaeva and Kazakov, 2016). In fact, the development of the tourism-market oriented products has led to the need to meet new sociodemographic challenges. Senior tourists tend to have also a greater power related with the consumption of leisure and tourism products contrasting with younger tourists, mostly because they usually have the highest incomes, in comparison to other age groups (Aln et al., 2012).

Thus, when thinking about an activity that could combine physical exercise and tourism with game components (*i.e.* gamification), cyclo-tourism seemed to be suitable for the task. If, in the past, riding a bicycle has been considered solely a physical exercise activity linked to the health and fitness sector, it has recently been playing an important role in mobility, transports and the tourism sector (Cox, 2012). Considering this fact, cyclo-tourism seem to be an unexplored sector that comes with a great sustainability potential in rural areas (Gazzola et al., 2018).

The aim of this research is to report on how gamification can motivate and change senior citizens' behaviours. A development research method was used, englobing focus groups, interviews and eye-tracking tests with senior citizens aged 55 years old and over.

The paper is structured as follows: Section "Related Work" explores the use of gamification, motivational design and potential benefits of cycling in active ageing, also describing cycling exergames, gamified applications in cycling and tourism, and gamification applied to the cyclo-tourism contexts. The materials and methods section covers the participatory design process, data collection, analysis procedures and ethical issues; it also presents the prototype of the cyclo-tourism app created, entitled 'Jizo'. Following the evaluation process and its discussion, the main factors to consider when designing a gamified app for active ageing in the tourism context were outlined.

RELATED WORK

Considering the aim of this paper, a set of strategies in tourism and cycling had to be analysed. The next three sub-sections provide an overview of those strategies, while showing some concrete examples of its applications that were selected based on the relevance and popularity.

Gamification in Tourism

Gamification is predicted to become a major tendency in tourism (Jeffrey, 2011) to obtain proper information about a destination in pre-, in loco and post-experience; and to be able to interact with others (Xu et al., 2013).
REXplorer was a game exclusively designed for tourists at Regensburg, in Germany, with the purpose providing a playful experience, while informing them about the city history (Ballagas et al., 2008). To play this game, individuals need to have a mobile phone with the app installed and a respective city map brochure to walk around freely and communicate to spirits of historic figures that are associated with important buildings and monuments.
Other example of a digital game applied to tourism is Eye Shakespeare, developed by Stratford upon Avon (*i.e.* hometown of Shakespeare in England) (Xu et al., 2017). This is a gamified mobile app that use Augmented Reality to introduce a 3D virtual Shakespeare character to tourists, giving them an untraditional tour guide, by announcing his birthplace and enabling them to take a photo together with his virtual figure. It provides a fun and interactive touristic experience by using reward and storytelling as game elements (Xu et al., 2017).
These games succeed to inform users about the history and culture of the city and even relevant historical figures in a playful manner.

Cycling Exergames

Despite the cognitive benefits of physical exercise in later life, only a small portion of senior citizens do it at the recommended levels (at least 30 minutes a day) and that has led to an increasing number of studies (*e.g.* Smith and Schoene, 2012; Barnett et al., 2013) that examine exergaming technologies (*e.g.* Microsoft Kinect, Nintendo Wii) in order to motivate senior citizens to do physical exercise, combining digital game elements and fitness activities.
Elliptical bicycles are a great example of usage for exercise by senior citizens, providing a convenient way to keep fit and healthy without having to leave home, although cycling alone at home or indoor can be monotonous and dull (Ortet, 2019), there are some projects that aim to change that.
In Join-in Exerbiking (2014), users participate in multi-player online rides where they can virtually ride their bike outdoors while using an elliptical bicycle with a tablet mounted on the handlebar, see a route map, textual information and other users' photos.
Pedal Tanks was created with a customized controller for the purpose of physical exercise, being the exercise itself a direct input to the digital game by the RPM sensors converting into speed and the handlebars buttons allow easy effort because it provides a wide-ranging set of actions (Hagen et al., 2016).
The Pedal Kart's objective was to design and build an exergame that could provide the weekly recommended physical exercise with an elliptical bicycle, while being enjoyable and pleasurable enough to motivate people to exercise during more time and more frequently, with different variety of movements intensity (Skjæran and Wang, 2018).
In these cycling exergames, exergaming is suggested to promote short-term and mid-term enjoyment and engagement and incorporate physical exercises in people's daily life.

Gamification in Cycling

When searching the terms "cycling", "tourism" and "cyclo-tourism" in Google Play and Apple Store between July 2018 and May 2019, more than 150 apps to track and register bicycle rides were found. Most of them were very similar and were excluded to avoid repetition, whereas others were not free and would not contribute in a significant way for this study, since most of the cyclers or new users tend to prefer non-payed apps. Therefore, only three apps were chosen taking into consideration (i) its popularity and classification (*i.e.* based on the number of downloads and comments in the Google Play and App Store); (ii) functionalities (*i.e.* related to the gamification elements); and (iii) relevance to the theme (*i.e.* Cyclo-tourism, subjacent Cycling and Gamification): Cyclers, Strava and Zwift.
Cyclers: Navigation and Community for Cyclists emerge from a gamification strategy (*e.g.* offers prizes and badges for the cycling achievements) with special relevance to social features in cycling (*i.e.* sharing and following friends). The app track and save the users' rides, as well as monitor their personal statistics; supports the discovery of cycling routes with public transport and bicycle sharing by enabling users to find the most popular route by crowdsourced heatmaps, rate the routes they have cycled and help cities to plan a better cycling infrastructure; warns about the dangers, closures and restrictions along the route and provide short-term weather prediction and voice guidance navigation (Ortet et al., 2019).
Strava is known as an "athlete's social media", since it enables millions of cyclists to connect with each other by sharing their ride activities and photos, commenting on each other's rides, give 'kudos' and enabling groups to create clubs to organize activities or to build communities (Strava, 2018). With this app, users can track routes displayed on a map, speed, distance, power output and heart rate, and also upload their ride activities using GPS data, either from the app on a smartphone or via a third-party GPS bicycle

computer (*e.g.* Garmin, TomTom, Fitbit). Users can sign up for several challenges (*e.g.* distance, challenge, climbing goal), since it can meet their intrinsic and extrinsic motivations (*e.g.* personal realization and rewards), by tracking their progress after each riding activity been registered and a badge awarded when a challenge is completed (Ortet et al., 2019).

Even though Zwift may seem to be an exergame, their creators described as a software that is gamifying cities and routes to motivate people to train indoors (Bailey, 2017). This software consists on: (a) riding virtual roads adapted from real world cycling routes (*e.g.* Tour de France, La Vuelta, Giro d'Italia); (b) discover a virtual and exclusive world named Watopia, by climbing mountains and riding inside a bubbling volcano; (c) structured workouts, alone or in group, with elite World Tour coaches with custom-made programs; (d) social group rides with users from all over the world; and (e) challenges and events with different levels (*i.e.* from social easy rides to intense races with real prizes) (Zwift, 2018).

MATERIALS AND METHODS

Given the research question "How can gamification motivate senior citizens to cyclo-tourism?", the use of Development Research Method was required since there is almost non-existent studies or reports that cover the case of gamification in cyclo-tourism, especially to active ageing. The main reason for using this method was because traditional research approaches (*e.g.* experiments, surveys, correlational analyses) with their focus on descriptive and inferential knowledge barely can meet the demands of diverse design and development problems in any research theme. Development research tends to be ambitious, innovative and complex, offering new perspectives of analysis, given to the factor that it is likely to occur in the participants' natural context and leisure environments, targeting at supporting the obtained results and giving credibility to the study (Sutton and Austin, 2015; Akker et al., 1999).

In the Development Research Method, the goal is not to elaborate and implement complete interventions and have a functional product, but to originate a successive prototype that increasingly meet innovative aspirations and requirements. The process is often cyclic or spiral until a satisfactory balance between ideals and development is achieved.

This research study was divided into a 3-step process, being in accordance with the procedures undertaken in Development Research Method. These steps were Analysis and Evaluation of the Situation; Conception and Design of the Prototype; and Implementation and Evaluation.

Analysis and Evaluation of the Situation

After the literature review conducted between July 2018 to April 2019 and app analysis a set of focus groups sessions, interviews and prototype evaluation with eye-tracking were planned and divided.

Adult learners of a Portuguese University of Third Age (*i.e.* UTA) were invited to four focus group sessions – UTA-GN –, whereas the learners of other Portuguese University of Third Age participated in an eye-tracking session – UTA-E. Additionally, an interview protocol was conducted to gather the perspective of cyclists aged 55 and over, from Portugal, United Kingdom, United States, Denmark, Netherlands, Canada, Italy and France, on the use of game elements and techniques to motivate to cyclo-tourism and posterior evaluation of the prototype that was designed.

Participants and Procedures

The sample used in this study was purposively selected and, therefore, data cannot be extrapolated to other contexts. It counted with a total of 56 participants with different backgrounds.

Regarding the interviewees, they were invited via Facebook and Strava cycling groups. The criteria used for the participants' selection were: (a) being a cyclist; (b) being aged 55 years and over; and (c) voluntary participation. The sample consisted in 31 participants, 54,8% females (n=17) and 45,2% males (n=14). Regarding the cyclists' nationalities, 42% were from UK (n=13), 26% from US (n=8), 13% from Portugal (n=4), 7% from Denmark (n=2), 3% from Netherlands (n=1), 3% from Canada (n=1), 3% from Italy (n=1) and 3% from France (n=1).

In relation to the focus group sessions, the criteria used for selecting the participants of the UTA-GN were: (a) being aged 55 years old and over; (b) know how to read and write; (c) know how to ride a bike; (d) voluntary participation; and (e) interest in learning Informatics. The sample consisted in seven participants, 71,4% males (n=5) and 28,6% females (n=2), aged between 57 and 80 years old.

In terms of eye-tracking session, the sample consisted in eight participants from UTA-E, 50% males (n=4) and 50% females (n=4), aged between 59 and 78 years old.

Data was collected from April 2019 to June 2019. The 31 interviews had a 10 minutes duration per person, focus group participants had a 2-hour session per week and the eye-tracking session lasted, on average, approximately 15 minutes per person. In ensuring internal validity, the following strategies were used: triangulation of multiple sources of data collected (*i.e.* field notes, questionnaires and document analysis) and repeated observations at the research site. After collecting the data, the participants' perspectives gathered from the interviews, focus group and eye-tracking were divided into words, phrases or sentences using open coding. Then, their compilation in different categories was followed according to its context and number of occurrences. Data collection and analysis was performed using the NVivo 12 Plus software.

This study was part of the SEDUCE 2.0 research project and it safeguards: (a) The informed consent of the participants aged 55 and over; (b) voluntary participation; (c) involvement of the research team in the process; and (d) that the risks of participating in the study do not outweigh the risks associated with the participants' daily lives. In order to assure voluntary participation, participants were given an informed consent form, which informed the participants about the circumstances under which the study was carried out, the purpose of the research, potential risks, and benefits, the right to withdraw at any time and to refuse to answer any question. Researchers assured that all participants understand the terms of any agreement before taking part in the research project.

Conception and Design of the Prototype

This step initiated with problem-solving led by the researcher and the participants.
In order to understand the requirements that a gamified app should have to motivate senior citizens to cyclo-tourism and foster active ageing, this step was performed by focus group sessions with Portuguese adult learners at the UTA-GN combined with the interviews with cyclists aged 55 and over, since combining observation with interviews enables to collect richer and useful information, minimizing self-reporting error (Goodwin, 2009).Between May and June of 2019, interviews and a set of 4 focus group sessions were carried out to assess the participants' context and, subsequently, co-design a gamified app.

Semi-structured Interviews
The interviews started with ice-breaker questions about their gender, age, nationality, duration and frequency of their cycling activity. In order to pursue and ensure in-depth information and focus, cyclists aged 50 and over were surveyed about the motivations to cycle, the destination, the use of an app and its gamification elements, the concerns and the contributions of multimedia to cyclo-tourism. After the inputs of the cyclists' answers, it was possible to conduct the co-design session in the focus group with senior citizens.

Focus Group Sessions and Co-Design
Each focus group session had an average duration of 90 minutes and took place at the University of Third Age of Gafanha da Nazaré in Portugal (UTA-GN). Since each participant owned a bicycle and knew how to ride it, the goal of the first session was to know their motivations and barriers to ride a bicycle, as well to discuss the benefits of cycling, what to bring to a bicycle ride, and how to plan and share a bicycle ride. A brief definition of tourism was provided, and the participants shared their insights. The session ended with an explanation of cyclo-tourism and a presentation of the following session.
The second focus group session was a 30km bicycle ride to assess the participants' main difficulties when interacting with the digitally mediated platform Strava in a cycling context and identify the app limitations. The route chosen included bicycle paths, helmets were given to all, each bicycle was checked before and after the ride, every person had a smartphone with Strava installed and a professional road cyclist assisted the activity to ensure participants' safety, guidance and motivation.
With the cyclists' inputs from the interviews, the use of Strava in the bicycle ride and the literature review, a set of applied theories and practices were used in the third focus group session, encouraging the participants to be co-designers. A set of mockup cards and paper cuts of gamification elements were given to the end-users in order to facilitate the scenario-building and collage co-design techniques, in which each participant created two scenarios of what the perfect cyclo-tourism app would be before, during and after a ride, in order to motivate them to active ageing.Based on the outputs from these sessions, the researcher developed a prototype and crossed the data obtained.

Prototype
Based on the literature review on game design and design for active ageing, the problems found in cycling apps, the co-design sessions and the inputs from cyclists, a prototype of a cyclo-tourism app was proposed.
The gamification elements that were outlined both in focus group sessions and interviews as being the most important for a cyclo-tourism app were: (a) Progression: To monitor their rides; (b) Social Relationships: To add friends, invite them to a ride, comment and like rides; (c) Challenges: Goals to achieve; (d) Competition: Rankings/Leaderboards to encourage to be better than others; (e) Feedback: To provide feedback by commenting the user rides and progress; (f) Rewards: To be awarded with badges (virtual or real) for accomplishing an achievement; and (g) Win States: Users' victory or loss conditions to be determined in each challenge.
In addition, the participants considered that some additional information would be an asset as (a) Attractions and Facilities; (b) Equipment and Safety; (c) Route Maps; (d) Weather forecast; and (e) Bicycle Maintenance.
While prototyping the app and after doing the sketches in paper, the typography, the colour, and the name and logo were chosen. The app was designed in Adobe XD.
Following guidelines when designing to senior citizens (*e.g.* Veloso & Costa, 2016), it was decided to use predominantly the font Gibson, which is sans serif, simple and easy to read because of the simpler lines. Open Sans, also a sans serif font, was used in some titles, in order to generate some visual hierarchy between the elements.
While brainstorming ideas for the name and logo, the purpose and the audience were in focus. After some attempts of using and combining the terms 'cycling', 'tourism', 'active ageing', it was decided that the app should have a symbolic name, leading to the choice of a god's name. Searching for travel gods and what they are known for, the name 'Jizo' came up. Jizo is a Japanese and Buddhist divinity that vowed to protect travellers in their physical and spiritual journey, is not only easy to pronounce, but also a short and meaningful name. As Figure 1 demonstrates, the logo was designed in Adobe Illustrator and the typographic representation of the word Jizo used a gradient in orange. In addition, such elements as a cyclist with a youngster on a digital device landed on the planet Earth represents the cyclo-tourism in an intergenerational context.

Figure 1: Logo - Jizo

Implementation and Evaluation

The prototype review process was done in order to validate the created model and meet the research implementation and evaluation goals. A demo of a gamified app co-designed with and for the end-users was presented, played and, lastly,

tested with eye-tracking. A group of cyclists' users aged 55 and over were also interviewed and tested the app, aiming at crossing different sources of data. In the end of prototype testing, the participants identified the app strengths, weaknesses, opportunities and threats. Later, the results were interpreted, and the participants' comments were taken into consideration for future improvements of the prototype that was build.

To ease the navigation and show all the app features, a cognitive walk-through protocol was undertaken, with the help of a script, in which the researcher carried out a set of tasks to the participants, while trying the app, in order to access and perform the same activities throughout the evaluation session.

The prototype contained a sequential navigation scheme to help the user to understand what the app proposes and what they will find when clicking the icons (Figure 2); the functionality to follow friends and their activities; the access to maps with routes suggestions and classification, nearby convenience places (*e.g.* bicycle stores, hospitals, restaurants, hotels) and possibility to invite friends to meet them in a ride is shown in Figure 3; an historic calendar with access to previous rides and/or weather forecast; a menu with guides for the cyclist, the bicycle, challenges and news; the option of recording an activity while seeing their performance, route trajectory and access to camera without leaving the app; and a profile with picture, an award shelf, weekly and monthly performance, number of activities done, friends followed and by whom the user is followed.

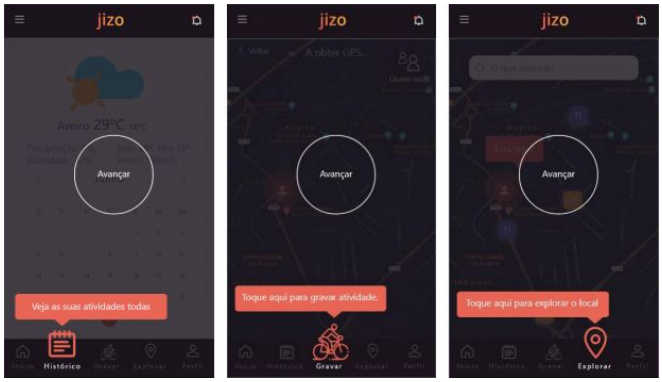

Figure 2: Tutorial navigation scheme

Figure 3: Routes suggestions and Ride with Friends' Invitation

Eye-Tracking

An eye-tracking session was held on May 29th, 2019 at the University of Aveiro, with participants of the University of Third Age of Esmoriz (UTA-E) that were not involved in the co-design of the app. The session included a visual presentation, a smartphone and desktop with the prototype and eye-tracker equipment (Figure 4). It is important to mention that, even though the eye-tracker was tested and prepared beforehand in a smartphone display, it was not anticipated that the equipment would fail with the target audience due to age related macular degeneration and ageing eyes, leading to an unrecognition of some of the participants' gaze.

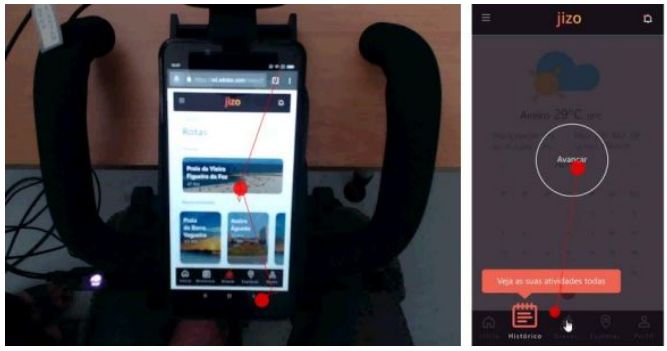

Figure 4: Eye-Tracking test in Smartphone (left) and Desktop (right)

RESULTS

In order to assess the psychosocial variables (*e.g.* health, socialization, participation in leisure activities, self-esteem) that a gamified app should take into consideration for active ageing, the Grounded Theory was used to data coding and analysis. Whilst using NVivo 12 Plus software such tools as crosstab, word frequency and matrix coding were applied.

Regarding the focus group participants (*i.e.* eight adult learners from UTA-GN), the reasons for cycling and possible barriers to this activity, the following categories emerged from the participants' statements relative to cycling motives: (i) health; (ii) environment; (iii) economic; (iv) transport; (v) physical exercise; and (vi) pleasure. For example, these were some of the highlighted participants' quotes:

"It has the ability to help both mental health and muscle health."

"I don't pollute when I am cycling."

In terms of barriers, these were: (i) sedentarism; (ii) weather; (iii) pavement; (iv) traffic; and (v) other preferences for alternative activities; as the following quotes corroborate:

"I'm lazy."

"Sometimes you do not cycle because of the weather or road conditions."

"I am afraid to ride in the traffic."

Overall, the participants acknowledge that they used the bicycle to improve their health, both mental and physical, and avoid traffic jams, while sedentarism lifestyles, weather and pavement conditions negatively affects their motivation to cycling.

In sessions 2 and 3, participants shared how a gamified app should be designed and emphasised the features they wanted to have were: access to information about the routes (*i.e.* the route and directions); weather conditions; access to bicycle mechanics and rental shops; monitor their statistics and improvements (*i.e.* distance, speed, calories, duration, bpm, elevation, climb); have incentives and competition (*e.g.* challenges, rankings and badges); feedback; share

information in the app and social media; and foster interaction (*i.e.* contact other users before, during and after the ride).

When analysing cyclists' data, they considered fitness, freedom, friends, health (mental and physical), enjoyment, people and scenery as their motivation to cycling. While observing if there was any relationship between cycling motivations and interviewees' gender, there were some considerable differences. Even though 'Psychological Reasons' (*e.g.* mindfulness and escape) were the most cited motivations by both genders (n=18 refs); the codes 'Health' (*e.g.* stop smoking) (n=7 refs), 'Physical Exercise' (*e.g.* lose weight) (n=10 refs), 'Social Reasons' (*e.g.* ladies' meetings; charity) (n=6 refs) and 'Tourism' (n=5 refs) were mostly found in females' statements; whereas 'Sport Passion' was highlighted by male participants (n= 5 refs).

Differences were also observed between gamified app features and interviewees' age group. The groups aged between 50 and 61 years old highlighted the importance of the 'Challenges' and 'Competition' features (n=7 refs) in a digitally mediated app; whereas 'Routes Maps' (n=19 refs) tend to attract the group aged between 62 and 73 years old. This fact may be owing to the willingness of younger target groups to compete and challenge or be challenged, and the preference of older groups for familiar routes with some guidance.

To evaluate the participants' eye-tracking performance, the fixation points and saccades were taken into consideration. For the analysis, the researcher analysed the videos from the eye-tracking session and was able to recognize the main difficulties found in the app. These were: (i) Dealing with digital devices; (ii) Understand the task; (iii) Find the task's correspondent icons to move to the next task; and (iv) Understand the icons' meaning.

While the participants who used the mobile stand had more difficulties due to dealing with a smaller display, the participants who used the desktop display had more saccades and difficulties in fixating the right icons. This act may be owing to the aging process of the eye.

In order to acknowledge Jizo potentialities, all the participants identified the strengths, weaknesses, opportunities and threats of the digitally mediated app. The Jizo strengths highlighted by the participants were the following: (i) introductory tutorial; (ii) the functionality to invite friends for a ride and tracking their location; (iii) explore local and touristic routes, and points of interest (POIs); (iv) take photos without leaving the app; (v) all cycling information available; (vi) originality; (vii) accessibility; and (viii) layout and design. The main weaknesses were: (i) icons identification; (ii) lettering size; and (iii) few monitoring statistics available. Relative to the opportunities, these were: (i) the ability to be used worldwide; (ii) extension for other activities; (iii) be an official cyclo-tourism app; (iv) connect people from all over the world; and (v) motivate to cyclo-tourism. The Jizo threats were: (i) other apps on the market; and (ii) the fact of not being well promoted and divulgated.

It was possible to identify several strengths relative to the Jizo app (*i.e.* introductory tutorial, the functionality to invite friends for a ride and tracking their location; see local and touristic routes; ability to explore the city POI; take photos without leaving the app; all cycling information were available; originality; accessibility; layout and design) and opportunities (*i.e.* ability to be used worldwide; to be used for other activities; to be an official cyclo-tourism app; to connect people from all over the world; and motivate cyclo-tourism), as well as improvements and modifications to be made to face the weaknesses (*i.e.* icons identification; lettering size; and few monitoring statistics available) and threats (*i.e.* other apps; and to not be well promoted and divulgated). Some participants share their opinion not only about Jizo, but also about their experience in the involvement of this project:

"I enjoyed participating in this project, it was interesting, I felt like my opinion mattered and it was really useful."

"I hope that this app goes to the market, I bet it can beat other cycling apps because is so much more complete."

To sum up, this app does not only have gamified functionalities that can induce inner user's motivations to cycling and active ageing, but also important aspects for tourism such as weather prediction, popular routes, nearby conveniences, points of interest and information relative to the sport culture.

DISCUSSION

Findings have suggested that gamification elements are important and can motivate senior citizens to cyclo-tourism and, therefore, contributing to active ageing.

It is imperative to recognize that senior citizens have some problems dealing with digital devices and technologies, as well as there is a predisposition of not being as active as before and, consequently, not ride a bicycle more often due to several constrains (*e.g.* physical limitations, pavement conditions, traffic, weather). Hence, the outcomes of this study have important implications for developing a gamified app targeted to active ageing and understand the intrinsic and extrinsic motivations associated to cyclo-tourism.

It was discovered that: (i) the main gamification elements that motivates senior citizens towards cyclo-tourism are the competition and challenges, with constant feedback about their progression, in order to receive rewards and share with social contacts; and (ii) the prototype Jizo motivated the sample of senior citizens by (a) providing information about the pre-determined cycling routes, weather conditions, rental shops, bicycle maintenance and safety concerns; and (b) offering the possibility to invite friends for a bicycle ride, challenges, among other features.

When applying these gamified elements to active senior cyclo-tourism, a set of endorsements were suggested to each experience stage:

- Pre-experience: route recommendations, weather forecast, information about cycling equipment and bicycle rental shops;
- In loco: route directions, performance monitoring, points achievements and rewards; and
- Post-experience: motivational quotes and feedback, unlock resources, badges earnings, rankings and leaderboards.

One of the major differentiator features of Jizo, when in comparison with other apps of the related work, is the possibility of inviting a friend, allowing to track the user location and, so, facilitating the meeting of users. Other important feature is the fact that this app was designed by senior citizens to active ageing, being more suitable for this audience. While other apps can shortly serve senior citizens

in this use, they fail to keep them engaged to the activity, not contributing for the fight against sedentarism and physical or psychological regressions. Thus, Jizo aims to revolutionize in this area, as, according to the results, it can increase intrinsic and extrinsic motivation, maintaining the user interested in the continuity of the cyclo-tourism activity.

A few limitations of this research study should be considered. Firstly, as mentioned before, gamification and cyclo-tourism for active ageing is an unexplored topic, being this research innovative and not a replication or adaptation from other comparable studies. Secondly, a convenience sample was used, so attempts to generalize beyond these defendants are not justified and outcomes should be analysed with extra caution. Considering that this study has an international dimension, getting a random sample of each country would be very interesting, but impractical and unfeasible in a short period of time. Thirdly, there may be some participants' bias in the results obtained, owning to the fact that the focus group participants were from the same institute. However, the researcher ensured that all participants expressed their individual and collective opinions and experiences.

Regarding future work, further research needs to be carried out in the motivational and the psychological field, in order to develop the understanding in gamification and motivation, while observing if there is an impact on behaviour change towards active ageing and frequency of cyclo-tourism. A game narrative could be a more interactive and efficient way to motivate senior citizens and different generations. During prototype design and development, mechanisms of artificial intelligence and augmented reality could also be considered in order to associate virtual avatars to a set of points of interest and local history or tourism as others works have gotten good results with such characteristics. The possibility of exergaming Jizo would be an endowment to this study and a significant contribution to people who are unable to ride outside due to psychological and/or physical limitations.

In addition, a long-term study with users' subjective and objective perspective on cyclo-tourism and considering additional usability and accessibility aspects in cycling apps and stationary cycling would be beneficial.

ACKNOWLEDGMENTS

The study reported in this publication was supported by Fundação para a Ciência e Tecnologia (FCT), I.P., COMPETE 2020, Portugal 2020 and European Union, under the the European Regional Development Fund – the project SEDUCE 2.0 nr. POCI-01-0145-FEDER-031696. The authors wish to thank the participants from the University of Third Age of Gafanha da Nazaré, from the University of Third Age of Esmoriz and the cyclists' interviewees. Also, a special thanks to Carolina Abrantes for the support on the eye-tracking sessions.

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EFFECTS OF DAILY ROUTINE ON STUDENTS' SDT NEEDS SATISFACTION: A PILOT STUDY TOWARDS DEVELOPING A DIGITAL GAMIFIED SYSTEM

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KEYWORDS
Self-Determination Theory, Autonomy, Competence, Relatedness, Digital Gamified System, Research Students

ABSTRACT

It is unknown about utilizing Self-Determination Theory (SDT) needs of autonomy, competence, and relatedness in postgraduate research students' motivation and the level of SDT needs are often lower among students. They are frequently confused on how they are progressing on research, causing feels of nonbeing a progression in achieving their research goal. They are more likely to feel less connected with colleagues and supervisors. To increase students' SDT needs, we developed a gamified system using User-Centered Design (UCD) three iterations and a one-week pilot study of the system informed that game-design element neither increased the effort among them to complete a weekly goal nor did it increase social interaction. This outcome guided us to conduct a one-week pilot study of the students' daily routine before re-developing the gamified system. This pilot study aimed to find out the views and comments regarding the usual daily activities on students' SDT needs satisfaction when performing their daily task and social interaction with others. The result of the study has informed us that the level of autonomy is relatively low among students, but the level of competence and relatedness are comparatively high. Future research will run over four weeks using a within-subjects technique with a quantitative and qualitative method. Intrinsic Motivation Inventory (IMI) measurement will be used to generate users' data output. This will demonstrate the effect of a gamified system on SDT needs compared with the daily routine of the students.

INTRODUCTION

Self-Determination Theory (SDT), seeks to underline how, why, and in what contexts an individual's behaviour is self-motivated (Deci and Ryan 2002). Over thirty years after the publication of SDT (Deci and Ryan 1985), there is now extensive research into SDT in many areas, for example, health care, work, sport, and parenting (Deci and Ryan 2008). Most of the SDT-oriented research has been performed on its relevance to learning (Spittle et al 2009) specifically in motivating students (Trenshaw et al 2016; Brooks and Young 2011). The empirical literature confirming the positive effects of SDT needs satisfaction is increasing (Deci and Ryan 2008). However, it is unknown about utilizing SDT needs (autonomy, competence, and relatedness) in postgraduate research (Hegarty 2011), particularly students' motivation. The level of autonomy, competence, and relatedness are often lower among them. Research students are frequently confused on how they are progressing on research, causing feels of nonbeing a progression in achieving their research goal. They are more likely to feel less connected with colleagues and supervisors. These bring adverse effects, e.g., health problems, disruption in research work, and dropping out of research programs (Appel and Dahlgren 2003; Wright 2003). Many technology-enhanced solutions are offered to support and motivate students to progress in research programs (Montrieux et al 2015). As an example, ProDoc and PhD Planner are doctoral monitoring systems aim to mitigate the problem of the early-stage researchers, i.e., delay in completion of their degree and supervision. These interventions are not grounded explicitly in student motivation theories, and the vast majority of these commercial systems (such as Classcrafts, Grammarly) are not designed, developed for students to help them with their daily tasks, support social interaction, and deliberates the effect on the SDT three needs.

This project is aimed to design and develop the SDT-driven digital gamified system applying the UCD process (an iterative process to design an application system focusing on how the users will use the application) (Smaradottir et al 2016) as a possible solution to the problem of the low level of autonomy, competence, and relatedness within students. This gamified system will enable them to set goals, upload research study tasks, and allow their supervisors and colleagues to review tasks. To increase students' SDT needs, a digital gamified system has been developed previously using an SDT-based proposed system model and selected game-design elements followed by the UCD three iterations (Haque et al 2017a, Haque et al 2017b, Haque et al 2017c). A one-week pilot study of the gamified system informed that game-design element neither increased the effort among them to complete a weekly goal nor did it increase social interaction (Haque et al 2018). This outcome guided us to conduct a one-week pilot study of the students' daily routine before re-developing the gamified system. This pilot study aimed to find out the views and comments regarding the usual daily activities of the students, measuring daily task-related stress and motivation to organize daily work in achieving significant milestones such as thesis work completion on their research journey and social interaction (peer-networking with supervisors and colleagues about the regular task submission) amongst them and any factors which may hinder their study progression and social

interaction. Hence, this study seeks to answer the following key research questions:
i) To what extent the daily routine affects research students' autonomy need satisfaction? ii) To what extent the daily routine affects research students' competence need satisfaction? And iii) To what extent the daily routine affects research students' relatedness need satisfaction?
It can be hypothesised that students in their daily routine
H1) feel a low level of autonomy need satisfaction in their research journey, H2) feel a low level of competence need satisfaction in their research journey, and H3) feel a low level of relatedness need satisfaction with supervisors and colleagues. To answer the research questions and to test the hypotheses, we conducted a one-week pilot study of the students' daily routine by utilising the Intrinsic Motivation Inventory (IMI) measurement questionnaire (Ryan 1982). The results will guide us to successfully re-developing our digital gamified system towards students' progression and social connectedness.
This paper is structured into five Sections. In Section I, an introduction has been presented. In Section II the literature review has been described. In Section III, the methodology has been briefly described. Then the results have been explained, discussed (Section IV) and conclusions have been drawn from them (Section V).

LITERATURE REVIEW

Self-Determination Theory

According to Self-Determination Theory (SDT), research students can be motivated intrinsically to progress in achieving their research goal and socially connect with other research students by fulfilling the three psychological needs of autonomy, competence, and relatedness. The psychological need for autonomy is defined as *"the perceived origin or source of one's own behavior"* (Deci and Ryan 2002). Autonomy means the sense of having the choice to assess one's societal environment and deliver choices to perform a task. An example, being able to choose a daily task, i.e., a 500-word goal in writing a section of literature review. The psychological need competence means *"feeling effective in one's ongoing interactions with the social environment and experiencing opportunities to exercise and express one's capabilities"* (Deci and Ryan 2002). Competence is the sense of managing a task to completion such as the ability to write a 500-word daily goal to complete a section of a literature review. The last need for relatedness is the desire to be connected to others (Deci and Ryan 2000).

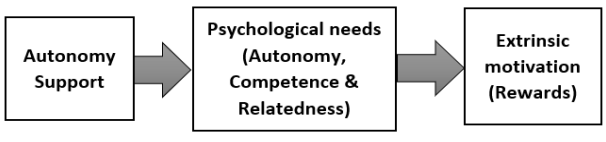


Figure 1: Approach of SDT sequence (Haque et al 2017c)

Relatedness is, therefore, the sense of managing to connect with others e.g., interacting with students and supervisors over a daily coffee break or weekly meeting. A higher level of self-determination motivation is the outcome of these three needs.
SDT needs are positively interrelated, and the satisfaction of these needs predicts student's psychological well-being, depression, and vitality (Vansteenkiste et al 2006). A high level of autonomy has been shown to protect against depressive feelings compared to lower levels (Vansteenkiste et al 2006). A recent study has revealed that healthcare practitioner's autonomy support promotes patients to engage in personal health behaviour actions, encourages their perceived competence in those behaviours, and can even enhance their sense of mindfulness also supporting them meet the SDT needs of autonomy, competence and relatedness (Martin et al 2017).
Dissatisfying the SDT needs could lead to serious consequences such as low levels of autonomy relate to releasing depressive feelings (Vansteenkiste et al 2006). Low levels of competence are linked with reducing intrinsic motivation (Vallerand and Reid 1984). Consequently, low levels of autonomy and competence may impede students' progress in accomplishing their research goal and hinder them to connect with their supervisors to express their capabilities to achieve their goals in the research study program. Low level of relatedness could lead to lack of interaction within groups, and students could be influenced by loneliness and isolation (Cornwell and Waite 2009).

METHODOLOGY

Study Design

To perceive the effects of the daily routine on students' SDT needs satisfaction, a one-week pilot study over a daily period (using IMI measurement technique) and face-to-face interviews after the study was conducted with eleven research students (nine PhD students and two MRes students). All the students participated in the pilot study in response to an invitation which has been sent to them earlier before the study. The study was taken for a week over the daily period in between 23rd to 26th April 2019 in the city of Oulu, Northern Finland (population, ~199,000).

Participants.

To recruit the participants, an invitation email to take part in the study was sent out to 38 postgraduate research students (see Fig 2). The email invitation was sent out based on personal contacts of a research institute from Finland (University of Oulu). All the invited students were enrolled at MSc by Research (working on their thesis) or PhD level on a full-time or part-time basis. Out of those, 29 students responded to participate in the pilot study. We then contacted those who did not use any digital intervention to their daily task submission. Twenty-six participants agreed to take part in the pilot study and a consent form was provided to them. Finally, 18 students consented to take part in the study. We planned to conduct the pilot interview session by fixing a pre-scheduled appointment with these participants. We concluded our pilot study with 11 active participants (3 females and 8 males) aged 22-33 years (N=11). Nevertheless, 7 participants dropped out as they were very busy in their everyday life (for example writing an abstract,

working on a lab-based report, thesis work correction and lack of time, part-time job, family issues etc.).

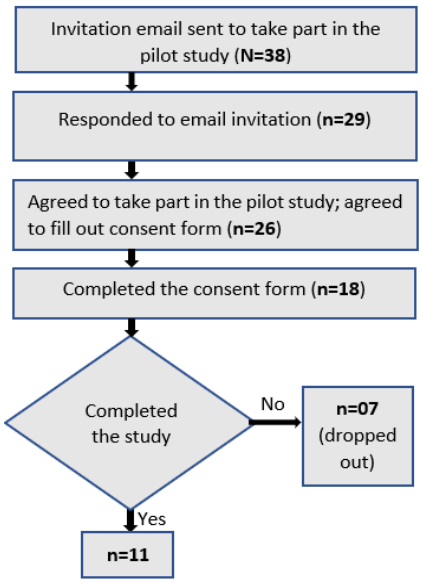


Figure 2: Flow chart of study participants

Questionnaire.

The quantitative questionnaire was based on Intrinsic Motivation Inventory (IMI) measurement questionnaire. The questionnaires were based on the 7-Likert scale: Not at all true (1); Not true (2); Somewhat not true (3); Neither true nor false (4); Somewhat true (5); True (6); Very True (7). Table 1 shows the IMI questionnaire for autonomy, competence, and relatedness. The reverse questions (R) were calculated by subtracting the answer of the participants from 8 (for example, if a participant filled one then, it should be (8-1) =7. For each need, we quantify their answers by adding all the answers and make it an average. An example, Autonomy, A = Q1+……. +Q7/7 = actual autonomy answer, Competence, C = Q1+……. +Q6/6 = actual competence, and Relatedness, R = Q1+……. +Q8/8 = actual autonomy
In this way, we calculated the participants' level of autonomy, competence, and relatedness for every day.

Table 1: IMI questionnaire (Ryan 1982)

Autonomy
Q1) I believe I had some choice about doing this activity.
Q2) I felt like it was not my own choice to do this task. (R)
Q3) I didnot really have a choice about doing this task. (R)
Q4) I felt like I had to do this. (R)
Q5) I did this activity because I had no choice. (R)
Q6) I did this activity because I wanted to.
Q7) I did this activity because I had to. (R)
Competence
Q1) I think I am pretty good at this activity.
Q2) I think I did pretty well at this activity, compared to other students.
Q3) After working at this activity for a while, I felt pretty competent.
Q4) I am satisfied with my performance at this task.
Q5) I was pretty skilled at this activity.
Q6) This was an activity that I couldn't do very well. (R)
Relatedness
Q1) I felt really distant to this person. (R)
Q2) I really doubt that this person and I would ever be friends. (R)
Q3) I felt like I could really trust this person.
Q4) I'd like a chance to interact with this person more often.
Q5) I'd really prefer not to interact with this person in the future. (R)
Q6) I don't feel like I could really trust this person. (R)
Q7) It is likely that this person and I could become friends if we interacted a lot.
Q8) I feel close to this person.

Interview.

Semi-structured 10-minute interviews (Kallio et al 2016) were conducted and audio recorded with all participants who completed the study. Participants were asked how they are going on their daily task in terms of their level of autonomy, competence, and relatedness. Conventional content analyses were performed by the first author to evaluate the answers of the participants. Microsoft Excel (Microsoft Corp, Redmond, WA) was applied to store and manage the data gathered during the interviews. Three steps analysis technique was carried out: (1) the data were repeatedly read for familiarity, (2) words associated with the main themes were underlined and coded, and (3) the context and frequency of theme-related sentences were recorded.

Procedure.

Few days before the experiment, the IMI measurement questionnaire was sent out to the participants and it was instructed to fill the questionnaire form every day after their daily task completion for one-week. They filled the quantitative questionnaire at the end of each weekday after completing their daily research tasks (apart from a bank holiday during the week).

Statistical Analysis.

Microsoft Excel (Microsoft Corp, Redmond, WA) was applied to analyse quantitative data. Mean for each of the levels of psychological needs of autonomy, relatedness, and competence was calculated individually.

RESULTS

Quantitative Results

Autonomy.

Of the participants who completed the study, 8 (8/11, 73%) participants' autonomy level was below or equal to Likert scale 4 (neither true nor false) and they included PR1 (Day 1,3-4), PR2 (Day 1,4), PR5 (Day 1-4), PR6 (1-4), PR7 (1-4), PR9 (Day 1-4), PR10 and PR11 (Day 1-4) (see Fig 3).

Competence.

Most of the participants (7/11, 64%) competence level were above the Likert scale 4 (neither true nor false). However, 4

(4/11, 36%) participants' competence level was relatively low such as PR7 (Day 2-4), PR9 (Day 1-4), PR10 (Day 1-4) and PR11 (Day 1-4) (see Fig 3).

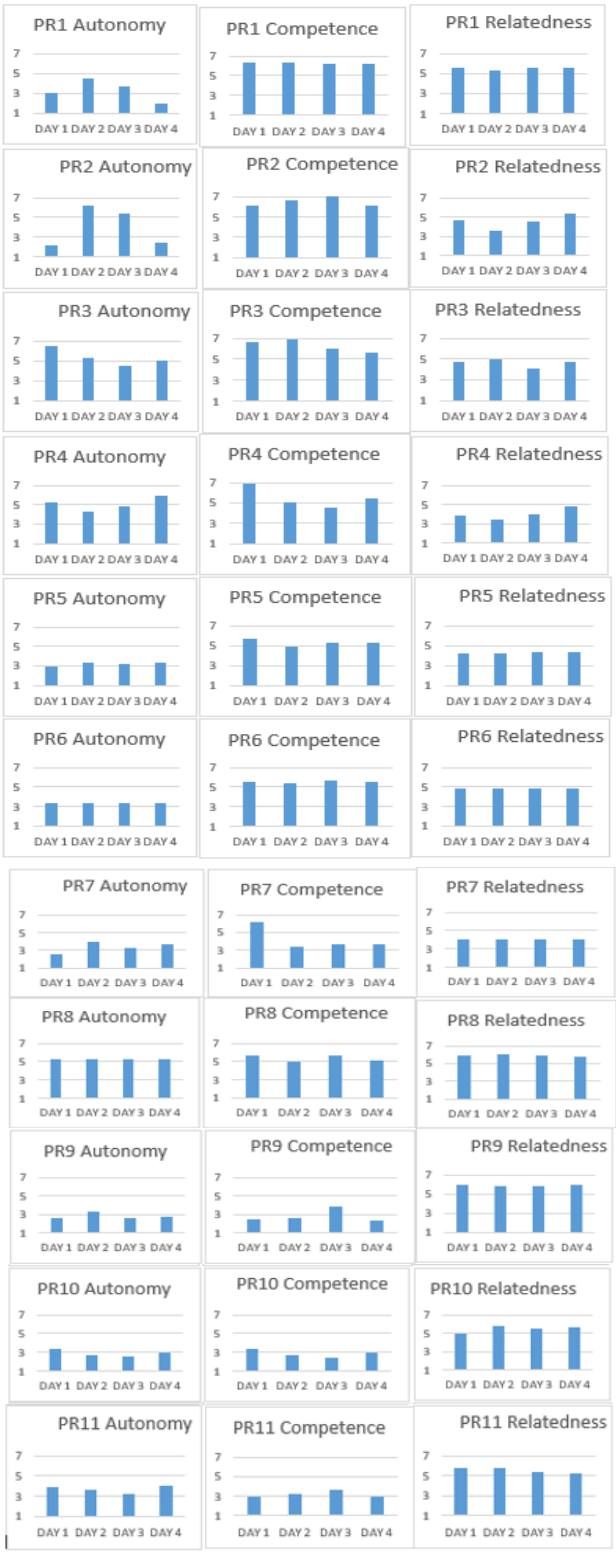


Figure 3: Participants' everyday response data for a week to IMI questionnaire of autonomy, competence, and relatedness

Relatedness.

Participants' (7/11, 64%) relatedness level was above the Likert scale 4 (neither true nor false). However, 4 (4/11, 36%) participants competence level was relatively low, and they included PR2 (Day 2-3), PR3 (Day 3), PR4 (Day 1-3) and PR7 (Day 1-4) (see Fig 3).

Research Hypotheses Results

The quantitative data gathered from the response of the users indicated the following result concerning our hypotheses.

Table 2: Hypotheses confirmation

Hypotheses	Level of SDT needs	Support
H1	Low	Yes
H2	High	No
H3	High	No

Based on the one-week pilot study, the data supported compliance with our hypothesis to one of the basic psychological needs, namely autonomy (H1), but not for the needs of competence (H2) and relatedness (H3) (Table 2).

Open Questions

Autonomy.

Participants (8/11, 73%) autonomy level were low. The participants were concerned particularly on meeting with supervisors [PR5;PR7], research plan/progress report writing [PR1;PR6], related work review [PR9;PR11] and personal development training [PR7;PR10] and practical issues such as health issues [PR1;PR2] and travel [PR2]. A participant mentioned; "I always work well, but when there is a meeting – there is a mess waiting for me!" [PR7]. Another participant mentioned; "I wish I could do more, but my health condition affect my mind to slow down my research" [PR2].

Competence.

Participants were asked to describe their daily competency and factors that may hinder their competency level. Participants' (7/11, 64%) competence level was comparatively high. Three participants were confident about their task [PR5;PR6;PR8]. One participant mentioned; "I know what I am doing" [PR5]. Four participants' (4/11, 44%) daily competency level were relatively low. They reported that some factors could cause it, and this includes work pressure, funding problem, and correction in writing/proofreading related stress. One participant responded, "it is like doing the same thing again and again and again" [PR9].

Relatedness.

Participants (7/11, 64%) were satisfied with the relationship they have with supervisors. The reasons may be due to their commitment to work [PR1; PR9; PR6], geographical, social environment [PR6]. For example, one participant was confident in his relationship and reported that he knows what he was doing [PR8]. Three (3/11, 27%) participants' sense of relatedness were relatively low. One participant stated that he argued with a supervisor due to computer connection issue to process the experiment data [PR4]. One participant

was busy with his practical matters such as visa application and dissertation writing, which may decrease their relatedness level [PR2]. Some other factors include working commitments, "did nothing due to other commitments (working somewhere and doing PhD study)" [PR3].

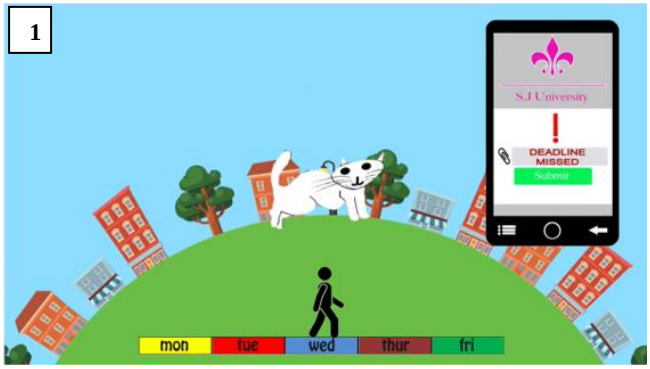
DISCUSSION

Principal Findings

Although many participants are affected by some other factors such as financial and personal factors (Wang et al 2019), we focused on the problems that are related to the primary considerations. Most participants autonomy level was low, and the factors in reducing their autonomy level are tension to meet with supervisors, research plan/progress report writing, related work review. Maybe some sort of fear was working within themselves that they were confused about what will happen in the meeting on their progress. Students anxiety is relevant to their academic performance, (Vitasaria et al 2010) such as reducing daily autonomy level towards study progression. One possible way to increase the level of autonomy, students might have a daily goal to meet the long-term goal and divide their task into small daily tasks to work daily towards a more significant milestone.

Students competence level was high which indicates that they might be confident enough to do their research study. Most participants relatedness level was high which indicates that most of the students' experienced that group work facilitated learning (Hammar 2014). Due to personal behaviour, some students do not want to connect with others tends to be a sign of a psychological health issue (Harley therapy 2020). They might need to reconsider their perspective or seek assistance to try new ways of thinking and behaving such as utilising our gamified system to work on daily research tasks submission.

Based on the pilot study, our future gamified system should focus more on the autonomy level compared to the level of competence and relatedness. This includes providing more features to overcome the problem of having anxiety. Moreover, the system could act as a personalised gamified system to which an option to choose avatars could be enabled that might bring value to the students. Previously a research team of five members from IT Carlow (two lecturers, two undergraduate and one post-graduate researchers) designed and developed an infographic video followed by iterative conceptual drawings of how our future system might be built (see Fig 4).



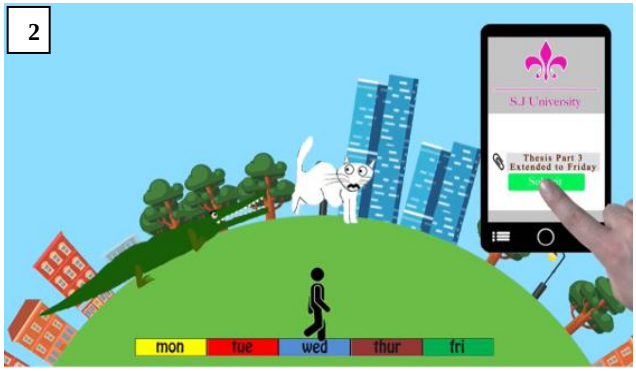


Figure 4: Print shots of infographic video showing how our system can be re-developed (Screen 1: cat avatar is running and daily work deadline is missed into the gamified system; Screen 2: Cat avatar is almost get eaten by a crocodile until the users uploaded their task for Wednesday into the system)

Limitations and Future Work

The number of the participants was comparatively low precisely the female participants. The study population was taken from Oulu, Finland but not from different regions in the EU countries. The data was self-reported, and participants filled their data manually in a sheet of paper and the first author collected them. This took extra time to transcribe data from the paper hard copies to electronic data. Online tools e.g., google-form could have been adopted.

This is a work-in-progress paper. Future research will run over four weeks using a within-subjects technique with a quantitative and qualitative method. IMI measurement will be used to generate users' data output. This will demonstrate the effect of a gamified system on SDT needs compared with the daily routine of the students.

CONCLUSION

In the research for this paper, we conducted a one-week pilot study on the research students' daily routine to address their level of autonomy, competence, and relatedness in the context of their study progression and social interaction. A one-week study was conducted with a group of MRes/PhD students using the IMI measurement technique. The result of the study has informed us that the level of autonomy is relatively low among students, but the level of competence and relatedness are comparatively high. This study demonstrates how the daily routine work without using any technological solution effects on research students' SDT psychological needs of autonomy, competence, and relatedness. The results of this study can be used to improve the effectiveness of designing and developing a digital gamified system. Future research should aim to develop the gamified system further based on students' feedback and test it on a larger scale, enabling the key components within the gamified solution to be studied.

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ACKNOWLEDGEMENT

We are indebted to Joseph Fuller, Sam Kallaf and Roxanne Burchartz from IT Carlow for helping us with the infographic video. This research has been funded by the IT Carlow Conference Fund Programme 2020.

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