Tim Marsh
Minhua Ma
Manuel Fradinho Oliveira
Jannicke Baalsrud Hauge
Stefan Göbel (Eds.)

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Serious Games

Second Joint International Conference, JCSG 2016
Brisbane, QLD, Australia, September 26–27, 2016
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Editors
Tim Marsh
Griffith University
Brisbane, QLD
Australia

Minhua Ma
University of Huddersfield
Huddersfield
UK

Manuel Fradinho Oliveira
SINTEF Technology and Society
Oslo
Norway

Jannicke Baalsrud Hauge
University of Bremen
Bremen
Germany

Stefan Göbel
Technische Universität Darmstadt
Darmstadt
Germany

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Preface

The second international Joint Conference on Serious Games (JCSG 2016) was held in Brisbane, Australia and hosted by Griffith University. JCSG 2016 brought together the 7th Serious Games Development and Applications (SGDA 2016) and 6th Serious Games (GameDays 2016) conferences, previously held in the UK, Norway, Germany, and Portugal.

The themes of Games, Play, Interactions, and Art with Purpose, brought together researchers, developers, practitioners, designers, writers, and artists of serious games from over 15 countries. As well as traditional serious games in areas including education and learning, health and well-being, accessibility, cultural heritage, and social impact, the themes also reflected the experimental focus, pushing the boundaries of possibilities to interact, play, and experience. Interactive installations and games of the Showcase and Exhibition in particular reflected the creative possibilities through Art with Purpose.

We received 41 submissions from which 16 were selected as full papers, 6 as short papers, and 5 as posters. All submissions were thoroughly peer-reviewed by the Organizing and Program Committees, and Showcase and Exhibitions' Panel of Experts consisting of 57 distinguished experts from 16 countries. We are grateful to reviewers for their timely and diligent work, for providing valuable comments and assessments and constructive feedback on all submissions, and contributing to the high quality and success of JCSG 2016.

Keynote presentations were given by Experimental Games Designer Tracy Fullerton, Director of the University of Southern California's Games Program and Chair of the Interactive Media and Games Division, and Sara de Freitas, Pro Vice Chancellor and Professor of Teaching and Learning at Murdoch University, Australia and former Director of the UK's Serious Games Institute. Invited talks were given by Ben Schouten, Director of Playful Interaction Lab, Eindhoven University of Technology (TUE) and Amsterdam University of Applied Sciences, The Netherlands, and Jon Weinbren, Head of Games Design and Development at the National Film and Television School (NFTS), UK. In addition, a workshop in creative writing for serious games was organized by award-winning playwright, games and serious games writer, Caleb Lewis.

Sponsors were Griffith University's Griffith Centre for Creative Arts Research (GCCAR) and Griffith Film School (GFS). Partners included IFIP Technical Committee on Entertainment Computing's (TC14) Working Groups on Serious Games (TC14.8), Art and Entertainment (TC14.7), Game Accessibility (TC14.9), and the German Association for Computer Science (FG Entertainment Computing) and the German Game Developers, Association (WG Serious Games). Special thanks to our conference organization team: Paul Wright for conference management, and Kellie O'Dempsey and Naomi O'Reilly for Creative Design. Thanks also to Diana Marsh for editorial work.

September 2016

Tim Marsh
Minhua Ma
Manuel Fradinho Oliveira
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Stefan Göbel

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Keynotes

Slow Play: Imagining the Serious Worlds of Walden and the Night Journey

Tracy Fullerton

Game Innovation Lab, USC School of Cinematic Arts,
University of Southern California,
Los Angeles, USA
tfullerton@cinema.usc.edu

The pace of play in digital games often takes on a rough-and-tumble swiftness that requires all of a player's cognitive bandwidth to process and react, leaving little time for emotional reflection, deliberation or interpretation of game events. In order to create games that respectfully address more serious subject matters, it would seem that the pace of these experiences and the relationship between the player, the game and the ideas generated during play must be examined as an area of design potential.

Over the past decade, Tracy Fullerton has worked on several experimental games, each of which posits a slower, reflective pace of play around the topics of spiritual and philosophical journeys. The open worlds of *The Night Journey* (a collaboration with media artist Bill Viola) and *Walden, a game* are designed to leave space and time enough for the player to approach the ideas within the play, with attention and time enough to respond fully to the experience.

In this presentation, Fullerton will discuss the design of these two experimental game worlds: *The Night Journey*, a game about the spiritual journey which game takes place in a visually abstracted landscape layering 3D imagery, post processing effects and archival video footage into a slow, surrealistic world of "explorable cinema," and *Walden, a game*, in which players take on the role of Henry Thoreau, living a simplified existence, balancing their basic needs such as food, fuel, shelter and clothing while also taking time out to seek inspiration in a deeper connection to nature.

With these experimental projects as a foundation for discussion, Fullerton will explore the potential that lies with slow play, and the way in which we might imagine serious worlds of play that allow and expect a deeper level of player reflection as one pillar of their experience goals.

The Efficacy of Gamification: Motivation, Flow and Feedback

Sara de Freitas

Murdoch University, Perth, Australia
S.deFreitas@murdoch.edu.au

Research on Gamification reveals gains for student motivation. This talk will explore the latest research around efficacy of gamification techniques in learning contexts. The presentation builds upon the notion of flow and motivation and considers how gamification can engage and re-engage students who are not being well retained with the current teaching pedagogy. The presentation will consider the theory of flow, motivational theories, latest gamification research findings and consider how findings from different studies can be used to support better uptake in different contexts. In particular, feedback modelling is considered as a critical aspect of learning with gamification and asks how far are we from easier tools and approaches for engaging different student cohorts.

Invited Speakers

Playful Empowerment, the Role of Game Design Innovation in Participatory Citizenship

Ben Schouten

Eindhoven University of Technology, Eindhoven, The Netherlands
Amsterdam University of Applied Sciences, Amsterdam, The Netherlands
b.a.m.schouten@tue.nl

Abstract. In this lecture we will address a changing perspective on design, one in which users are defined as social and economical actors who co-create products and services. We will see that the role of play in its contemporary and digital form for instance through games, apps, interactive toys is essential in this process. This lecture consists of two parts. The first part focuses on our research in play and civic interaction design. We will define play in its digital form and its intrinsic qualities, such as fun, experience, creation, collaboration, and competition. We will then show that through these qualities a new digital culture has emerged in which, instead of a top-down, one-to- many vertical cascade, we find bottom-up, many-to-many, horizontal, peer-to-peer communications (Jenkins 2009). In the second part, I will sketch the research and game designs in relation to research and education at the Amsterdam University of Applied Sciences, including further collaboration with partners in industry and research. The main focus in this lecture is on the challenge of how to design for these collective opportunities, e.g. in health care, education and city planning.

1 Introduction

In today's world, we are immersed in information. Just a single click brings us to online news websites or newsgroups full of conspiracies, a swipe with our finger connects us with weather reports or reviews of restaurants nearby; wearable's like smart watches monitor our health condition without us even needing to point, click or swipe.

What's new is that this media universe of websites, apps, sensors, social media, data streams and open source repositories is largely created by our selves. Voluntary when we post, click, call, like, add, and share. And sometimes involuntary when software or sensors record our actions in the physical and the media world, turning the amalgam of all our individual lives into this amorphous thing called big data. On the downside: more than ever citizens find themselves swamped in a deluge of information, caught in webs of observation and control. On the upside: More than ever, citizens find themselves empowered through new technologies to organize themselves around issues that matter to them. Examples abound of groups of citizens that have turned away from centralized solutions, taking the helm to organize themselves to create ownership and meaning (Salah et al. 2014).

This shift in our (media) culture has consequences for the field of design. We see designers as well as ordinary users stepping up to create tools that allow citizens to organize them selves, to create meaning out of the data deluge. Or to look for new mechanisms to engage around issues, that provide social exchange and cultural experiences. Play has started to become a central element in these approaches as a mechanism to engage citizens in processes of co-creations. Through gameplay, players create meaning and social bonds; interactions from which a societal play experience emerge. As such, play has become an increasingly important aspect in our media saturated culture. Now that we live in media, it's playful experiences that often allow us to make sense of the world around us and to forge meaningful connections with those around us.

In this lecture we will address a changing perspective on design, one in which users are defined as social and economical actors who co-create products and services. We will see that the role of play in its contemporary and digital form for instance through games, apps, interactive toys is essential in this process. With civic interaction design, we mean the design of products and services that enable citizens to improve the quality of both their individual and communal lives, and that equip them with agency to act as citizens in a media-saturated world. That could be for instance as health care patients who are encouraged to change their lifestyle, or who are given tools to overcome the burden of a severe illness (Schouten et al. 2013) and share their experiences; or as citizens who participate in a game aimed at revitalizing a neighborhood together with decision makers in a negotiated and mediated outcome, experimenting with different final results (World of Citycraft, 2010).

The Games for Change organization is a good example of how new initiatives empower citizens. Founded in 2004, Games for Change facilitates the creation and distribution of social impact games that serve as critical tools in humanitarian and educational efforts. They piloted 9 Minutes, a mobile game aimed at poorly served communities in India, Kenya, and Tanzania. *9 Minutes,* see Fig. 1, is about healthy birthing practices; the game leads you through the nine months of pregnancy with nine levels that reward good prenatal choices in a twitch game. The evaluation shows measurable positive shifts in knowledge and behavior towards safe pregnancy and delivery actions.

Fig. 1. The game 9 Minutes (Game for Change Organization, 2012) focuses on good prenatal practices in Kenya

This process of participation and empowerment can be seen in many domains. Apart from health care and city planning, we find it in education and in other social, cultural and political practices. Our research group focuses on the design of playful and meaningful contexts and experiences for citizens in a post- digital culture, by which we mean that the digital media and its communication networks can no longer be understood as a separate realm, but have become an inseparable part of everyday life.

Interactive technology has penetrated all possible facets of our life, from bed to work. Social media are just an example of this, and they have undoubtedly empowered us in many cases, although others might argue that this technology digitally connects but does not provide us with collective meaning, or with memories or awareness at the level of society at large (van Dijck 2013). And perhaps in that observation lies our main challenge in our research. We need to cast a critical eye on the deployment of new media technologies to position ourselves as citizens in inclusive, democratic societies.

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Games with Meaning and Consequence

Jon Weinbren

National Film and Television School, Beaconsfield, UK
jweinbren@nfts.co.uk

Abstract. Looking beyond the idea of 'Serious Games', this paper explores techniques and tools that can facilitate the development of meaningful games experiences, which afford the creation of meaning for players – not only through portrayal, representation and signification, but also through the enactment of tangible and empathic consequence arising from player interaction. This is discussed within a variety of practical contexts. We take as our starting point the development of games which have a significant story component. Rather than focussing only on the formal components of the games themselves, the paper also looks at how as educationalists we can best develop and nurture the future creative talent for the design and development of meaningful games experiences for increasingly diverse audiences.

1 Introduction

For many, the phrase 'Serious Games' evokes a sense of awkwardness. It represents a medium which is not at ease with itself, an attempt to distinguish purposeful and serious endeavours from an area of leisure activity which was seen as essentially facile. The adoption of the label in the early 2000s seems to have acted as a counterpoint to the commercial games industry whose outputs were focussed mainly on entertainment and escape. However, it has been widely recognised the idea of applying games and play to specific purposes – in business, educational and cultural contexts – of course predates the turn of the last millennium by a significant period.

A more up to date view sees digital games as an emergent form, increasingly included as part of the arts and culture landscape: a responsive, interactive moving image medium which is beginning to deliver experiences beyond the sum of its many complex components. And unsurprisingly, there are games being made outside of the explicitly educational, purposeful, political or promotional context which offer their players the ability to increase their understanding of the world around them, or moreover to contemplate their own place within it. Beyond the notion of 'Serious Games', we can begin to consider in general how digital games as a 'medium' can be taken more seriously as an essential cultural form.

In many ways, 'Serious Games' merely describes the intentions of the makers rather than the constituents of the game or the experience of the player. Games can and should be more than merely playful, but in the same way they can and should be more than merely serious. Like other examples of artistic or cultural endeavour, it is the capacity for videogames to enable the derivation of meaning by their playing audience which allows them to be elevated above and beyond the superficial.

So how is the making of meaning enabled in a games context? What are the ingredients? And perhaps more importantly, how do we educate and nurture future creative talent to design and develop these experiences, making the most of the opportunities provided by the rapidly developing audio-visual and computational technologies which are now increasingly accessible to makers and audiences alike?

One approach to the creation of ‘meaningfulness’ well established in the arenas of literature and drama is through the orchestration of empathy. In simple terms, empathy enables us to emotionally connect with each other in the real world, and in fictional worlds it allows us to share and understand the emotions of the characters imagined and created by the writers, makers and/or performers of the literary or dramatic work. While not all games include strong narrative or dramatic elements, many do, and where these elements are well formed and successful, there is a clear opportunity for the player to feel a sense of empathy and from there derive meaning from the playing experience.

Games design and development is an inherently cross-disciplinary practice. It is also one which inherits much from other media and performing arts, such as theatre, film and television. Collaboration is a key element of the process, so there is much to be gained from mixing games specialists from those whose normal activity is creating filmed or theatrical drama. In particular, a mix of game developers with screenwriters, film sound specialists, production designers, and digital artists.

This talk will explore these and other pertinent questions relating to the future of serious games and related areas.

Bardcraft and General Wordsmithery for Serious Games (Workshop Synopsis)

Caleb Lewis

Write Club, Australia
cnathaniellewis@gmail.com

Every day we consume hundreds of stories – each new morning we wake hungry for more. For thousands of years we've gathered to tell stories. Story has ever been our way of sharing knowledge, of understanding; of empathising; it helps us come to grips with the world.

And although stories are as old as spoken word, their form is constantly shifting as new technologies arise. From the Gutenberg press to the silver screen, the personal computer and the internet, our stories have continued to adapt and evolve. And just as television, once dismissed as cinema's poor cousin, now enjoys a golden age, the supremacy of the video game is fast approaching, if not already here.

Although comparatively young, the medium is fast evolving and its potential is limited only by the imagination. Yet in our rush to master the intricacies of *Unity, Game Maker* and *Unreal Engine*, have we forgotten some of the basic fundamentals of storytelling?

Bardcraft and General Wordsmithery is a hands-on workshop for writers and designers aimed at blowing the dust off history and revisiting the great storytellers, from Aristotle to Shakespeare to Pixar. Along the way we'll look at character development; realistic dialogue; exposition, conflict and the need for suspense. Lastly we'll discuss the unique challenges of writing serious games, using several well-known games as examples.

This is a hands-on workshop for writers keen to brush up on their classical narrative while delving into new strategies for storytelling.

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Education, Learning and Training

Serious Games to Develop Social and Emotional Learning in Students

Victor Lim-Fei(✉), Huey Ming Woo, and Ming Yew Lee

Ministry of Education, Singapore, Singapore
victor_lim@moe.gov.sg

Abstract. This paper proposes that the development of social and emotional learning (SEL) can be supported through the use of serious games. The Collaborative for Academic, Social and Emotional Learning (CASEL) has defined "five interrelated sets of cognitive, affective and behavioral competencies" that make up SEL. In Singapore, the Ministry of Education has appropriated these understandings to broadly refer to "skills to manage self, relate to others positively, and make responsible decisions". While the use of games in educational settings is not new, the notion of using games to social emotional competencies stand against traditional views. In this light, this paper advocates a provocative position that games can contribute positively to the development of social emotional learning and offers, for discussion, examples from Singapore.

Keywords: Social and Emotional Learning · Serious games · Pedagogy

1 Introduction

Gee (2008: 21) proposes that well-designed "games offer players experiences and recruit learning as a form of pleasure and mastery". Following in this direction, this paper discusses the use of serious games to foster the development of social and emotional learning (SEL). This paper is exploratory in that it draw brings two disparate notions – SEL and serious games – together. Specifically, the paper suggests that, while recognising the risks of gaming, such as addiction, and exposure to undesirable content, serious games can foster the learning of SEL. The prevailing understanding is that social emotional competencies are best learnt and developed through real-world interactions with people. The use of games for teaching and learning has typically been viewed with suspicion as they take time away from students who arguably would have spent the time socialising and interacting with people. As such, the conventional view is that games distract and inhibit the development of such social and emotional skills and are best to be kept at bay. This paper sets forth the proposition that well-designed games, rather than detracts, can foster SEL and paves the way for further development and empirical studies in Singapore towards this direction.

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2 Socio Emotional Learning (SEL) in Singapore

Social and Emotional Learning (SEL) is an umbrella term that refers to students' "acquisition of skills to recognise and manage emotions, develop care and concern for others, make responsible decisions, establish positive relationships, and handle challenging situations effectively" (CASEL) (Fig. 1).

Fig. 1. Social and emotional learning core competencies (Source: CASEL)

CASEL has identified five interrelated sets of cognitive, affective and behavioral competencies. The definitions of the five competency clusters for students reproduced here are:

- Self-awareness: The ability to accurately recognize one's emotions and thoughts and their influence on behavior. This includes accurately assessing one's strengths and limitations and possessing a well-grounded sense of confidence and optimism.
- Self-management: The ability to regulate one's emotions, thoughts, and behaviors effectively in different situations. This includes managing stress, controlling impulses, motivating oneself, and setting and working toward achieving personal and academic goals.
- Social awareness: The ability to take the perspective of and empathize with others from diverse backgrounds and cultures, to understand social and ethical norms for behavior, and to recognize family, school, and community resources and supports.
- Relationship skills: The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. This includes communicating clearly, listening actively, cooperating, resisting inappropriate social pressure, negotiating conflict constructively, and seeking and offering help when needed.
- Responsible decision making: The ability to make constructive and respectful choices about personal behavior and social interactions based on consideration of ethical

standards, safety concerns, social norms, the realistic evaluation of consequences of various actions, and the well-being of self and others. (CASEL). The SEL competencies developed by CASEL have been appropriated by the Ministry of Education, Singapore (MOE). MOE states that "through SEL, our students acquire skills, knowledge and dispositions to manage self and relationships effectively and make responsible decisions essential for personal and social well-being. Research shows a strong link between SEL and student outcomes in the areas of mental well-being, character development, school success, career success and responsible citizenship" (Ministry of Education, Singapore, Social and Emotional Learning).

SEL is a critical part of our students' learning to prepare them to live and work as adults in the 21st Century. SEL is taught within the Character and Citizenship Education (CCE) curriculum in schools. "Together with the core values, SEL form an integral part of MOE's Framework for 21st Century Competencies and Student Outcomes" (Ministry of Education, Singapore 21st Century Competencies) (Fig. 2).

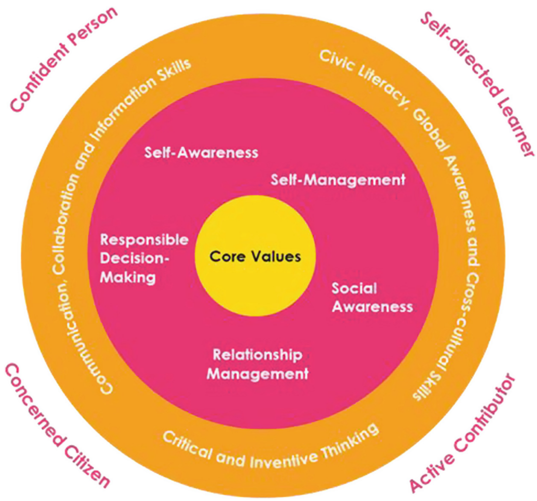


Fig. 2. Framework for 21st century competencies and student outcomes (Source: Ministry of Education, Singapore, 21st Century Competencies)

3 Serious Games and Social and Emotional Learning

In the 2015 World Economic Forum report 'New Vision for Education: Unlocking the Potential of Technology', a set of sixteen proficiencies for education was identified as the most critical 21st century skills, which were broadly characterised into foundation literacies, competencies and character qualities. More recently, the 2016 World Economic Forum report on 'New Vision for Education: Fostering Social and Emotional Learning through Technology' together with the Boston Consulting Group, presents findings from surveys with more than 2000 educators and parents in five countries (China, Kenya, South Korea, United Kingdom and United States) and interviews with technology experts and investors to understand the educational technology landscape for SEL. Following from the report, this paper proposes that serious games, when used meaningfully and appropriately, can contribute positively to the development of SEL in students.

Research by Garris et al. (2002) and Hromek and Roffey (2009) concluded that games are powerful tools to strengthen SEL. Boye & Tapp, wrote an article on Using Games in the Classroom on the Texas Tech University website. They argued that games have multiple benefits such as enabling knowledge assimilation, increasing students' motivation, encouraging analysis, synthesis and evaluation of concepts. Prensky (2001) also found that games which provide rich simulations of reality expose students to different social rules and norms which help develop their social, emotional and interpersonal literacies.

To ensure a transfer of skills outside the digital-game environment, the games must be coupled with effective pedagogy. Pre- and post-game discussions are necessary to tie the learning in games to other contexts. While games are useful in developing SEL, there are concerns over the additional screen time that reduces face-to-face human interaction as well as potential gaming addiction issues. It is recommended that the use of digital games must be measured and not excessive.

4 Examples of Serious Games for Social and Emotional Learning in Singapore

See Table 1.

Table 1. Summary of featured technologies being explored and adapted in our system

Description	Local examples
Role-playing games Players assume the roles of fictional characters to exercise a variety of options and experience different consequences.	MOE has developed a scenario-based game, Collin's World that teaches students to make sound decisions for different Cyber Wellness issues. North Spring Pri designed and implemented ICT-enriched game-based learning experiences, iWorld@NSPS, to develop 21st century competencies in students during CCE and Social Studies lessons.
Strategy games The games allow players to devise appropriate strategies to achieve the goals of the games.	Wellington Pri engaged students in an online game, Unfavourable Conditions, as part of the project work module to build a new city for displaced citizens by applying Science concepts.
Sandbox games The games focus on open-ended and nonlinear play to complete the objectives of the games.	Greenridge Pri designs an online game, Let's Build, to teach students about values of fair play, responsibility, teamwork and leadership.

4.1 Collin's World

Collin's World is a scenario-based game learning software program for students to learn, understand and engage on cyber wellness. In the game, students will be put through different scenarios of the issues faced online; and allowing them to make decisions on these issues. Each choice they make comes with a consequence. This allows students to understand the process and be aware of the consequence of their decision (E.g. in the game a friend of a student faced with cyber-bulling, he or she have to make a choice to help or not. And based on the student's decision, he or she will be put through the subsequent events based the decision made). The game also includes quest for students compete to do some assessments such as MCQs or match the correct answers (Fig. 3).

Fig. 3. Collin's world (Source: ICT connection, MOE)

4.1.1 iWorld@NSPS

iWorld@NSPS is an initative by North Spring Primary School for students to learn various subjects by playing virtual games. The games are specially designed and customised with a few quests for students to complete. The design of the games also allows students to apply and learn lifelong skills such as decision-making. Below are the few virtual games under this initiative:

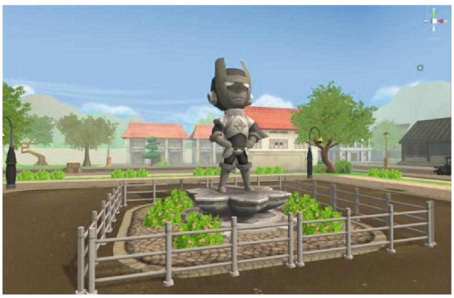
(i) Cultures in Singapore: A platform for students to explore and observe various symbolism and traditions of Chinese New Year, Hari Raya Puasa, Deepavali and Christmas. Students will be tasked to decorate or run errands to prepare the open house for festival celebration. Hints are also prompted to the students such as "bringing oranges for Chinese New Year" in the game.

(ii) Vanishing Trades: Student will play the role of a person from a vanishing trade: Samsui woman, snake charmer and milkmen to help neighbour raise money for her son's education. There are videos for students to learn about the trade in the game. Students are tasked to perform these trades such as building houses (Samsui women) and milking cows and goats (Milkmen) in the game to experience and learn the trades that are vanishing.

(iii) Racial Harmony: Students are put through a situation in the game where the village have neighbours are being extremely inconsiderate and people turning against each

Cultures in Singapore

Vanishing Trades



Racial Harmony

3rd Generation Army

Fig. 4. iWorld@NSPS (Source: Playware Studios' 3DHive)

other. The game is designed to allow students to aware of the issues that causes racial discord by helping Captain Harmony by helping to resolve conflicts in the virtual village.

(iv) 3rd Generation Army: Students will be put through a series of situational training at different train stations. At each station, students have to work together to complete missions before moving on to the next station. The 4 station objectives are: hostage rescue, building barricades, demolishing towers and bringing medical supplies to the injured. Through this game, students will be exposed to the roles and functions of military for them to aware of it (Fig. 4).

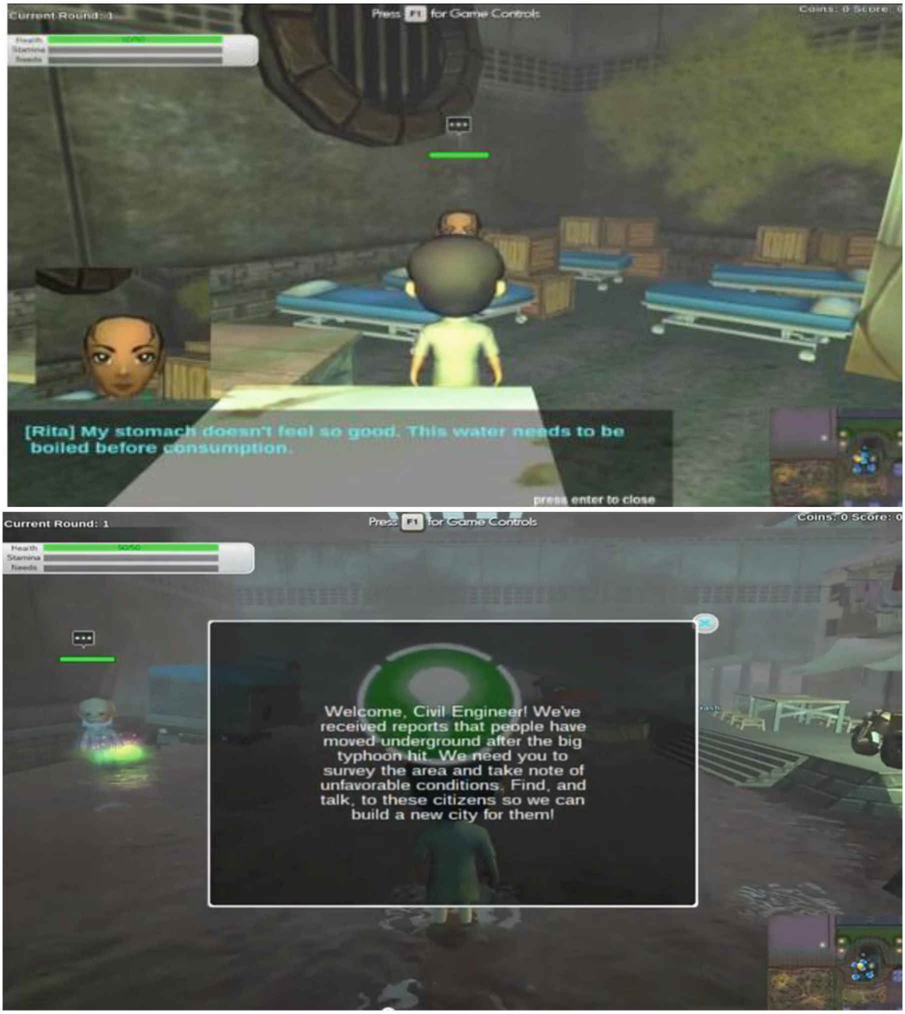


Fig. 5. Unfavourable conditions (Source: Playware Studios' 3DHive)

4.1.2 Unfavourable Conditions

Unfavourable Conditions is a 3-D game for students to apply their science knowledge based on what they have learnt in class. In the game, students will explore an underground city with displaced citizens lived in unfavourable conditions. The mission requires student to identify these existing conditions that are unsuitable for humans to live (E.g. drinking non-portable water). In turn, students will build a liveable new city above ground for the displaced citizens (Fig. 5).

Fig. 6. Let's build (Source: Playware Studios' 3DHive)

4.1.3 Let's Build

Let's Build is a game developed by Greenridge Primary School for Primary 5 students. The game aims to teach the values of fair play, carrying out tasks dutifully, teamwork and leadership. In the game, students are divided into four groups to build a site. The building of the site requires group effort, with each of the students roaming round to collect different materials required to build the group's site. The group to build the site first wins (Fig. 6).

5 Conclusion

Although the use of games in fostering SEL has been observed, in varying extent, in Singapore, its benefits have not been fully explored. The adoption of serious games in SEL is low with few success stories being shared in the fraternity. There is also a need for more research studies in the Singapore context to understand how the design serious games for meaningful learning and the development of SEL. Slovak et al. (2015) highlighted that the facilitation of SEL through technology is an important but under-researched area. To close the gaps between stakeholders' capabilities on how best to use serious games for SEL and expectations, more detailed empirical evidence of the effects of their use are needed. This may be realised through deeper collaboration with multiple stakeholders (educators, parents, researchers, policy-makers) to explicate those aspects of SEL that can most likely benefit from technology and examine how the existing pedagogies can drive the effective use of technology for SEL and building educators' capacity in the appropriate and meaningful use of serious games for SEL through professional development.

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Exploring Play-Learners' Analytics in a Serious Game for Literacy Improvement

Shamus P. Smith[1(✉)], Daniel Hickmott[2], Erica Southgate[2], Ross Bille[1], and Liz Stephens[2]

[1] School of Electrical Engineering and Computer Science, The University of Newcastle, Callaghan, NSW 2308, Australia
{Shamus.Smith,Ross.J.Bille}@newcastle.edu.au
[2] School of Education, The University of Newcastle, Callaghan, NSW 2308, Australia
{Daniel.Hickmott,Erica.Southgate}@newcastle.edu.au

Abstract. The collection and analysis of analytics incorporated into serious games provides researchers with objective data on player behavior related to serious game design elements and learning. Such analytics offer insights about play-learners engagement that is not possible to capture through traditional techniques. Visualization of learning behavior data can allow for a comparison between the pedagogical intent of the game design and the play-learners actual behavior within the serious game. This paper describes the use of game-play logs to identify pathways through gaming content in a serious game app for literacy improvement. The paper describes the technical aspects of processing game-play logs and their transformation into visualizations, and considers how these visualizations can be used to explore play-learner behavior in relation to the pedagogical intent of activities embedded in the serious game app.

Keywords: Game-play analytics · Serious game · Literacy app · Visualization · Pedagogy · Gamification · Learning

1 Introduction

The collection and analysis of analytics incorporated into serious games provides researchers with objective data on player behavior related to serious game design elements and learning. Such analytics offer insights about play-learners engagement in serious games that is not possible to capture through traditional techniques [11]. There is increasing interest in the use of game-play logs and the transformation of this data through visualization techniques, as a means of exploring evidence on effectiveness [11, 13]. Visualization of learning behavior data can allow for a comparison between the pedagogical intent of the game design and the play-learners actual behavior within the serious game. The purpose of this paper is to: (i) describe the technical aspects of processing game-play logs; (ii) account for the transformation of game-play logs into visualizations that have scalable form; and, (iii) to use these visualizations to explore play-learner behavior in relation to the pedagogical intent of learning activities within a serious game app. These three areas will be examined in the context of an evaluation

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conducted on a literacy improvement app called *Apostrophe Power*. For this paper, three questions relating to play-learners' behavior during game-play were explored. These were:

– In which areas of the game do play-learners spend most of their time?
– What order do play-learners complete the game levels?
– After making mistakes, do play-learners choose to view the training videos?

This paper is structured in the following way. Section 2 describes the serious game app, *Apostrophe Power*. Section 3 provides a brief overview on work related to serious game analytics and use of game-play logs. Section 4 outlines preparation of the logs and the pipeline for visualization. Section 5 provides three cases of game-play log visualizations and interprets play-learner behaviors in the context of the pedagogical intent of the game. Section 6 offers suggestions on the use of game-play logs and visualizations, and discusses their implications for learning design in serious games.

2 *Apostrophe Power*: A Literacy App

The *Apostrophe Power* serious game is an app that students can use to improve their apostrophe use. Lukač [12] notes that "apostrophe 'misuse' is the most popular topic in the field of language advice", with misuse common in social media communication attributed to incorrect usage of apostrophes [6, 12]. The app focused on the main functions of apostrophes, referred to as categories:

– *Contractions* - for example, the contraction of cannot is can't.
– *Ownership* - for example, singular and plural ownership, e.g. Dad's car.
– *Misfits* - the appropriate use of "it's" and "its".
– *Combination* - exercises that combine the use of the previous three categories.

These categories were used to organize learning exercises in the game. *Apostrophe Power* provides learners with a series of increasingly difficult unlockable levels across these four categories. In addition, short instructional training videos on these categories were also provided and could be returned to during the game to scaffold learners towards mastery [7]. Events in the game were logged when play-learners interacted with any of the game components. An example of a game level in *Apostrophe Power* can be seen in Fig. 1. In an *Apostrophe Power* level the play-learner's goal is to get a mouse character across sinking platforms, from left to right, to a prize (a block of cheese) on the final platform.

To get to the next platform, the play-learner corrects sentences on the bottom half of the screen and taps the Jump button. If the sentence has been corrected successfully, the mouse will jump to the next platform. Each level has ten platforms, so the play-learner must correct ten sentences to complete a level. The play-learner places apostrophes, by tapping their finger in the appropriate positions to make the sentence correct. The platforms begin to sink once the mouse has landed on them, adding time pressure to the game. If the platform sinks into the water the play-learner has to restart the level. An incorrect answer will result in a popup dialog that offers play-learners the choice of another question or the option to view the training video associated with the current category, or to return to the level selection screen.

Figure 2 shows the possible navigation paths through the app between the different areas of the game. The main motivation for the analysis of the game-play logs was to discover how play-learners navigated through and interacted with the learning activities.

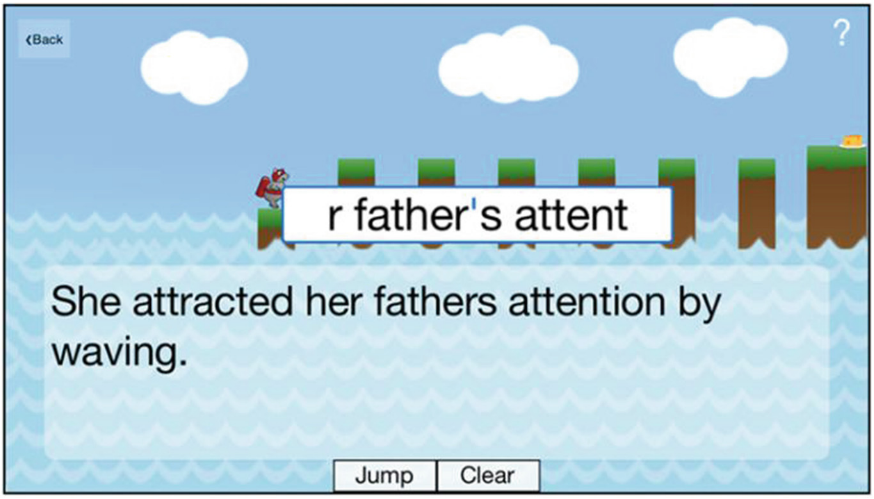

Fig. 1. Game screen of *Apostrophe Power*

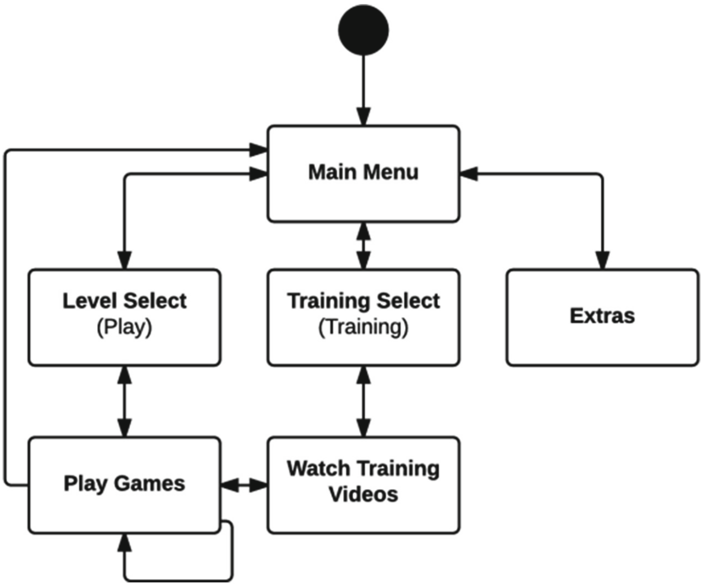

Fig. 2. Possible navigation paths within the *Apostrophe Power* app

3 Related Work

According to Loh, Sheng and Ifenthalder [11, p. 22], the primary purposes of serious games analytics are to "obtain valuable actionable insights to better the game or learning design", and to "improve skills and performance of the play-learners to better convince stakeholders of the game's effectiveness". The collection methods for data used for serious games analytics can be separated into two categories: *in-situ* and *ex-situ* [11]. In-situ collection occurs in the game itself (for example, logging game-play events), whereas ex-situ is data collected outside of the game. Focus group discussions and post-test surveys are examples of ex-situ data. Barab, Gresalfi and Ingram-Goble [1] assert that the analysis of game-play logs (collected in-situ) can reveal insights about the understanding play-learners have of the concepts covered in the game.

We were unable to find any studies that involved in-situ data collection that were specifically related to serious games that aim to improve adults literacy skills, the target demographic for the *Apostrophe Power* app. Browne, Anand and Gosse [2] designed and evaluated a series of m-learning literacy apps for adults using ex-situ techniques, with pre-test and post-test questionnaires. However, they did not perform any in-situ collection. Snow, Allen and McNamara [15] applied a variety of techniques, including random walks, entropy analysis and Hurst exponents, on game-play logs collected from a game-based system, titled iSTART-2 which involved the teaching of self-explanation and comprehension strategies at a high-school level. These techniques were used to gain an understanding of play-learners' decision and behavior patterns.

In studies that involved serious games analytics with *in-situ* data collection there were some common methods used for discovering patterns in play-learners' decision making behavior. Cluster analysis is often used to profile play-learners, using feature vectors of different metrics derived from game-play logs [3, 8, 10]. The aim is to identify particular patterns or strategies used by play-learners. Bayesian networks are another method of analysis that has been used [4, 10]. Bayesian networks model probabilities of decisions as a graph. In a serious game, the nodes in the resulting graph could be states in the game and the probabilities of certain transitions between these states could be used to gain insight into play-learners' decision making during game-play. Loh and Sheng [10] note that Bayesian network models may be suitable for the educational testing industry, but that the serious games industry should use other, more innovative methods of analysis.

The most widely used technique for analysis of *in-situ* data is visualization. Visualization is often used at the end of serious games analysis [13]. This is because visualizations are an effective way of sharing results as graphical representations can show a large amount of detail in a small amount of space [4]. Dicerbo et al. [4] notes that visualizations can expose relationships more effectively than other methods. Data visualization can also be used to discover patterns in play-learners' use of serious games [9, 16].

The technical details of the processing of the game-play logs and the creation of visualizations are not typically described in the literature. The current work provides a case study of this and focuses on custom software, which used 3rd party libraries where appropriate, to perform the data processing and visualization.

4 The Preparation of Game-Play Logs for Visualization

The process used for analysis of game-play logs can be separated into three main steps: *Pre-Processing*, *Data Transformation* and *Visualization*. The first two steps are explained in this section while the visualization of the results is detailed in Sect. 5. An overview of the process can be seen in Fig. 3, that shows how different parts of the process fit into these three steps.

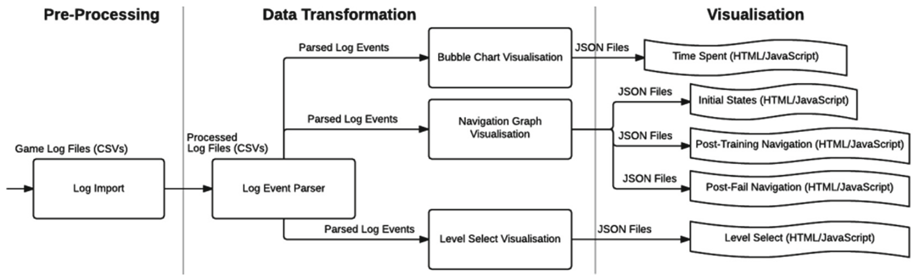

Fig. 3. Game-play log processing pipeline

4.1 Data Collection and Pre-processing

During 2015, a series of *Apostrophe Power* evaluation sessions were conducted at The University of Newcastle, Australia. The participants were provided with Samsung Galaxy Tab3 Android tablets, with the app pre-installed, and were asked to play the game for approximately 45 min. While they played, their interactions with the app were recorded as events to a local SQLite database on the tablet. At the end of the session, the recorded interactions were exported as a CSV (Comma Separated Values) file via email from the tablet.

A total of 17 participants took part in the evaluation sessions. The highest number of events that were logged was 3780 and the lowest was 1692. An example of the contents of the CSV file of game-play events can be seen in Fig. 4. The first step was to write code (the *Log Import* module, shown in Fig. 3) to pre-process these CSV files, changing the structure of the data and removing events that were not needed for the current analysis. The first six lines of the file were removed, as these were either administrative entries, e.g. data separator identifier, the unique device ID, or summary metrics from the device, e.g. the Boolean values of level completion. Next, all of the events that did not take place on the evaluation day were removed. Finally, a row of headers were added, the separators changed to commas and the modified rows exported to a new file.

The exported CSV files were then input into the *Log Event Parser* module (see Fig. 3). This module was responsible for transforming the recorded events into a list of objects representing the different states of the game in the order, and with the duration, that the play-learner had navigated them in. The different states map to different areas of the game, for example *Playing Game* or *Watching Training Video*. The resulting data included the current category and/or level, when relevant to the state. The type of transition that the play-learner made to the state was also recorded in the event. For example, the play-learner may have navigated to a game level after completing a training video.

The results from this parsing were used in the visualizations described in Sect. 5. An example of the parsed events, from the data in Fig. 4, in CSV file format is shown in Fig. 5.

```
sep=;
30044c60c720b100
ownership;[true, true, true, true]
contractions;[true, true, true, true]
misfits;[true, true, true, true]
mixed;[true, true, true, true]
2015-08-28 07:48:35.448; close_dialog_ClearAppState; ;
2015-08-28 07:48:38.220; close_activity_Settings; ;
2015-09-01 14:02:05.485; open_activity_MainMenu; ;
2015-09-01 14:02:09.147; click_button_Play; ;
2015-09-01 14:02:09.564; open_activity_LevelPicker; ;
2015-09-01 14:02:11.659; click_button_ownershipLevel_0; ownership; 0
2015-09-01 14:02:12.017; open_activity_Game; ownership; 0
2015-09-01 14:02:12.234; load_question(The airports terminal is busy.); ownership; 0
```

Fig. 4. Fragment of a data file from a game-play session

```
Begin, End, StateName, TransitionFrom, Category, Level, DurationSeconds
1/09/2015 2:02:05 PM,1/09/2015 2:02:09 PM,Main Menu,Start,,,3
1/09/2015 2:02:09 PM,1/09/2015 2:02:11 PM,Level Select,From Main Menu,,,2
1/09/2015 2:02:11 PM,1/09/2015 2:03:16 PM,Playing Game,From Game Level Select,ownership,0,65
1/09/2015 2:03:16 PM,1/09/2015 2:04:49 PM,Playing Game,From completed level,ownership,1,92
1/09/2015 2:03:16 PM,1/09/2015 2:06:42 PM,Watching Training Video,From incorrect question,ownership,,205
```

Fig. 5. New data file exported to CSV after performing event parsing

4.2 Choice of Technologies

The code for the analysis of the *Apostrophe Power* game logs had two main purposes: the processing of the logs and the visualization of the transformed data. In this section we explain our reasons of choosing F# for data processing and HTML and JavaScript for visualization.

F# is a functional-first programming language, developed and maintained by the F# Software Foundation and Microsoft (http://fsharp.org/). F# is referred to as a functional-first language. This is because it is possible to use imperative programming constructs, such as while loops, in F#. However, developers are encouraged to use functional constructs as much as possible. Although F# is not a commonly used programming language[1], it provides features that made it an appealing choice for data processing and transformation. Firstly, F# allows compilers to infer types from a sample file in CSV, JSON and other formats without having to write a parser. Thus the transformation of the CSV files was straightforward with no need for new code for parsing the files.

Secondly, F# has higher-order functions and piping syntax for manipulating collections. This makes it possible to approach the design of the data processing and

[1] F# is ranked #36 in the TIOBE Index. See http://www.tiobe.com/tiobe_index [last access 10/05/2016], an index of rankings of the popularity of different programming languages.

transformation in a way that Fowler[2] refers to as a *Collection Pipeline*. This aided the process (as seen in Fig. 3) of data transformation and visualization that involved taking collections, performing some manipulation and then sending it to the next step in the processing pipeline. Finally, F# focuses on immutability. Unless specified all variables declared in F# will be immutable. If the data processing and transformation was to be executed in parallel, for example through multi-threading, the use of immutability would make the implementation of this safer [5]. Loh, Sheng and Infenthaler highlight the need for serious games analytic methods to be scalable [11] thus algorithms that can be run in parallel may be an appropriate way for scaling methods.

In this project HTML and JavaScript were used to produce data visualizations for three reasons. Firstly, there are several high-quality JavaScript libraries available for creating visualizations in SVG (Scalable Vector Graphics) format, such as Data-Driven Documents (see *d3.js*, http://www.d3js.org/) and *vis.js* (http://visjs.org/). Secondly, if future work is performed on the project developers will not need to install additional software packages to create visualizations. Developers would only need access to a modern web browser. Thirdly, the researcher working on data analytics of this project was more familiar with these technologies than other data visualization software packages. This accelerated the development of the processing pipeline and the resulting visualizations.

The graphs presented in Sect. 5 were originally produced using the graph visualization software Graphviz (http://www.graphviz.org/). However, using Graphviz would mean that anyone doing work on the project in the future would have to install and configure this software package to produce visualizations. The creation of these graphs was then implemented in HTML and JavaScript instead (by using vis.js). This meant that if a developer wanted to reproduce these visualizations with new data, they will only need to run the F# code and would be able to view the resulting visualizations in any modern web browser. This provides a level of robustness and future proofing to the analytics pipeline described here.

5 Game-Play Log Visualization

In this section we discuss the visualizations generated through the process described in Sect. 4. The aim is to consider questions relating to play-learners' decisions during the *Apostrophe Power* evaluation (see Sect. 1).

5.1 In Which Areas of the Game Do Play-Learners Spend Most of Their Time?

Discovering how much time play-learners spent in different parts of the game is an important metric. If, for example, play-learners spent most of their time outside the training area of the game, this could indicate that the training area was unattractive or that the game was too easy, with implications for learning design.

[2] See http://martinfowler.com/articles/collection-pipeline/ [last access 11/5/2016].

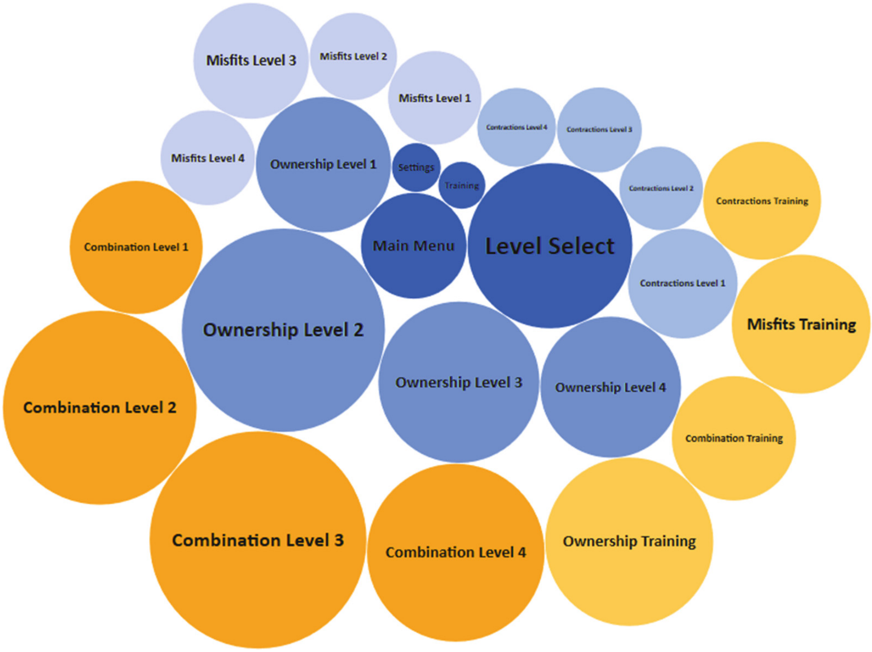

Fig. 6. Bubble chart of time spent in different areas of the *Apostrophe Power* app

A bubble chart visualization[3] was produced from the parsed game-play logs (see Fig. 6). The bubbles in Fig. 6 with category name, "Level" and a number represent time spent in that level. The bubbles with the category name and suffixed with "Training" represent time spent watching videos. As can be seen in Fig. 6, the participants spent most of their time playing through the game levels. The play-learners spent significantly more time in the Combination category than in any of the other category. This suggests that the play-learners found the questions in this category more difficult than in the other categories. This is consistent with the pedagogical intent of the design where play-learners need to bring together their knowledge of all the functions of apostrophe use to successfully master the Combination levels.

The bubble chart produces a high level view of activity to indicate broad trends. However, one advantage of this visualization is that if more logs were collected, the bubble chart could be produced for the new data with minimal effort. Thus it provides scalability.

5.2 What Order Do Play-Learners Complete the Game Levels?

A visualization (Fig. 7) was created to represent the order that players completed the game levels in. We were interested in both the navigation between levels and how this

[3] Source d3.js bubble chart example from https://bl.ocks.org/mbostock/4063269 [last access 11/5/2016].

corresponded with our interface design. Thus the visualization layout has been mapped to the level selection screen (see Fig. 8). Each of the arrows in Fig. 7 represents a transition from one of level to another. The thickness of an arrow indicates how common the transition was. From this visualization, it can be seen that the most common path for completing the game was to navigate the game by completing all the levels in a category and then continuing to the next category.

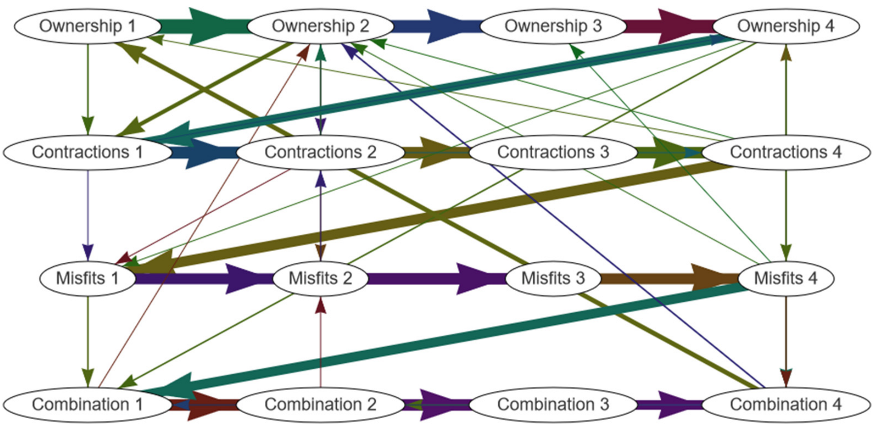

Fig. 7. Visualization of the order that players completed the game levels. The thickness of an arrow indicates how common the transition was with participants

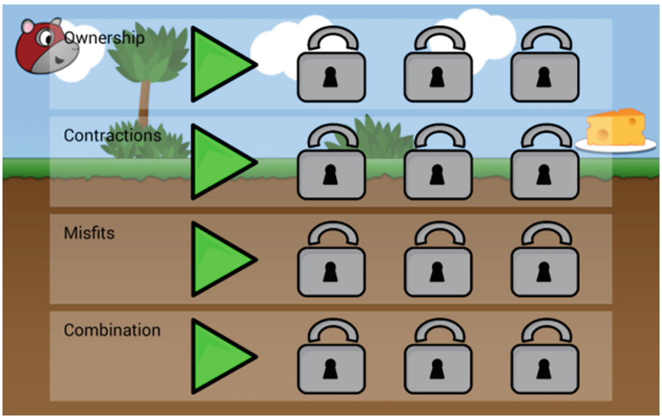

Fig. 8. Level selection screen in *Apostrophe Power*

In addition to completing all the levels in a category from easy to most difficult (left to right) the play-learners also attempted to master single categories of apostrophe use before attempting the levels where apostrophe functions are combined in activities (hence the movement from top to bottom). This was consistent with the pedagogical intent of the design where play-learners needed to bring together their knowledge and mastery of all the functions of apostrophe use before attempting to complete the Combination levels.

5.3 After Making Mistakes, Do Play-Learners Choose to View the Training Videos?

The transitions after a play-learner made an unsuccessful attempt were classified into three groups: (i) *Level Menu* - the play-learner returns to the Level Select Menu; (ii) *Watch Training Video* - the play-learner chooses "Go To Training", which navigates to the relevant training video; and, (iii) *Try Again* - the play-learner chooses to make another attempt, which will generate a new exercise in the current category. These transitions were combined for all play-learners, and the percentages of these transitions were calculated. This was visualized by creating a state transition diagram, using viz.js (see Fig. 9).

The percentage (1.66 %) of transitions to a training video after making an unsuccessful attempt was very low compared to the percentage (96.46 %) of transitions where play-learners tried again after making an unsuccessful attempt. This suggests that, while there is a pop-up dialog that offers the play-learner the choice to navigate to the training section after an unsuccessful attempt, it could have been more effective to force play-learners to watch videos after a number of unsuccessful attempts.

This is an example where the pedagogical intent in the design did not manifest in the play-learner behavior. Player-learners generally did not use the instructional training videos as a scaffold. Instead, player-learners persisted with repeated unsuccessful attempts. A key question that this raises is how the unsuccessful attempts relate to the different apostrophe categories and levels of difficulties. This requires further investigation.

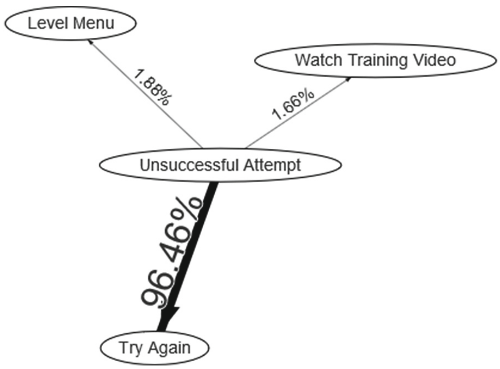

Fig. 9. The pathways play-learners took after unsuccessful attempts

6 Conclusions

This paper has described the use of game-play logs and their visualizations to identify pathways through gaming content in the *Apostrophe Power* app, to elucidate learning behavior. As the aim of the project was to produce a serious game, mapping the engagement between game-based learning exercises and the associated training videos was useful. It provided evidence on the appropriateness of each component, e.g. the difficulty of the exercises or the value of the training videos. This paper focuses on the value of visualization to conduct such analysis.

This paper outlines the process of taking event logs and processing them into a form to support visualizations for analysis. Specifically, this paper describes the use of F#, HTML and JavaScript to build a scalable pipeline for visualizations. The aim has been to define an environment that is both scalable, with potential support for parallelism, and with future proofed visualization output. In this case the visualizations are accessible via standard web browsers. Thus the methods described here are scalable and maintainable, so that later evaluations could be analyzed using the same methods and code with minimal effort.

Three questions relating to play-learner behavior during game-play were explored. In two cases, namely "In which areas of the game do play-learners spend most of their time" and "What order do play-learners complete the game levels", the visualization confirmed that the play-learners behavior was consistent with the pedagogical intent of the serious game design. However, in the third case - "After making mistakes, do play-learners choose to view the training videos?" - where it was assumed that unsuccessful attempts would prompt player-learners to view an instructional video, there was limited evidence of this choice. Thus, the pedagogical intent did not manifest in the play-learner behavior. This said, findings from the evaluation, reported elsewhere [14], indicated that the apostrophe use of player-learners did improve.

Serious games provide a space for autonomous learning and risk taking. These can be positive and motivational attributes of learning environments. More investigation into the balance between play-learner autonomy and more direct instructional approach is required. Data analytics, transformed into different types of visualizations, can provide an objective representation of the relations between gaming elements, learning behavior and pedagogical intent. Bringing together these three domains of knowledge is important for the advancement of serious game design and for promoting genuine interdisciplinary dialogue about learning within serious games.

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[4] The *Apostrophe Power* app is available for free download on the Apple iTunes App Store (iOS) and Google Play (Android). See http://dice.newcastle.edu.au/resources.html.

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Reflection on Assumptions from Designing Female-Centric Educational Games

Corey D.C. Heath(✉), Tyler Baron, Kevin Gary, and Ashish Amresh

Arizona State University, Tempe, AZ, USA
{corey.heath,tyler.baron,kevin.gary,amresh}@asu.edu

Abstract. In this paper we present a detailed analysis of the design and implementation of an educational game targeting young women entrepreneurs by a predominantly male team. During the process, we arrived at assumptions based on intrinsic and extrinsic influences that effected the design of the game. After creating a prototype, the game was provided to the target audience during a usability test. Our observations reveal that even after following a rigorous and agile development model that included stakeholders at several time frames, we were not successful in delivering the desired experience to our target audience. We conclude by presenting a strategy for changing the agile development model to be inclusive of the target audience.

Keywords: Game studies · Agile/SCRUM · Game mechanics · Gender · Inclusive design

1 Introduction

The video game industry has been justifiably scrutinized for its exclusivity both in terms of targeting a specific player demographic and in promoting a homogenous work environment that is hostile toward perceived 'outsiders' [1]. In order to create games that are inclusive to all players, a more inclusive work environment is needed. To achieve this, the industry needs to both attract a more diverse workforce, and train industry professionals to think inclusively. This paper presents the development of an educational virtual world based game targeted at a female demographic, and the challenges faced by the development team in overcoming assumptions for designing inclusive games.

The demographic of video game players is typically seen as adolescent males. In entertainment games, this limited focus leads to less involvement, and ultimately less fun, for players who fall outside the target demographic. In educational games if the player is not able to connect with the game, they will most likely not be optimally achieving the learning objectives [2].

The DreamBuilder program [3], developed by the Thunderbird for Good division of Arizona State University focuses on training women to start and grow their own businesses. The program incorporates multimedia materials into a cohesive, interactive course exploring the fundamentals of entrepreneurship. The game *Sold!* was developed in conjunction with DreamBuilder to be a companion application for the program. The

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purpose of *Sold!* was to provide a virtual world where DreamBuilder participants (predominantly women) could practice important concepts from the course materials.

Sold! was developed as a project for a game based learning course comprised of graduate students. The goal of the *Sold!* development team was to create a virtual world that would not alienate players based on gender or ethnicity. *Sold!* was designed to provide the player with a safe environment for failure, and promote learning through experiential and constructivist pedagogy. It was also designed as a burst game, incorporating short play time and repetition to boost learning [4].

To implement the game, the development team followed the Agile/Scrum [5] software development process within a period of 5 months. During the design and implementation, six key assumptions made by the team became apparent. The assumptions were made both explicitly through the influence of a literature review on designing female centric games, and implicitly through the preconceptions of the development team. These assumptions were:

1. Target audience would understand how commercial games work
2. Third person point and click avatar movement would be implicitly understood
3. Exploration of the game environment would not require prompting [6]
4. Interaction with non-playable characters (NPCs) would occur naturally
5. A strong narrative was necessary for promoting game play
6. Puzzle mechanics would facilitate requisition of the key learning objective concepts

The following sections present the current research into designing culturally agnostic virtual worlds, the design mechanics for the *Sold!* game, the agile methodologies employed, findings from play testing, and the development team's recommendation for future work. As a result of this work, we make the case for adapting the agile/Scrum methodology when used to develop educational games to promote inclusivity.

2 Background

To design a game that would be an impactful addition to the DreamBuilder program, it was important to understand program's goals and values, along with their target demographic. DreamBuilder is an online curriculum aimed at training women interested in owning their own businesses in a manner that is accessible, applicable to real-life, and fun. Throughout the course, the students learn the fundamental concepts of entrepreneurship. The DreamBuilder course facilitates learning through a multimedia distribution of information along with prompting students to engage in practical critical thinking. This is accomplished by guiding the students through important business concepts, such as creating a business plan. One of the key demographics for the DreamBuilder program is young women in South America. DreamBuilder aims to provide cross-culturally accessible materials, and offers the program in both Spanish and English. A virtual world based game is an ideal component for the program as it provides an environment that promotes experiential and constructivist learning of practical and creative skills [7, 8].

For a game accompanying the DreamBuilder program to be successful, its design had to consider both gender and culture bias. Research into gender-related concepts in video games has been a prevalent trend in academia and industry for the last few decades. Bonanno and Kommers [9] conducted research into the attitude of students towards incorporating games into educational curriculum. Through a survey of 581, 212 male and 258 female, Maltese college students, they found several differences in the perceptions of video games as both an instructional tool and a leisure activity based on gender. Additionally, it was concluded that although both male and female students responded that games were effective learning experiences, females were generally more skeptical about the role of games in education. Through their results, Bonanno and Kommers [10] concluded that female students were less likely to consider video games as having unique affordances in education that could not be met by other means. Bonanno and Kommers [9] also found that female students rated themselves lower in their familiarity with technical hardware and navigating virtual worlds than their male peers. *Sold!* addressed this issue by creating a strong story and narrative that was closely connected with the real world and practical issues that entrepreneurs would face.

Research undertaken by Winn and Heeter [10] examined the gender differences in leisure time. Through survey, they found that women of all ages tended to report having less leisure time than their male counterparts. In order to take this into account, Winn and Heeter recommended designing games that could be played in short intervals. This becomes particularly important when designing educational games for adult students, who may have limited spare time. *Sold!* was designed to be incremental with players achieving their goals in short bursts.

Studies have been conducted on what design elements resonate the most with female students, as different design approaches engage different types of players [11]. Miller, Chaika and Groppe [12] found through survey that female students preferred elements of exploration, challenge, social interaction and role play. Similar results were found in a survey conducted by the American Association of University Women (AAUW) [13]. The AAUW found that female students in focus groups ranked engaging characters, communication/collaboration, puzzle game play, opportunities for creativity, and skill-based game play as the most important features for virtual worlds. In a study that facilitated game design in students, Heeter et al. [14] found that when given the opportunity, female students designed games that focused on adventure, with little or no direct confrontational elements or violence. They also found that female students designed games with winning strategies and conditions that were not linked to defeating an opponent. Additionally, Heeter et al. [14] observed that female students added more humor to their games than their male counterparts. These studies lead to the initial concept of *Sold!* incorporating exploration and puzzle mechanics as primary gameplay features.

Less research has been conducted on the representation of ethnicity and designing games for different cultural identities. Much of the work on ethnicity in virtual worlds has focused on the representation of ethnic characters, particularly looking at the game's playable character(s). In a survey of role playing games (RPGs) Dietrich [15] found that the majority of games with custom player avatar creation would not allow players to create a character that had features typical of ethnic African people with dark skin tones. He examined player creation mechanics in terms of skin tone, facial features and hair styles. Dietrich concluded that even in games where skin tone was changeable, the darkest tones were often not available and facial features and hair styles did not reflect realistic African features. Dietrich's work illustrates either a disregard for ethnic identity in regards to player creation, or the inclusion of ethnicity as an afterthought. Similar research on avatar creation interfaces was conducted by McArthur, Teather and Jenson [16]. They found that terminology, default character features, and buried design options favored creation of Caucasian male characters in many of the leading commercial games.

Predicting the preferences of female players new to gaming is difficult at best [17, 18]. It can be tempting to stereotype games by gender, however it is important to remember each individual will have their own preferences. As more female gamers are recognized, the trend in designing games has become less about gender as the barrier and more about 'hardcore' versus 'casual' gamers, which implies that some people have only cursory knowledge of popular games [19]. Whether or not this implication is accurate or fair, it has led to the notion that gender no longer poses a significant barrier to basic knowledge about games. This notion that gender is no longer a major barrier formed the basis for our first assumption. It was assumed that students interested in an educational game, even those who play games rarely or not at all, would have at least minimal knowledge of how commercial games function. Also regardless of gender, a new player can be expected to have some issues with learning the controls for a game. Hayes [17] found two players, both women, who were unfamiliar with open world game play had difficulty with the first and third person controls in *Morrowind* [20]. This difficulty led to our second assumption, that moving the character by clicking on the desired location was a more intuitive way to control the character and explore the world.

While gender may no longer be as much of a barrier, gender preferences still persist, possibly driven by media influence [20]. For example, women reported disliking competitive elements in game [17]. Instead, it has been shown that women prefer exploration when given an open environment [22]. This led us to our third assumption that exploration would occur naturally without further direction from the game. Another example of gender preferences was found by a study done by Hartmann and Klimmt [17] which found that a lack of meaningful social interaction was one of the main reasons females said they disliked video games. This lead to our fourth assumption, that dialogue with NPCs would occur naturally as part of exploration.

Immersion and relatability is important for attracting a female audience [23], which in combination the importance of social interaction [17] led us to our fifth assumption, that a strong narrative would be needed to promote gameplay. Our final assumption, that puzzle based game mechanics would be the ideal way to teach core concepts was based off of findings by Seisto et al. [24] which found that females in their study preferred puzzle based games the most compared to other game genres.

The Agile process was utilized in *Sold!* to provide a structured environment for developing the game, and to give students participating in the project the opportunity to gain practical experience with development methodologies. Agile development is a type of iterative development methodology [25]. In agile development, the development team makes a series of *sprints* to complete product features within a time window. At the end of each of these, those features are evaluated. If the feature is not determined to be complete, it is reprioritized to be completed in a future sprint.

3 Project Description

Sold! was developed as a project for a course on game-based learning. The goal of the project was to design and develop an educational virtual world game for a client from outside the university. The project development process can be broken into three distinct phases: design, implementation, and delivery.

3.1 Design

Throughout the project, the development team worked closely with the stakeholders from the DreamBuilder program to identify and refine the core game features and design. Communication between the stakeholders and the development team was maintained throughout the design and development process.

To begin designing the game, it was important to determine what concepts would be best suited for incorporation into a virtual world. The stakeholders had identified the concept of assessing product value and assigning a price to be a particularly weak area for many of their students. This is likely due to relative lack of practical experience, which causes the student to not consider all of the costs involved in creating and selling a product or service. It was decided that the game would focus on giving players the opportunity to participate in pricing products and conducting market research. In addition to addressing the learning objectives, the stakeholders emphasized a need for the virtual world to be accessible for a diverse demographic of users.

To correctly price a product or service, one needs to consider the direct costs, indirect costs, and customer's perceived value of the product. The direct costs consist of all the supplies and labor associated with producing the product or service. Indirect costs encompass the expenditures of running a business that are not directly associated with the product or service, such as equipment purchase costs or utility bills. The amount of value a customer places on the product or services is an important consideration in pricing that is often neglected by entrepreneurs. This value is determined by the customers' level of need or want of the product along with their view of the company or product's reputation. If the company or product has a reputation for quality or prestige, the customer will be willing to pay more.

A good method for determining what customers will pay is known as conjoint analysis [26]. In conjoint analysis, a sales person asks a customer which of two products they would prefer to buy at given prices. One product is priced higher than the other, but has additional incentives such as a brand name or additives. Whether or not the customer is willing to buy the higher priced one helps determine the value of those incentives. Conjoint analysis questions were worked into a conversation system that players could have with Non-Player Characters (NPCs) in the game.

The design of *Sold!* focused on creating a safe space for players to interact with virtual potential customers. Throughout the game, the player will uncover information that will help them price and sell their virtual product. To accomplish this, *Sold!* was designed to have four primary phases in the application: the start screen and main menus, an open world market research scene, a scene for pricing the virtual product, and a scene for selling the product to virtual customers.

The game interface focused primarily on using a mouse or touch screen controls. Keyboard controls were used only to input monetary values when pricing products. The main menu and pause menus relied on buttons for user interaction. These buttons were designed to be conspicuous and clearly labeled to help players that were not familiar with video game interfaces infer their use. The player also used the mouse or touch input to move the character in the open world scene as shown in Fig. 1.

Fig. 1. The player character moves to where the player clicked the mouse

The open world portion of the game is set in an open air market. The player assumes the role of a baker that specializes in cakes. Cakes were chosen as the product due to the variety of options that would affect the cake's price. The player's goal is to sell their cakes for a profit and repay a loan from the bank. The game's premise focused on creating a world where the player can interact with potential customers. Through a dialog system, the player could ask NPCs questions that emphasized courtesy, consumer preference, and soft sale skills. The courtesy option focused on polite greetings, farewells and small talk. For consumer preference, the player was able to choose between two or three options. One option would yield information that would aid the player later in the game, while the other options would give information that was vague or misleading. This was done to enforce the concepts presented in the DreamBuilder program. Some dialog options would lead the conversation to the point where the player could invite the NPC to visit their market stall later. The questions the player asked, and the information they received, were used to augment the selling simulation scene of the game. If the player had invited the NPC to visit them, more NPC customers will generate during the simulation. An example conversation is shown in Fig. 2.

The game mechanics emphasized exploration and constructivist learning. The expectation was that the player would explore the market and interact with NPCs and game objects without the need for linear directions. The goal of this approach was to engage the player in the experience by allowing them to make their own decisions on how to proceed.

Fig. 2. The player character discusses cake preferences with an NPC

Pricing features in the game focused on deciding what types of cakes needed to be made and what price customers would be willing to pay. If the player successfully interacted with the NPC, they would have a general strategy for how to proceed. There are two basic strategies for determining how many cakes need to be made, and at what price to sell them. The first strategy involved selling many cakes, particularly the common variety, at a lower price. The second, converse strategy is selling fewer cakes, but comparatively more specialty cakes, at a higher price. The player wins *Sold!* by making enough profit to pay off the in-game character's predetermined debt to the bank. The player achieves this by determining the correct product creation and pricing strategy for each level. Having multiple levels with similar content affords the player the opportunity to fail but still continue to have new experience in the game. Levels follow the same structure, however they differ in the NPCs that populate the environment, and what the best pricing strategy will be. If the player does not price their product well and fails to make a profit, they will have the opportunity to try again with a new set of characters. This will keep the game entertaining by presenting new experiences, but still facilitate learning through repetition. The player can only completely fail the game if they lose all of their money and are unable to pay the costs to create more cakes. At this point, the player will need to restart.

3.2 Implementation

The development team followed the Scrum variant of the agile family of methodologies [2] for the implementation of *Sold!*. In Scrum there are four key roles, the product owner, the scrum master, chickens, and pigs. The product owner is the person who dictates what the product is and what features it requires. The Scrum master acts as an organizer and reports progress to the product owner. Pigs are regular developers who are working on the product. Chickens are consultants, advisors or individuals who do not work on the product directly, but have an influence on the product design. The team consisted of seven students, including five developers who assumed the role of pigs, the professor acted as a chicken, and two students acting interchangeably as product designers and Scrum masters. The roles remained unchanged throughout the implementation phase, however, the product designers assisted with development and testing due to the small team and time limitations. In addition to the development team, a staff member from the stakeholder assumed the role of product owner. It is important to note that only two of the nine people directly involved in the project were women, one of the developers and the stakeholder from the DreamBuilder program. The professor and remaining students were men.

In accordance with Scrum, development was conducted in short iterations known as *sprints*. Features were catalogued on a Product Backlog, mapped to a Sprint Backlog, and implemented in potentially shippable increments at the conclusion of each sprint. Upon completing a sprint, the game was demonstrated to the stakeholders to get feedback on whether or not they met expectations. The agile approach allowed the design process to remain important throughout the project. In contrast to traditional design methods that focus on *big up-front design (BUFD)*, the application of agile was critical so continuous design feedback could be incorporated each sprint. The ultimate release goal was to create a functional prototype that incorporated the main game mechanics and learning objectives at the end of four sprints.

In Scrum, sprints are a predetermined fixed period of time that encompasses the development process for a set software features. The requirements for the product are written as *User Stories*, which are proxies for conversations with the actual customers. This is an ongoing process; customers and developers can identify user stories at any time and place them on the Product Backlog. During a collaborative meeting called *sprint planning*, customers and developers negotiate what are the highest priority features to implement in the next sprint. Developers analyze these features, conduct design activities to the extent required, and identify the set of implementation tasks for the sprint. Like design, testing is done throughout the sprint, though at the conclusion of the sprint there is typically a greater emphasis on testing tasks. Each sprint produces working software for feedback, and at the end of a set of sprints (in this case four sprints), a minimally-viable product (MVP) has (ideally) been produced. This process is shown in Fig. 3.

Sold! was developed with the 3D game engine Unreal Engine 4, created by Epic Games. The work conducted in this project focused predominantly on game mechanics. Features that were implemented in the game include conversation systems, character movement for player and non-player characters, and a proximity audio playback system. For the prototype version of *Sold!* the expected execution platform was a desktop or laptop computer, however, mechanics were designed with consideration for expanding to other platforms, such as mobile devices, in the future. Similarly, instructions and

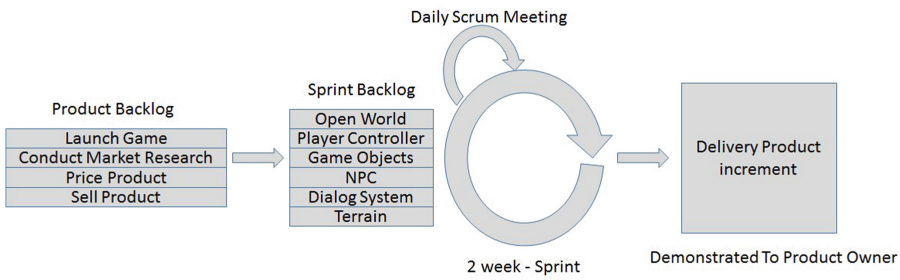

Fig. 3. The agile development cycle utilized during the implementation of *Sold!*

dialog are presented solely in English, but the components were implemented to support other languages dynamically.

For art design, *Sold!* relied on basic assets and models provided by Unreal, supplemented with a small number of custom 3D models. Because of this, *Sold!* has only basic visual components, including generic character and object models.

4 Research Methodology

The prototype version of *Sold!* was provided to the stakeholders for product testing with DreamBuilder students. A 52 question survey was created by the development team in order to get an assessment of students' views on the game and how it related to the curriculum. This survey collected demographic information from the respondent, information about their video game habits, background knowledge on business related topics, and their reflections from playing the game. The stakeholders provided the link to several individuals involved in the program, resulting in 13 survey responses.

In addition to the survey, *Sold!* was used in a DreamBuilder classroom where 22 participants, 20 students, one instructor, and one administrator, had the opportunity to play the game and provide feedback. A member of the development team was in the classroom to observe users, answer questions and record feedback. The development team member observing the participants gave a brief introduction to the project and its objectives, but did not initially offer any verbal instructions. Seven of the 22 participants in the classroom demonstration later took the online survey, resulting in 20 total survey responses.

5 Results

The classroom demonstration consisted of 22 participants, all of which were women between the ages of 30 and 65. The participants were provided the web address for *Sold!* and given time during the class period to play the game and take the survey. The majority of the participants spent approximately 15 to 20 min playing the game. Two of the participants quit the game after approximately five min, and stated an unfamiliarity with video games. Both of these participants stated that this was their first attempt to play one.

They expressed that the controls were difficult to use, and they did not understand what they were expected to do. The remaining participants played long enough to experience the three main aspects of the game: the open world market, the pricing game, and the selling simulation.

The observer was called over by three separate people to explain what the player should be doing after the initial in-game instructions. After directing the player to explore the world and talk to the NPCs, the participants were more assured of what needed to be accomplished.

Several comments were made regarding the in-game objects, particularly the character design. The characters were based off of free content provided by Unreal. Although the character designs do not reflect human design and are androgynous, the shape of the figures represent traditional masculine features. Similarly, the choice of using cakes was criticized as implicit bias, and patronizing due to the association of baking with traditional domestic roles. Future work with *Sold!* will examine the need for avatar creation and product selection.

The observer also noted that technical issues with the game often caused uncertainty in a few participants. If the game took a prolonged period of time to load, or the gameplay lagged, the participant would ask if they had done something incorrectly.

The aspect of the game that classroom participants viewed most positively was the pricing game. Participants enjoyed contemplating the best strategy for making cakes.

Survey participation included both participants from the classroom demonstrations, as well as individuals provided the game and survey links by DreamBuilder staff. Females between the ages of 25 to 65 accounted for 14 of the 20 survey respondents. The demographic information from the survey is presented in Fig. 4. Figure 5 shows the self-reported time survey participants play video games on average per week. The three areas of the survey that are most worth noting are in regards to in-game instructions, learning objectives and entertainment value.

Out of the 52 questions in the survey, five were directly related to in-game instructions and knowledge on what the player should be doing. These questions related to using the player controls and interface, and knowing what tasks need to preformed at a given time. The data regarding controls was neutral, with approximately half of respondents answering the controls were easy to understand, and the other half stating they did not understand the interface. Responses to in-game task-related questions reflected that most players did not know what they should be doing during the game play. In addition to the negative responses on the instructions, the top recommendation for future versions of the game reflected in the survey was a tutorial level.

Survey responses for questions relating to learning objectives illustrated a mixed reaction for the game. Six questions on the survey directly queried the takers as to whether they understood the learning objectives, if they learned something new, or if they were able to practice a previously learned skill. Questions related to market research, pricing, and relatable material scored more positive responses than negative. Conversely, questions related to brand value and strategy had more unfavorable responses.

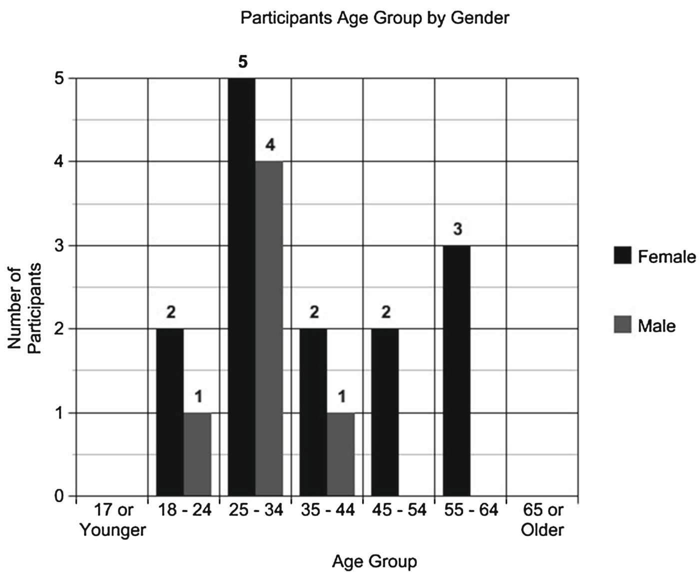

Fig. 4. Age group of participants reported by gender

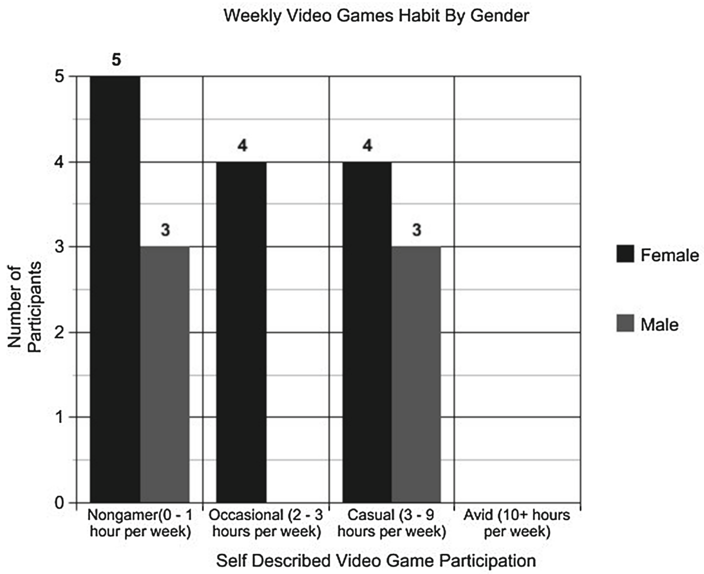

Fig. 5. Self-reported time spent playing video games by survey participants reported by gender

For entertainment value, the survey reflected a neutral view of the game. When asked if they found the game fun, one respondent responded negatively, five responded positively, and the remaining responded with a neutral answer. Figure 6 illustrates the percentage of Likert scale responses female survey participants selected for statements regarding learning objects and entertainment value of the *Sold!*.

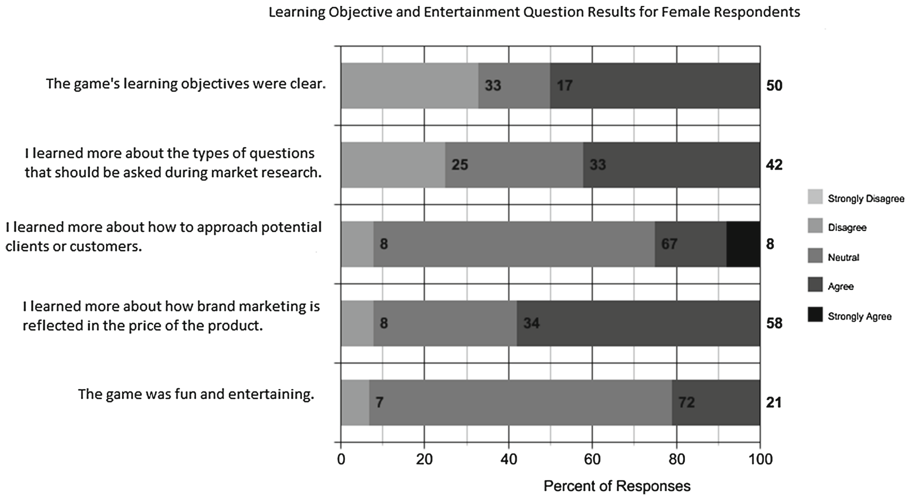

Fig. 6. Response percentages for female survey participants for statements related to learning objectives and entertainment

6 Analysis and Discussion

The results from the survey and classroom observations illustrate a fundamental flaw in the design of *Sold!*. *Sold!* was designed to include an open world component that would allow the player to explore and interact with in-game objects and characters. This is in accordance with the assumptions the development team made in the design phase. The research results show that the freedom comes at the cost of direction, and the assumptions regarding game play were incorrect.

Most of the players who played the prototype version of the game reported that they were unsure of what to do. This likely reflects an unfamiliarity for open world video games and exploration mechanics. This is directly in opposition to our first assumption, that players would understand how commercial games function. This, along with the survey results reflecting players were unsure what they should be doing, refutes that exploration of the virtual world would happen innately. This shows our third assumption was invalid.

On the survey, the top two responses for which types of video game genres participants enjoyed were strategy games and puzzle games (with seven responses each), while five responses indicated that the players were non-gamers. This implies an unfamiliarity with the character control scheme, exploration mechanics, and interaction with in-game objects. This implication shows a failure of our second and fourth assumptions, that a point and click control scheme would be obvious, and interaction with in-game objects and characters would occur without prompting. More instructions, a tutorial level, and directed gameplay need to be addressed in a future version of *Sold!*.

Closely related to the need for instructions was the need for more feedback and reinforcement during the gameplay. As most of the players in the research testing were unfamiliar with open world games, or games in general, they require more affirmation that they are interacting with the game correctly to build confidence. This is also illustrated in the observations during classroom testing where players perceived technical difficulties as a problem they unwittingly introducing. The concept of positive affirmation is an important consideration when designing games for students with less diverse technical backgrounds.

The entertainment value of the game received a neutral score on the survey. This prototype focused primarily on game mechanics for presenting the learning objectives, and lacked sufficient detail in the puzzle game play. Also, it likely the generic and sterile characters and environment affected players' enjoyment. Future work on the game would need to reexamine the game play and art assets in order to make the game more enjoyable.

The mixed results regarding the learning objectives reflect that the game mechanics can present the material favorably, however, the content and instruction need to be revised. Additionally, adding more levels and varying difficulties in gameplay would give greater opportunity to present the material.

Our fifth and sixth assumptions resulted in more favorable results than the previous assumptions. The majority of participants indicated that a background story helped them connect with the game. Only 3 survey participants had negatively to statements regarding including a background story. Observations and feedback about the pricing aspects of the game illustrate the effectiveness of puzzle based mechanics. This is further shown in the survey with the positive responses regarding pricing and market research learning objectives.

7 Future Work

For future work on *Sold!*, the development team needs to add more direction and positive feedback in order to build confidence in users, particularly those with less familiarity with open world video games. This reflects an important design consideration for developers building content aimed at accompanying adult education materials. More research is needed in exploring the connotation students in adult educational programs have towards game-based learning and how virtual worlds can be designed to complement adult education curriculum.

One of the most difficult challenges the development team encountered was how to address implicit bias in the foundational aspects of the game. This becomes particularly evident when examining controversial issues, such as sexuality and relationships. Although sexuality is not a primary focus of *Sold!,* the design of a real world setting based on realistic representations of people leads to inferences regarding gender roles and views on sexuality. For instance, in *Sold!* the player is able to interact with a heterosexual couple that is planning their wedding. Having a male-female relationship and not a male-male or female-female relationship could be seen as reinforcing the opinion that only male-female relationships are valid. The problem here is that this implicit interpretation could be seen as a deliberate attempt to exclude homosexuality from the game world and thus alienate homosexual users. Conversely, including homosexual relationships in the game world could cause people from cultures that oppose homosexual unions to be less engaged in the game, or avoid it. Currently, more research needs to be conducted on recognizing implicit bias, and how to best design games for cross-cultural appeal.

Similar to implicit bias, the concept of gender raises issues. Work on *Sold!* was based on assumptions regarding gender, reflecting traditional and contested definitions. A broader definition of gender needs to be addressed in order to create more inclusive virtual experiences.

Part of the design goals of the *Sold!* project is to create a culturally inclusive virtual world learning experience. The prototype version lacked language support outside of English, limiting its ability to be tested in more diverse settings. The next phase of the *Sold!* project will include Spanish language support and will target a test demographic in Central and South America.

In addition to *Sold!*, more research needs to conducted on creating educational games with a broad cultural appeal. This involves analyzing the game features, content, and hardware specifications that need to be considered when designing games for a diverse audience.

To facilitate the future work, the development team also needs to consider a variation on the agile process that more prominently emphasizes user modeling and frequent feedback with end users. The application of continuous design in an agile fashion is useful for micro-elements of the game, but at the expense of user-centered design activities before implementation. This resulted in significant failures to identify assumptions and bias in the user population before detailed design. An integration of user-centered design methods, such as persona development, with continuous low-level design adjustments by obtaining end user feedback on a continuous (or at least per sprint) basis should mitigate the risks that led to design failures on this project [27].

The proposed framework incorporates the use of persona development and player-centered design into the Scrum workflow as shown in Fig. 7. During the requirements planning phase, the development team along with the product owner, identifies personas that represent the game's end users. Incorporation of personas keeps the development team focused on the end user when real end user input is not feasible. These personas are giving a name and photo, along with their relevant motivations and abilities, in order to promote realism [28]. Application of personas helps promote inclusive design by keeping the needs of the end users at the forefront of design decisions.

In accordance with universal design principals, personas are selected that represent the average users and the edge case users. Average and edge case users could be identified by different characteristics and abilities, and should represent the diverse target demographic. For *Sold!*, the average persona would represent an adult female that is familiar with technology but less gaming experience. Our edge cases would be an adult female with less technical knowledge and no gaming experience, and an adult female who is an avid gamer.

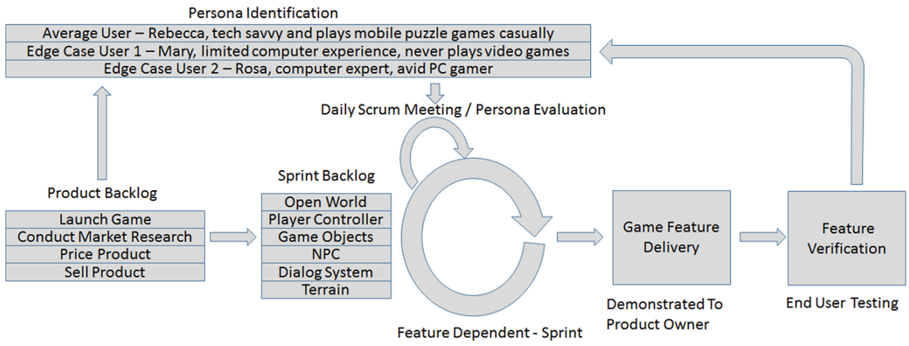

Fig. 7. The agile development cycle recommended for future use

In addition to incorporating persona development, end user testing should be implemented. End user testing should occur with the completion of each game feature. This will give the development team the opportunity to observe end users interacting with the game features, and analyze feedback frequently in during development [29]. Based on this feedback, the development team can determine and address necessary revisions more efficiently than if user testing is only conducted after development is complete.

As part of the iterative process, the development team evaluates the progress of a feature based on the identified personas. Evaluation based on personas should be constant throughout the development cycle and occur as part of the daily Scrum meeting. End user testing is implemented as the final stage of the sprint. After the user testing, the personas should be reevaluated to ensure they accurately depict users.

8 Conclusion

The *Sold!* project was intended to be an exercise in inclusive design, but was limited due to the incorporation of a predefined set of assumptions. Of these, only two were shown to be correct. A strong story line helped players relate to the in game player character and players preferred puzzle based mechanics to other types of gameplay. At the same time, we found that it was wrong to assume that our target audience would have even basic knowledge of how to control a game of this type. Control schemes that seemed very intuitive to us were unclear and confusing to our play testers. To prevent such problems from occurring in other projects, we proposed a new version of the agile development cycle emphasizing end user involvement. Because it is often not feasible to have constant end user testing, we also propose the development cycle should include persona based evaluation as part of the iterative cycle to ensure end users remain the focus of design choices throughout the process. Considering the end users' needs and preferences throughout the process, along with incorporating frequent feedback from the end users themselves when possible, will help developers create games that provide an inclusive experience.

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A Propriety Game-Based Learning Game as Learning Tool to Learn Object-Oriented Programming Paradigm

Yoke Seng Wong[1(✉)], Mohamad Yatim Maizatul Hayati[2], and Wee Hoe Tan[2]

[1] KDU University College, Utropolis Glenmarie Campus, Selangor, Malaysia
yswong217@gmail.com

[2] Sultan Idris Education University, Tanjong Malim, Perak, Malaysia
{maizatul,whtan}@fskik.upsi.edu.my

Abstract. Understanding the significant of object-oriented programming, a propriety game-based learning game has been designed and develops as a learning tool to improve the student understanding toward object-oriented programming and self-motivation to learn. The proposed game is a simple role-playing game named ZTECH that motivates users to learn Object-Oriented programming in an easy and interaction environment. Players will play along the flow of each game quests and they will learn and pick up the object-oriented programming paradigm easily. Thus, this paper is a case study of an academic who worked with game designers, game developer to design and develop a propriety game-based learning game for learning object-oriented programming.

Keywords: Game-based learning · Propriety game · Learning programming · Object-oriented programming

1 Introduction

Object-oriented programming is a required fundamental skillset for all computer science or ICT students [1]. However, teaching object-oriented programming to undergraduate year one students is challenging and academics need to use different approached to find suitable methods to enhance student understanding, self-interest and self-experimentation. This is because most of the Malaysia student without object-oriented programming concept prior enrolls to any programming courses [2]. The proposed game is a simple role-playing game named ZTECH that motivates users to learn Object-Oriented programming in an easy and interaction environment. Players will play along the flow of each game quests and they will learn and pick up the object-oriented programming paradigm easily. A group of 60 students in the first year of Bachelor of Game Development at KDU University College were offered to test out the game. The result obtained from the respondents show that more than 65 % of the student agreed the proposed game to be interactive learning tool to help them better understand the object-oriented programming paradigm. Thus the invention of this role-playing game is for those novice or beginner learners to learn object-oriented programming is necessary.

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The classroom based learning and teaching methods are insufficient to support the learners or students especially learning programming related subject [2]. A game-based learning approach could be an efficient way for the students to learn object-oriented programming. Mainly because the empirical evidence that validates computer games are efficient tools for learning object-oriented programming is still absent from the literature [3]. Thus the objective of this paper is to discuss about the development of a propriety game-based learning game to learn object-oriented programming paradigm. In the proposed game, several relevant theories such as cognitive apprenticeship [4], self-determination theory [5], flow theory [6], ARCS theory of motivation[8], distributed practice [8], episodic memory [9], operant conditioning [10] and the taxonomy of intrinsic motivations for learning [11] are included to ensure the entire learning process is motivating and easy to learn.

2 Related Work

Compared with other game for learning programming such as Alice 2D [12], Greenfoot [13], Darwin [14] and, CodeCombat [15], the proposed game focus on the game play and game mechanic to carry out the learning objective (no coding exercise type of game play needed). Player actually learning the object-oriented programming paradigm which without learning what he or she is intended to learn. Most of the existing games for learning programming are required coding practice type of game mechanics. For example, CodeCombat [16] required player to use script languages such as javascript, Lua, phyton as in order to progress through a small story or compete against other players. Alice is a 3-dimensional interactive animation program visualization environment. Novice programmer builds animated 3-D movies and authors' games at they learn introductory OOP concepts. The new version of Alice, Alice 3 will enable the typing of Java code to build Alice world [17]. Another example, Greenfoot [18] is an educational development environment highly specialized for the development of interactive, graphical application, it is based on Java programming. The use of text-based programming based on Java makes very sophisticated applications possible, matching students high expectations and prepare them for progression to more general programming environment [19]. Besides that, another example Darwin, is a game that features artificial intelligence creatures competing to either control a map or be the first to complete a task and it teaches programming by creating creature in java. Most of the programming game mentioned are required coding exercise, thus it is necessary to develop a propriety game-based learning games to learn Object-oriented programming.

3 Development of ZTECH

ZTECH is a propriety game-based learning game that motivates users to learn Object-Oriented programming in an easy and interaction environment. Players will play along the flow of the program step-by-step and they will learn to grow their characters (ZTECH). To enhance the learning process, this game possesses an attractive storyline, pleasant game environment, nice and suitable sound effects, elegant character design and appealing animations. When the game starts, the main character will have the navigation system that allows it to travel around the game world, the game world is divided to 3 environments. In order to become stronger and more powerful, it has to fight with enemies who are the terrorists. By defecting those enemies, player able to gain experience and gold. The purpose of the experience is for the level in order to gain more attack skill, while the use of money is for trading purpose with the in game trading shop. Some NPCs will help the character by providing it with some missions and some of them are the guidance for the player which delivering the learning content to the player. Moreover, when the character finished the mission, it can earn rewards, either increasing experience or improving current abilities by obtaining new equipment. As the player are having fun with the game, they are actually learning the object-oriented knowledge. Besides that, ZTECH is a stand-alone game in which each player will play and learn in his or her own application. This is because saving function is provided with 5 saving slots. The game guides player to understand the concept of object-oriented. The gaming part aims to increase and foster users' interest to learn the knowledge. The game provides users with all the basic object-oriented concepts like encapsulation, inheritance and polymorphism. In addition, the game includes some basic programming concepts which could improve users' understanding. Ten mini puzzle games are featured with basic programming knowledge through 8 quests in the game. With these features, ZTECH could be a catalyst to smoothen the path of learning object-oriented.

3.1 Game Level Design

This game consists of 8 quests for the main character. First, the basic knowledge of object-oriented approach is introduced to players. They should pass through the first level after going through the objects and classes test (Fig. 1). In level two, players are guided to learn about the control statement like if…else and switch… case as well as the structure of the method declaration (refer to appendix for other levels). In the third level, the players are led to learn about the array and three types of looping statements. Quests are assigned to the players to ensure they comprehend the concepts behind the

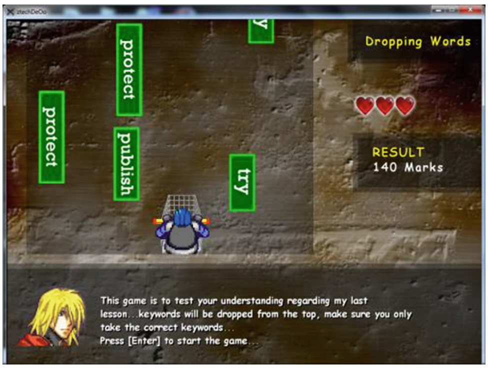

Fig. 1. Quest 1

knowledge. By completing the quest, players can proceed to the next level. In the fourth level, players start to learn about the main principle of object-oriented. They are exposed to the concept of encapsulation and inheritance. Examples are provided to bolster their understanding. At last level, the game guides the players to learn about polymorphism principle. The game ends when players defeat the boss, called Virus. From time to time, players are rewarded for their learning enthusiasm, in which they are encouraged to continue to learn new knowledge and skills.

3.2 ZTECH with Constructive Alignment

In order to ensure the learning outcome can be achieved via the gameplay and in game mechanic, it is necessary to align the learning outcome and in game mechanic appropriately. The alignment of learning content with game-based learning approach can be achieved by adapting Biggs' constructive alignment. There are two major ideas from constructive alignment, as shown below:

- how to get students engage in learning activities that are likely to enable them to attain intended outcomes
- how to set up a learning environment that supports the learning activities

In game-based learning perspective, the player is engaged in the game world, and searching it difficult to escape without learning what he or she is intended to learn. According to Prensky, in order to achieve constructive alignment the intended learning outcome (observable behavior, degree of attainment and conditions of attainment) should be aligned to structural elements (rule, goal and feedback) of games proposed. Tables below are showing constructive alignment of intended Learning Outcome and game elements of the proposed game.

Quest 1	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Identify and remember …	Condition of attainment: … all basic object-oriented programming keywords …	Degree of Attainment … to collect required number of programming keywords
Setting elements of game	Goal: Collecting the right programming keyword	Rules of play: … by collecting the right programming keywords, e.g. moving to the left and right; collect the required number of programming keywords	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. moving avatar to right and left direction 2. to collect the right programming keyword		Victory debriefing: Collecting the required number of programming keywords can be achieved based on the speed of the

(*Continued*)

(*Continued*)

Quest 1	Outcome of extraction and alignment	
	3. avoid incorrect keyword, if collect the wrong keyword, game end 4. player need to obtain 400 score	player and the ability of recognition of the player.

4 Result and Discussion

A group of 60 students in the first year of Bachelor of Game Development (total of 3 batches) of KDU University College were offered to evaluate the proposed game. There are required to play the proposed game in computer laboratory with given time frame. Upon completing the game, they are required response to a survey, which consists of 15 questions. The first 3 questions are asking about the student personal detail and programming experience. Following 5 questions is asking about the overall game story, game play and game mechanic. The last 7 questions are collecting respondent perception toward game-based learning approach as an interactive tool for learning object-oriented programming.

The questionnaire collected from the students is analyzed and the results showed overall average of students who strongly agreed with the ZTECH being efficient is 65 %. This percentage is quite high as most of the students are engaged and excited with the game. The average for students who are not sure is just 15 %, while 11 % disagree and only 9 % strongly disagree. This clearly shows that the majority of students are satisfied with the game developed and agreed that ZTECH could help them to understand Object-Oriented Programming paradigm efficiently. Most of the students agreed that the computer game is able to meet the learning and teaching objectives. All of them agreed that game based learning is an effective tool for learning and teaching object oriented programming because 15 out of 60 participated students obtained grade A in the Object Oriented Programming module that offered in year 1 semester 3.

The proposed research identified an educational game (ZTECH), which covered the object-oriented programming paradigm. This was to motivate student learning by making the learning experience fun and attractive. Based on the findings, it indicated that games-based learning is a useful learning strategy for before subject is taught and after subject has been taught. The game-based learning experiment showed that students could be actively engaged in applying object-oriented programming paradigm with defined game mechanics. The proposed study has demonstrated the effectiveness of using game-based learning as a teaching and learning tool. Participated students felt confident to learn object-oriented programming paradigm more efficient. With inclusion of gaming mechanic with traditional teaching practices in object-oriented programming will bring about more interactive learning. This will be beneficial for students because games-based learning could enable students to learn programming related topics efficiently in a more enjoyable and fun learning environment. This research add-on to teaching and learning pedagogies and could lead to further research in designing of other programming related subject, where learning outcomes of different subject modules could be mapped to related gaming mechanics from basic to advanced levels.

5 Conclusion

The main challenges in the gamification of ZTECH is make the learning implicitly while keeping the game fun. One possible approach to overcome this challenges is to keep players' motivations and mental state in the flow of channel, in which the learning content, challenges and the gameplay should be balanced. Programming syntax should replace with pseudocode to afford beginner players to comprehend the object-oriented programming concept while enjoying the game. As a case study presented in the paper could be used as analytic tool to determine the efficiency and effectiveness of game-based learning. For example, with the adaption of Biggs' constructive alignment, all the motivation and learning theories that applied and the data collected from the players have proven the game-based learning can be one of the efficient way of learning object-oriented programming.

Appendix

Quest 2

Quest 2	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Understand and analyze the control structure …	Condition of attainment: … that include if statement, switch case …	Degree of Attainment: … to understand all the control structure algorithms
Setting elements of game	Goal: Escape from the jungle	Rules of play: … by escaping from the jungle, e.g. moving to the right direction; get score	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning	Intended observable behavior that abide rules of play:		Victory debriefing:

(*Continued*)

(*Continued*)

Quest 2	Outcome of extraction and alignment	
Outcome components & game elements	1. obtain and analyzing the given question 2. moving the avatar to the direction with right answer 3. moving the avatar to direction with wrong answer will result to game end and need to obtain 200 score	Escaping from the jungle successfully can be achieved based on the ability of the player answer the question about all control structure algorithms

Quest 3

Quest 3	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Understanding looping…	Condition of attainment: … that consists of do loop, do. while loop and for loop …	Degree of Attainment: … to understand all looping algorithms
Setting elements of game	Goal: Avoid the flying meteor, and shoot on the block (with D, W, F)	Rules of play: … to trigger the question and select the right answer e.g. avoid meteor, shoot the W, F, D dropping block; achieved required score	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. moving around in the game world 2. avoiding the flying meteor 3. shooting the flying block with the word of W, D and F (W for while loop, D for Do.. while and F for for loop)		Victory debriefing: Obtaining 2000 score by answering the question that trigger by shooting the flying block can be achieved based on the player understanding of looping algorithms

(*Continued*)

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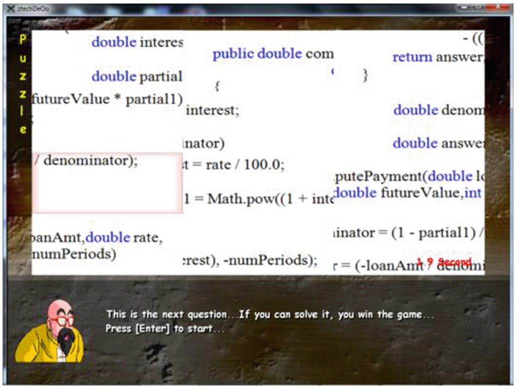
Quest 3	Outcome of extraction and alignment	
	4. upon shoot the block successfully, question will be display and player need to answer the question 5. player need to obtain 2000 score to complete this quest	

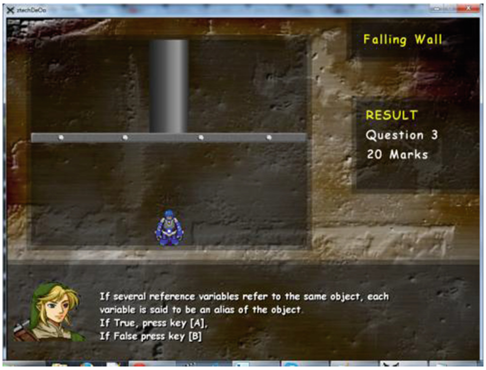


Quest 4

Quest 4	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Understand and recognize the functions …	Condition of attainment: … that consists of function declaration, function heard and function body	Degree of Attainment: … to form a proper function
Setting elements of game	Goal: Arrange the puzzle to the right position	Rules of play: … by completing the puzzle, e.g. moving the puzzle, time pressure	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. analyzing the given puzzle (2 puzzle need to be solve) 2. 5 s will be given for the player to analyzing the puzzle 3. moving the puzzle by pressing arrow keys from keyboard 4. solving the puzzles within the given time		Victory debriefing: Solving both puzzles within the time given can be achieved based on the player ability of recognition and understating of function declaration

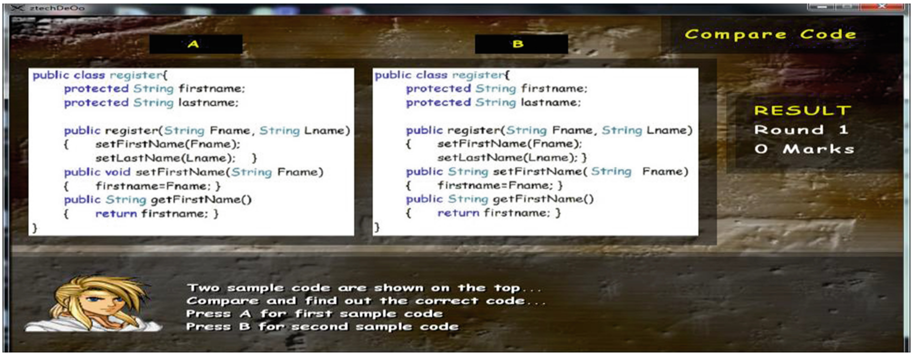
Quest 5

Quest 5	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Understand and evaluate array…	Condition of attainment: … in term of single dimensional in integer data type and string data type	Degree of Attainment: … to arrange the right answer in right location
Setting elements of game	Goal: Arrange the answer to the right statement within the time frame given	Rules of play: … by overcoming challenges, e.g. select and moving the answer to the right statement; time pressure	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. analyzing the given array 2. evaluate each array statement 3. arrange the right answer to the right statement 4. player required to use the arrow key from keyboard 5. completed the answer arrangement to all statement within the time limit		Victory debriefing: Arrange the right answer to the right statement within the time frame given can be achieved based on the player ability and the understanding about array



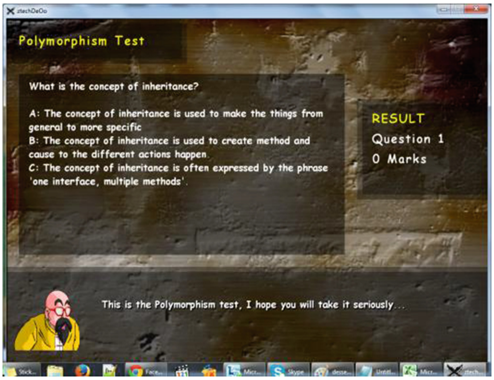
Quest 6

Quest 6	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Understanding the concept of object and classes…	Condition of attainment: … by analyzing the question and answer…	Degree of Attainment: … to obtain 200 score
Setting elements of game	Goal: Maintain the bar and avoiding the bar dropping down…	Rules of play: .. by selecting the right answer for the question given, e.g. select the right answer to ensure the bar not dropping down; when the bar collide with the player then game over	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. observe the moving of the bar 2. obtain and analyzing the question 3. select the right answer 4. if select wrong answer, the bar will drop down one level 5. when the bar drop until the level which collide with the player, game end		Victory debriefing: Score of 200 can achieved based n the player ability to select the right answer and the understanding about class and object by selecting the right answer



Quest 7

Quest 7	Outcome of extraction and alignment		
Extracting components of Learning Outcome	Observable behavior: Compare and find the right inheritance code snippets …	Condition of attainment: … the inheritance syntax code snippet …	Degree of Attainment: … to obtain 100 score
Setting elements of game	Goal: Answer correctly for all 10 questions	Rules of play: … by selecting all the answer correctly, e.g. comparing the code snippet given; achiever required score	Feedback: Victory – show debrief that explains attainment Mission fail – try again
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. obtained the question 2. analysis the inheritance code snippet given 3. select the answer by pressing A or B from keyboard		Victory debriefing: Score of 100 can be achieved based on your understanding and ability about inheritance by answering correctly



Quest 8

Quest 8	Outcome of extraction and alignment		
Extracting components of LO	Observable behavior: Identify the right answer about polymorphism topics…	Condition of attainment: … from the answer given for the questions about polymorphism	Degree of Attainment: … to obtain 100 score
Setting elements of game	Goal: Select right answer from the option given	Rules of play: .. by selecting the answer correctly, e.g. analyzing the answer option; achiever required score	Feedback: Victory – show debrief that explains attainment Mission fail – try
Alignment of Learning Outcome components & game elements	Intended observable behavior that abide rules of play: 1. obtained the question 2. analyzing and understanding the polymorphism question 3. select the answer from the option (A, B, C), by pressing A, B and C from keyboard		Victory debriefing: Score of 100 can achieve based on the player understanding and ability about polymorphism by selecting the right answer

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Creating Authentic Experiences Within a Serious Game Context: Evaluation of Engagement and Learning

Joshua Hall(✉), Peta Wyeth, and Daniel Johnson

Queensland University of Technology, Brisbane, QLD, Australia
joshua.v.hall@gmail.com, {peta.wyeth,dm.johnson}@qut.edu.au

Abstract. The potential of serious games is in their ability to facilitate engaging learning experiences for the user. This paper describes a serious game that has been designed using a framework that aligns instructional objectives with core-gameplay. Catastrophe, the Occupational Health and Safety game developed for this project, has been evaluated to determine the extent to which it promotes both engagement and learning. In comparison to e-Learning methods, the game produces significantly better learning outcomes and significantly higher levels of intrinsic motivation. The quantitative and qualitative results of this study are reported and discussed.

Keywords: Game design · Core-gameplay · Evaluation · Engagement · Serious games

1 Introduction

The potential and usefulness of serious games for training and assessment purposes is leading to growing demand for their use and development. The potential stems from the players feelings of engagement while interacting with the playful learning activity. The usefulness can be demonstrated by the evidence suggesting serious games can be an effective learning activity [3]. However, there remain ongoing challenges in designing serious games that achieve a balance between producing player engagement and meeting learning outcomes [18]. Systematic support for the effective design of games to facilitate such learning is only beginning to emerge.

Our previous research has involved the development of a serious core-gameplay framework that guides the development of core-gameplay mechanics within serious games through an alignment of these mechanics with instructional objectives. The framework is designed to produce authentic learning experiences through design steps that consider the quality of the learning in terms of performance, conditions and criteria [8]. Authentic learning experiences can be described as learning activities that focus on real world problems and their solutions, using role-playing exercises, problem-based activities and/or case studies [11]. Learning objectives are framed around these authentic experiences and then mapped to a game environment. This paper investigates the engagement and learning effectiveness of a serious game titled "Catastrophe". The aim of the research is to understand the extent to which this serious game is more effective than an alternate e-Learning method (i.e. an audio-visual presentation). The motivations

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behind this evaluation are twofold. There was a desire to understand if Catastrophe delivered an engaging learning experience. Through evaluating the game we also aimed to gain some understanding of the value and applicability of the serious core-gameplay framework that was used to design the game [8]. The use of this tool ensured the design of Catastrophe carefully considered the process of mapping instructional objectives to the core-gameplay to achieve positive learning and motivational outcomes. To demonstrate the effectiveness of Catastrophe, a between-groups experiment was conducted to evaluate the learning and engagement outcomes. Catastrophe was based on the topic of Occupational Health and Safety (OH&S) and focuses on teaching the user about OH&S concepts such as potential hazards in the office and how individuals should respond to them if found. This paper first discusses some of the background literature in the field of motivation and OH&S training. The study design is then discussed, outlining how and why methods were used. The quantitative and qualitative results of this study are reported. Following this report, a discussion of these results highlights the implications for the observed outcomes of the game, the value of the framework as a design tool, digital training activities and implications for the wider serious games community. The results of the study contribute to evidence that serious games have the potential to engage users, and be useful in facilitating a learning experience. The results of this work also highlight the value of the design tool that was used to develop Catastrophe.

2 OH&S Training

The benefits and need for OH&S training leading to a reduction in both injuries and associated costs [4] is relatively well known and accepted. In particular Slips, Trips, and Falls are some of the most common injuries sustained in workplaces and are a common topic in OH&S training [19]. Slip, trips and falls are often the result of hazards in the workplace such as contaminants, floor surfaces, cleaning, obstacles, environment lighting, human activity and incorrect footwear [19]. Managing these risks often involves the simple processes of identifying hazards, assessing the risks, understanding and applying control measures, as well as monitoring, and reviewing those control measures. Research has shown different training activities aimed at improving knowledge and awareness can reduce the number of injuries in the workplace [2]. When employees are well trained in recognising hazards, safety precautions, rules and procedures, their safety performance improves [5, 9, 19]. Obvious forms of role-play and real life scenarios can be implemented to enhance the training experience, however, issues arise regarding certain safety challenges involved in re-creating hazards and human resource costs involved in face-to-face training. Serious games and simulations have been used in the past to help fill this gap and provide alternate and complementary training and assessment tools [22]. The use and effectiveness of serious games and simulations for OH&S training has been investigated in the past [1, 6, 9, 10, 13]. However, to date, little empirical evidence exists that serious game-based training produces engaging and effective learning experiences. The study reported in this paper aims to contribute to games, education and OH&S research fields by conducting a rigorous evaluation of the learning and engagement outcomes of an OH&S serious game.

3 OH&S Serious Game: Catastrophe

The serious game prototype being investigated in this study ("Catastrophe") has been designed using a process (Serious Core-Gameplay Cycle) that guides the mapping of instructional objectives to core-gameplay [7]. The outcome from using this process is a serious game that can facilitate an engaging learning experience for the player due to the tight coupling of instructional objectives and core-gameplay. The way in which our framework enables the mapping of instructional objectives to core-gameplay has been outlined in a previous publication [8].

In summary, the Serious Core-Gameplay Cycle (see Fig. 1) works on the basis that players will face many core-gameplay cycles scaffolded in difficulty and content during a game experience. Within a core-gameplay loop, the player is presented with a Goal designed with learning objectives in mind. Meaningful Choices are designed to be acted upon in order to progress towards their objective. Based on previous knowledge and skill, the player determines the correct Action to take and performs it (actions should be playful, yet intuitive and functional). The cycles Rules to evaluate user actions are designed to support the educational objectives and assessment criteria. The evaluated result is sent back to the player as playful and engaging Feedback. The player potentially learns to adjust any further decisions made when presented with similar choices. The design of these qualities will determine if the player can utilise this new knowledge beyond the game-based situation.

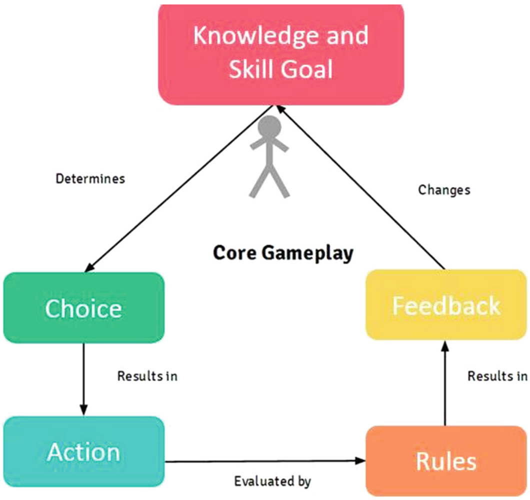

Fig. 1. Serious Core-Gameplay Cycle.

Catastrophe (see Fig. 2) is a top down crisis management game where the player manipulates the environment to keep non-player characters (NPCs) safe. Whilst game goals and concise safety information is delivered to the player via image and text, the learning activity is primarily focused on enabling the player to make interesting decisions, interact with the content and receive real-time feedback i.e. prevent injuries from occurring by making choices while they interact with the hazards e.g. deciding which control measure to apply to a hazard before an accident occurs. The results of these choices are feedback to the player via positive/negative in-game events e.g. (audio-visual effect, change in game score, NPC injuries).

Fig. 2. Catastrophe - Game Learning Condition.

4 Study Method

4.1 Aims

The aim of this study is to evaluate the effectiveness of the serious game "Catastrophe". The evaluation involved comparing the engagement and learning outcomes of those who played the serious game and those who interacted with an audio-visual presentation. Intrinsic motivation and engagement outcomes are measured by examining participants' responses to a motivation and engagement survey. Knowledge and understanding is measured by examining participant's responses to a Slip and Trip Hazards Assessment. This assessment investigates an individual's knowledge of potential hazards, as well as an understanding of how to apply control measures to hazards in an office environment. The measurement of these learning outcomes demonstrates the extent to which the serious game facilitates experiences that meet the instructional objectives. A secondary aim of this study is examine the value of framework for effectively mapping instructional objectives to core-gameplay. The results of the study will aid in understanding if there are engagement and learning benefits from taking this design approach.

Four hypotheses have been proposed that explore the primary aims of evaluating engagement and learning. The hypotheses for this study are:

- H1: Playing a game about hazards in the workplace will be more intrinsically motivating than an audio-visual video about the same topic.
- H2: Playing a game about hazards in the workplace will be more engaging than an audio-visual video about the same topic.

- H3: Playing a game about hazards in the workplace will result in greater recollection of hazards in the workplace than an audio-visual video about the same topic.
- H4: Playing a game about Hazards in the Workplace will result in greater understanding of hazard control measures than an audio-visual presentation about the same topic.

4.2 Study Design

This study uses a between-subjects experimental design to determine if there is a difference in learning and motivation outcomes between individuals who interacted with the serious game (Game Learning), an audio-visual instructional method (Video Learning) and an activity where no learning is expected to occur (Video Unrelated Topic). The four outcomes assessed were intrinsic motivation, engagement, potential hazard knowledge and hierarchy of controls understanding. Fifty-five people over the age of 18 were recruited from the university population and local area to participate in the study. Participants were a wide array of office-based workers from the area, non-academic and academic staff of the university, as well as some students. Participants were randomly split between the three conditions (Video Learning Condition (n = 18), Game Learning Condition (n = 18), and Video Unrelated Topic Conditions (n = 19)).

<u>Video Learning Condition:</u> The purpose of the Video Learning Condition is to help determine if the game-learning condition is different to a standard e-Learning OH&S method such as audio-visual presentation. The six-minute video (image, text audio) covered information on how to apply good risk management behaviour in the office to avoid hazards such as slips, trips and falls. This video was directly based on the existing university Health and Safety induction e-learning module, which all staff and postgraduate research students must watch annually. The e-learning module was primarily an image and text slideshow with optional audio narration. Only information that directly related to the following topics was included.

- Hazards in the workplace
- Risk management
- Slips, Trips and Falls
- Housekeeping
- Hierarchy of controls

<u>Game Learning Condition:</u> The purpose of the Game Learning Condition is to act as the primary intervention used to compare e-Learning forms of training such as audio-visual presentation and consisted of 10–15 min of gameplay. The first five minutes of gameplay involve the participant learning the controls of the game. Following this, five minutes of gameplay is directly related to presenting the learning content covered in the audio-visual learning condition. The final five minutes allows the users to play with the simulated environment free from assistance and learning material. The game consists of the following levels: (**Level 1:** Tutorial – learning the controls and rules, **Level 2:** Hazards in the workplace – instructional material mirrored with the video learning condition mixed with gameplay, **Level 3:** Office environment simulation – gameplay).

Video Unrelated Topic Condition: The purpose of the Video Unrelated Topic Condition is to act as a control activity and consisted of an 8 min 30 s (image, text, audio) video covering how to fight hazards in the workplace such as fires. This video was directly based on the existing university General Evacuation Instruction e-learning module that all university staff and postgraduate research students must watch annually. The e-learning module was in the same presentation format to the video learning condition. Only information directly related to the following topics was included.

- Fire blankets
- Fire hose reels
- Fire extinguishers
- Types of fires
- Portable fire extinguisher guide

Motivation Outcomes: Motivation and Engagement Survey. The Intrinsic Motivation Inventory (IMI) was found to be the most suitable instrument to measure the motivation outcomes in the study [15]. The IMI is a multidimensional 7-point Likert scale intended to assess a participant's intrinsic motivation related to an activity [12] and has been used previously within an educational games research context [16]. The IMI Interest/Enjoyment subscale was selected as it directly measures interest and enjoyment during the activity [14]. Three additional 7-point likert scale questions were also constructed to directly measure a participant's level of engagement e.g. "I felt this activity was engaging", "I found this activity interesting."

Learning Outcomes: Slip and Trip Hazards Assessment. Learning outcomes were evaluated using a custom made Slip and Trip Hazards Assessment. This assessment consisted of a Potential Hazard Knowledge component, and Hierarchy of Controls Understanding component each of which related in a score.

Potential Hazard Knowledge: The purpose of the Potential Hazard Knowledge component is to measure an individual's ability to recall potential hazards that could be found in an office environment. Demonstrating knowledge of what could potentially be a hazard can lead to safety accidents being more predictable and avoidable [17] e.g. "List up to eight different hazards that could cause trip related injuries in an office environment".

Hierarchy of Controls Understanding: The purpose of the Hierarchy of Controls Understanding component is to measure an individual's understanding of hazard control measure used within an office environment. Image-based scenarios of hazards in an office environment were used to elict a short answer response of how they should respond to a hazard scenario. An example "Understanding" response of a Hierarchy of Control would be to "Isolate" a workplace hazard e.g. (liquid spill) using a barrier or signage.

Procedure. Total time for the study was approximately 40–50 min. Participants filled out a demographic survey and then were directed to one of the study conditions: video learning, game or video unrelated topic. Participants then completed the motivation and engagement survey and the online assessment. Upon completion of the online assessment, the participant was invited to discuss experiences in a semi-structured interview. The interview questions were based on the motivation and engagement survey questions used in this study.

5 Results

5.1 Motivation and Engagement Survey Analysis

Intrinsic Motivation and Engagement mean scores were normally distributed for all groups. Homogeneity of variance for the Intrinsic Motivation mean score was not equal for all groups $F(2,52) = 3.64$, $p < .05$. There was however homogeneity of variances for Engagement mean scores $F(2,52) = 1.83$, $p = ns$. As some of the data violated the assumption of homogeneity of variance it was decided to run a non-parametric test (Kruskal-Wallis H Test) to determine if the Intrinsic Motivation and Engagement results were significantly different from one another. Intrinsic Motivation mean scores were statistically significantly different between the intervention groups $H(2) = 33.960$, $p < .001$. Engagement mean scores were statistically significantly different between the intervention groups $H(2) = 31.771$, $p < .001$. Subsequently, Mann-Witney U post hoc tests were conducted in order to identify differences between groups. A Bonferroni correction was employed for all post-hoc Mann-Whitney U tests. Consequently, all follow-up results are reported with a .0083 level of significance. Values are median unless otherwise stated. This post-hoc analysis revealed the following results.

Intrinsic Motivation: There was a significant difference in Intrinsic Motivation mean rank scores with participants in the Game condition ($Mdn = 5.64$) reporting higher intrinsic motivation then participants in the Video Learning Condition ($Mdn = 2.78$), $U = 6.50$, $z = -4.92$, $p < .001$, $r = -.82$. There was a significant difference in Intrinsic Motivation mean rank scores with participants in the Game condition ($Mdn = 5.64$) reporting higher intrinsic motivation then participants in the Video Unrelated Topic Condition ($Mdn = 2.57$), $U = 2.00$, $z = -5.13$, $p < .001$, $r = -.84$. There was no significant difference in Intrinsic Motivation median scores between the Video Learning and Video Unrelated Topic Condition ($p = ns$).

The qualitative data collected complements these results as they provided insight into participants feelings of intrinsic motivation, i.e. interest and enjoyment during the activities. Participants who were in the game condition commented that gameplay and interactivity contributed to their feelings of interest during the activity e.g. “Yeah I like it, I thought it was fun. The game part of it particularly” (P3), “being able to interact with it did make me more interested in it than just watching a video” (P2). Participants who were in the video conditions commented that lack of interactivity and feedback were reasons why their interest and enjoyment was low e.g. “… because it is not interactive …” (P52, “… would have liked some kind of interaction” (P22), “there wasn’t any feedback, like I didn’t need to answer any questions or do anything” (P24).

Engagement: There was a significant difference in Engagement mean rank scores with participants in the Game condition ($Mdn = 6.00$) reporting higher engagement then participants in the Video Learning Condition ($Mdn = 2.16$), $U = 13.00$, $z = -4.72$, $p < .001$,

$r = -.78$. There was a significant difference in Engagement mean rank scores with participants in the Game condition (Mdn = 6.00) reporting higher engagement then participants in the Video Learning Condition (Mdn = 2.33), $U = 6.50$, $z = -5.01$, $p < .001$, $r = -.82$. There was no significant difference in Engagement mean rank scores between the Video Learning and Video Unrelated Topic Condition (p = ns).

The qualitative data collected complements these results as they provided insight into participants' feelings of engagement i.e. an engaging and involving activity. Participants who were in the game condition commented that they not only found it engaging but that they would wish to engage in the activity again in the future e.g. "It was fun I think it was useful. Very engaging for me and I would be doing it again if I have a chance" (P19). Participant comments also provided insight into how users felt about the video activities e.g. I did not want to interact with it, yeah was not engaging (P35). I wasn't involved in the activity, it wasn't engaging … (P22). Some participants in the video conditions felt the need to highlight the activities value rather than comment on their feelings of interest or engagement "I enjoy the information, but it could in a better or more involving or engaging way" (P30).

Hazard Knowledge and Understanding Analysis. The Potential Hazard Knowledge mean scores for the Game Condition group was not normally distributed as assessed by a Kolmogorov-Smirnov test of normality $D(18) = .434$, $p < .05$. All other groups for this variable were normally distributed. The Hierarchy of Controls Understanding mean scores were normally distributed for all groups. Homogeneity of Variance for the Potential Hazard Knowledge mean score was not equal for all groups $F(2,51) = 4.481$, $p < .05$. There was homogeneity of variances for Hierarchy of Controls Understanding mean scores $F(2,51) = 2.361$, p = ns. As some of the Potential Hazard Knowledge score data violated the assumption of normality and homogeneity of variance it was decided to run a non-parametric test (Kruskal-Wallis H Test) to determine if the Potential Hazard Knowledge were significant. As the Hierarchy of Controls Understanding data didn't fail any of the statistical assumption tests a one-way ANOVA was used to determine if there were significant differences between the condition groups.

<u>Potential Hazard Knowledge Results</u>: Potential Hazard Knowledge scores were statistically significantly different between the intervention groups $H(2) = 26.08$, $p < .001$. Subsequently, Mann-Witney U post hoc tests were conducted in order to identify differences between groups. A Bonferroni correction was employed for all post-hoc Mann-Whitney U tests. Thus, all follow up results are reported with a .0083 level of significance. Values are median unless otherwise stated. This post-hoc analysis revealed the following results:

There was a significant difference in Potential Hazard Knowledge mean rank scores with participants in the Game condition (Mdn = 100) reporting Potential Hazard Knowledge then participants in the Video Learning Condition (Mdn = 75), $U = 49.00$, $z = -3.76$, $p < .001$, $r = -.62$. There was a significant difference in Potential Hazard Knowledge mean rank scores with participants in the Game condition (Mdn = 100) reporting Potential Hazard Knowledge then participants in the Video Unrelated Topic Condition (Mdn = 62.50), $U = 13.50$, $z = -4.84$, $p = .001$, $r = -.80$. There was no significant difference in Potential Hazard Knowledge mean rank scores between the Video Learning and Video Unrelated Topic mean rank scores (p = .ns).

The qualitative data collected complements these results as they provided insight into participants' thoughts on what they had learned from the activities. Participants who were in the game condition commented that the game allowed users to recollect more specific potential hazards e.g. "… all the little details of specific hazards and a the way they were dealt with in the game was … unique and different to stuff I had learned before" (P3). Participant comments also provided insight into how users felt about the video activities. Participants who watched the video also felt they gained something from the experience e.g. "Basic awareness. Awareness of what type of things. Basic categories of hazards types … treatment of hazards" (P21), "Yes I learned the basic message but I would have learned more if I was more engaged" (P22).

Hierarchy of Control Understanding Results: A one-way ANOVA was conducted to determine if there was a significant difference in Hierarchy of Control Understanding mean scores between the different groups. Data is presented as mean and standard deviation. Hierarchy of Control Understanding scores were significantly different between different intervention conditions, $F(2,51) = 13.508$, $p < .001$, $n2 = 0.346$. Bonferroni post hoc analysis revealed that the mean increase from Video Learning Condition to Game Condition (12.25, 95 % CI [1.25, 23.26]) was statistically significant ($p < .05$), as well as the increase from Video Unrelated Topic Condition to Game Condition (23.10, 95 % CI [12.09, 34.10], $p < .001$). There was no significant increase between Video Unrelated Topic Condition and Video Learning Conditions (p = .ns).

The qualitative data collected complements these results as they provided insight into participants' thoughts on what they had learned from the activities in regards to the hierarchy of controls and awareness of hazards. Participants who were in the game condition commented that the activity did facilitate an understanding of applying hierarchy of controls e.g. in reference to applying substitution control measures learned in the game "… I have a carpet myself at home and it is curved so that's why I think it could apply that to my home as well" (P10), "I thought about things I haven't really thought about before … engineer the stairs to make them a bit more visible" (P18). A few participants from all groups commented that they were already knowledgeable about OH&S, but saw value in being refreshed and becoming more aware e.g. "yeah maybe a little, refreshed I guess" (P4). "not much because I have done similar activities before … there wasn't any new knowledge presented … it's good to get a refresher on it from time to time" (P28).

6 Discussion

The findings with respect to intrinsic motivation and engagement support Hypothesis 1 and 2, demonstrating that playing a game about hazards in the workplace is significantly more intrinsically motivating and engaging than an audio-visual video about the same topic. Gameplay and interactivity were common reasons why users were interested and enjoyed the game condition. Lack of interactivity, feedback, quality and delivery in the video activities were aspects that video condition participants noted as issues that impacted on their intrinsic motivation. Game activity participants commented that they felt engaged in the activity and would want to play the game again in the future. This is in contrast to video activity participants who felt they were not very engaged in the activity and were not as interested in doing the activity again in the future. The level of interaction, choice and feedback offered in a game far outweighs that found in an instructional video. Future comparisons may look at how the game compares to existing OH&S serious games with similar learning goals, or even more interactive forms of OH&S training e.g. branching scenarios or quizzed based instructional content. The results also highlight the need to carefully design interactivity and feedback during any digital learning activity.

The findings with respect to potential hazard knowledge and hierarchy of controls understanding support Hypothesis 3 and 4 demonstrating that playing a game about hazards in the workplace results in greater recollection of hazards and understanding of control measures than an audio visual presentation about the same topic. From this evidence it can be seen that a serious game could be an effective OH&S training method. There were no significant differences in potential hazard knowledge and hierarchy of controls understanding between the two audio-visual presentation conditions. This may have resulted from participants' existing base level of knowledge about hazards in the workplace from prior training and experiences.

It could also be argued that an alternative explanation for the results in the current study is that the improved learning outcomes are a result of spending more time with the OH&S content in the game condition in comparison to the video condition. However, the design of the game and video conditions ensured identical information was delivered to participants. The nature of the game-like environment (e.g., control mechanisms) meant that it took more time to deliver the content than the video condition. Future research may look at matching the condition exposure times between all groups to rule out any affect overall time may have had. The study design didn't aim to measure the individual affect of each game mechanic i.e. goals, interaction, choice and feedback had on the players feelings of engagement and learning outcomes. Rather it aimed to measure the core-gameplay experience as a whole. Future work could look at comparatively measuring individual game mechanics to determine which ones are most effective.

7 Conclusion

This study was able to empirically demonstrate that a serious game based on potential hazards in the workplace is capable of facilitating a better learning experience than alternate methods used in this study. This could be a result of the games ability to offer task-based choice, interactivity and feedback with the learning content through gameplay. This outcome also highlights some of the value and applicability the serious core-gameplay framework that was the basis of the game. By designing the core-gameplay around specific instructional objectives the game was able to infuse less engaging learning content with interesting and enjoyable gameplay. The successful application in an authentic OH&S learning experience is significant due to the growing demand for evidence-based serious games and effective OH&S training. The applicable outcome is that there is further evidence that serious games can improve understanding/retention of OH&S knowledge, thus leading to safer workplace environment.

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The Use of Game World Tasks Concepts in Higher Education

Renée Schulz(✉), Andreas Prinz, and Ghislain Maurice N. Isabwe

Department of Information and Communication Technology,
University of Agder, Jon Lilletuns vei 9, 4879 Grimstad, Norway
{renee.schulz,andreas.prinz,maurice.isabwe}@uia.no

Abstract. The link between tasks presented in games and tasks used in higher education might have more in common than we think. Analysing how tasks work in games and applying those structures to higher education teaching can enable teachers to develop more creative, situated and exciting tasks for their students. In addition, it can improve communication and feedback. Analysis shows that tasks are an area where elements of gamification work. This article looks into the possibility of reproducing the flexibility and key components of game tasks in actual tasks in higher education. We look at the challenges and limitations and ways to solve them. Therefore, we analyse the concept of quest-logs in games, look into the structure and its connections to the game world.

Keywords: Game structure · Gamification · Higher education · Mobile learning · Wearable technology

1 Introduction

Too few teachers integrate new technology into their teaching process today. To improve this situation, we looked into technology integration problems and found that many tools do not meet neither the needs of the teacher nor the students. Further analyses revealed several commonly used teaching practices. Among them are *task design and distribution*. Additionally, teachers stated that it would be highly motivating to use technology if that can increase the frequency and quality of communication and feedback between the students and the teachers [1].

To solve the motivational problem of integrating more technology into teaching, we want to develop a gamified system, which addresses the needs of task design and distribution, communication and feedback between teachers and students. The first step was to analyze how games deal with tasks. This involves how tasks are designed, visualized, integrated into the world and how gamers interact with them. We found that there is a common concept, which we name the "*quest-log concept*" that handles the interaction between gamers and tasks but is also far more complex than that. The key concept behind tasks in games is their personalization and dynamics. We found that, in games there is more than one way of task assigning involved. It is possible that the concept of dynamic tasks might be very useful and motivating in higher education. A game-like experience can be created by combining the visible interaction possibilities (mobile interfaces) and

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the all-knowing game-world (through sensors) supported by mobile and wearable devices.

This article starts in the next chapter with related work. Section 3 deals with the analysis of the different layers of interaction and explains the dynamic concept of tasks used in games. Conclusion and future work are presented in Sect. 4.

2 Related Work

There is more than one way to integrate games or game elements into a more serious context such as higher education. One of the possibilities is to make use of games to transform the education into a game or use games as a motivational element [2]. The other option is to use game aspects as a useful mean to solve certain real world problems. Deterding et al. [3] define gamification as the use of game elements in non-game context. The utilization of gamification is not always successful. It is noted that underlying game dynamics and concepts (Freedom to Fail, Rapid Feedback, Progression, Storytelling) are very important and not just achievements, badges and game-like graphics [4]. Therefore, we argue that not only visible, easily distinguishable elements such as badges and points are gamification, but also more complex game concepts and cognitive elements. This matches some of the thoughts presented in the essay: "Gaming science: this "Gamification" of scientific thinking" [5]. This rough definition allows defining what exactly game elements are and how we can make use of them for learning. The following section discusses gamification beyond simple achievements, badges and graphics.

Haimari and Koivisto [6] identified nine dimensions of a gamified environment: challenge-skill balance, clear goals, control, (immediate) feedback, autotelic experience, loss of self-consciousness, time transformation, concentra-tion, and merging action-awareness. These nine dimensions represent outcomes of gamification, but [6] does not state not how they are achieved. More research in the area of gamification looks at game structures, which might be useful in order to gamify non-game contexts. According to Prensky [7] there are six elements of game structure: 1. Rules, 2. Goals and Objectives, 3. Outcomes & Feedback, 4. Conflict/Competition/Challenge/Opposition, 5. Interaction, 6. Representation or Story.

Our work identified that teachers want to have a supportive tool that was able to enhance task design and distribution as well as the communication between teachers and students [1, 8], heavily relied on all of these six dimensions [7]. Tasks follow rules and have goals, as well as outcome and feedback. Further on, tasks can be challenging and they offer competition, conflict or opposition either on purpose or indirectly.

Tasks do also help for personalized learning and teaching. It is interesting to see how games handle the aspects of personalized gaming/learning and how the interaction between tasks, gamers, environment and goals are structured. This research work attempts to answer the question of how to learn from the game world and use that to create better, more contextualized tasks in higher education.

3 Analysis of Game World Tasks

We need to know about the game structure to redesign this structure in the educational setting. Therefore, we analyze the game world first, then how tasks are stored in games. After that we look into the dynamic concept and structure of task finding, triggering and delivery in games and then analyze its potentials for education.

It is important to understand how the communication between the player and the game world works. To interact with the game world, the player's action possibilities are presented by most games with graphical user interfaces (interface layer). That means, we can distinguish between the "*game world*" view and its "*interface*" as two separate layers of interaction possibilities. The interface is most commonly a layer on top of the game world (game world layer), guiding the player through the interaction possibilities. This clearly differs from the real world where action possibilities are not restricted by a number of action buttons to determine the next move. This interface-layer could be simulated by using mobile technology, showing us possibilities for our next moves and interactions. In addition, most games have settings (settings layer) where certain properties of the game can be changed. They may not necessarily have a direct impact on the game, but may change the game experience drastically. The simple change of the resolution can make visuals more clear, as well as simple helping options like "automatically follow up if there is a next task available" possible. Settings clearly affect the usability and user experience of the game. Therefore, we can distinguish between three main layers of interaction in games: Game World, Interface and Settings [Fig. 1].

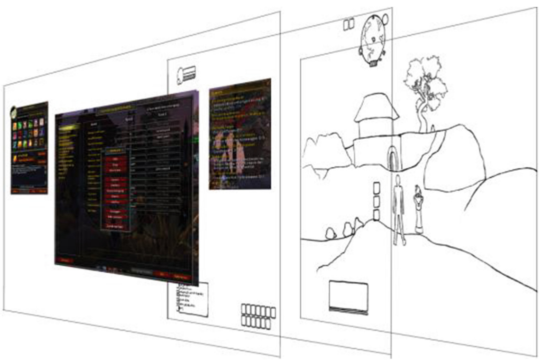

Fig. 1. Game world layers adapted after [25]. From left to right: settings, interface, world.

The next step is to look into the design of tasks directly (from 17 games [9–25]). This step automatically leads to a widely used concept to get, store, collect and view new and old tasks in the game: the quest-log [10, 21] (other names can be: "missions" [9], "journal" [11, 15, 22], "tasks" [16], "diary" [19], "objectives" [18] and others). This log is part of the interface (layer 2) and visualizes the tasks the player gets through game world encounters.

A visualized quest-log is the central accumulation of tasks and therefore often perceived as "to-do list". This makes sense, since it shows the tasks that are available.

Depending on the different quest-log approaches, it shows also a description, context of the task, requirements, location (map), objectives, pictures and rewards.

There are rather simple quest-logs as in ArmA3 [12], showing only a list of tasks and more details in a dropdown menu. This log is located directly in the game world. Logs can also be shown without a connection to the direct game world and can also contain game looking graphics, a very rough description and detailed objectives. However, both logs have the same structure: a list of quests and details of the selected quest. The details in quest logs from [9] are for example clearly assigned to "About", "NPC", "Goals" and "Reward".

But a quest-log is more than that. Unlike to-do lists, quest-logs are used as visualization for dynamically changing tasks. Due to their connection to the game world, tasks can change, or new ones can appear and others may fail. Those changes are represented in the different layers: either in the world or on the interface layer. In some cases tasks can be adapted on the settings layer as well.

The quest-log concept involves the quest-log itself (the visualization of the tasks) as well as the concept where these tasks come from. The quest-log visualization can differ from game to game. The following elements were analyzed from 17 games [9–25]: Quest title, short and/or long description, hints towards resources, characters/Non-Player-Characters (NPCs), travel location or area of quest completion, often with a map attached and rewards for completion.

The concept strongly supports personalization. Some players may get different tasks than other players, because their gameplay differs. Depending on skill, exploration and the way to approach problem solving, tasks can be automatically adapted. The advantage of the game world here is that it has all the data needed to do so, since the characters of the players in the game are fully emerged and every action can be tracked. This means, tasks are influenced by the environmental variables, the player's behavior or other occurring events. For example, when entering a new area, new tasks can appear and old tasks can disappear if an important NPC dies. We call these actions, events and happenings that lead to task changes "*triggers*". We do not have access to students' real world situation in the same way as games have, but we have technology, which can help to get environmental information. By adding the possibility to sense environmental information (and to design triggers for tasks) or other variables of the student's situation, the game experience of adapting and personally individual tasks can be simulated.

As mentioned, the quest-log concept involves triggers, which lead to tasks. Tasks can be picked up by interacting with NPCs, due to events happening, because of the time or because of the completion of previous tasks and more. All sorts of game-world interaction can lead to further tasks and those task-chains can differ from player to player. The player can encounter situated tasks by reaching a specific location. For example, the player finds a cave and gets a task to do inside. The task triggered by location is automatically stored in the quest log. In most games it is not necessary to complete all tasks, it is rather important to follow a main task-chain with an option to choose side-quests to complete. Since the game world knows "all" about the interacting character, it is easy to tailor tasks to the area, speed and skill of the individual gamer. Therefore, many games provide a personal and individually specific gaming experience through personalized tasks. This concept could be implemented in education, using sensors to collect data about the student's learning progress. By adding the possibility to sense environmental information (and to design triggers for tasks) or other variables of the student's situation, this game-experience of adapting and personalizing individual tasks could be simulated. The information about students' performance can be collected and analyzed to improve the learning (and teaching) activities. The main goal is to motivate individuals to participate in the learning process, by increasing the fun and playability and creating more lively opportunities for feedback. That can also enhance communication between students and between teachers and students; hence supporting the teacher in his or her teaching approach.

The tasks themselves come with new opportunities. Normally, the teacher creates the tasks and hands them out, but in a task-supportive system, the sensors of the mobile and wearable devices can be used to sense environmental variables so that tasks are triggered according to the situation. An example could be to trigger a specific task based on a student's location, as it is done in games when a player enters a specific area. Tasks can also differ based on variables such as time, temperature, light, acceleration, heart rate or simply on variables obtained from previously completed tasks such as performance and level of difficulty. We found in [1] that teaching tasks normally possess: Task title, short description, possibility for a long description, resources, (affiliated people, location) and rewards for completion.

This matches the average quest-log entry from games. Some games have richer descriptions, depending on how the game is build and how complex the tasks are. This indicates that tasks can be translated into "quests" and therefore interaction design concepts from games could be borrowed for use in higher education. It should be possible to re-structure educational tasks in a similar, dynamic way as games do.

4 Conclusion and Future Work

This work explores concepts from the game world in order to help address the challenge of how to design and distribute learning tasks in a motivational and useful manner. The intention is to increase motivation through the integration of innovative technology into teaching. There are indications that due to their flexibility, mobile devices can simulate the interface layer of the game world to support tasks. For example students in outdoor context can carry this interface to get updated tasks and feedback on their learning. Devices with sensors, for example smart watches, can simulate the game world's knowledge about context and progress of the student. Game like event triggers can be implemented by using the sensors to get information about the students' location, speed acceleration and other sensor data. These event triggers can lead to personalized tasks that promote contextualized and meaningful learning. Using sensors can also provide data about the interaction with the tasks. This can include number of attempts to solve and solved tasks; student's location, speed, acceleration and time. It is noted that especially in outdoor education, students often have to train on their own, without the teacher. With mobile and wearable devices as technology for the quest-log concept, teachers can give and get feedback about the students' progress. This can motivate teachers to integrate innovative technology into teaching, since it acts as a supportive tool and not a replacement of the teachers.

Future work includes the implementation of this concept for outdoor education including skiing and snowboarding as well as other disciplines like orientation and survival. Teachers should be able to design tasks on the fly as well as in advance as tasks dynamically triggered by sensor measurements. An important work is the usable and meaningful design of the teachers' interface beyond the graphical component. Cognitive overload should be avoided and regardless of the teaching approach, they should be able to find into the system quickly.

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Exploring Emotion Representation to Support Dialogue in Police Training on Child Interviewing

Maria Margoudi[1(✉)], Jennefer Hart[2], Anne Adams[2], and Manuel Oliveira[1]

[1] HighSkillz, London, UK
{maria.margoudi,manuel.oliveira}@highskillz.com
[2] Open University, Milton Keynes, UK
{jennefer.hart,anne.adams}@open.ac.uk

Abstract. Police officers when dealing with interviewing children have to cope with a complex set of emotions from a vulnerable witness. Triggers for recognising those emotions and how to build rapport are often the basis of learning exercises. However, current training pulls together the full complexity of emotions during role-playing which can be over-whelming and reduce appropriate learning focus. Interestingly a serious game's interface can provide valuable training not because it represents full complex, multimedia interactions but because it can restrict emotional complexity and increase focus during the interactions on key factors for emotional recognition. The focus of this paper is to report on a specific aspect that was explored during the development of a serious game that aims to address the current police-training needs of child interviewing techniques, where the recognition of emotions plays an important role in understanding how to build rapport with children. The review of literature reveals that emotion recognition, through facial expressions, can contribute significantly to the perceived quality of communication. For this study an 'emotions map' was created and tested by 41 participants to be used in the development of a targeted interface design to support the different levels of emotion recognition. The emotions identified were validated with a 70 % agreement across experts and non-experts highlighting the innate role of emotion recognition. A discussion is made around the role of emotions and game-based systems to support their identification for work-based training. As part of the graphical development of the Child Interview Stimulator (CIS) we examined different levels of emotional recognition that can be used to support the in-game graphical representation of a child's response during a police interview.

Keywords: Facial expressions · Serious games · Police interviewing · Emotion recognition

1 Introduction

Interviewing vulnerable children and using them as witnesses is a difficult and sometimes challenging issue, especially for new recruits and early career front line police, who may have limited training and real-life experience of interacting with children. Past research within child interviewing has often focused on the controversy around

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suggestibility and reliability of a child's statement, their vulnerability in the judicial setting, and a child's perception of the police as an authority figure [1–3]. To support police practice in this field there are important 'Achieving Best Practice' (ABP) guidelines provided on how to safeguard children's welfare whilst facilitating the collection of high quality evidence [4, 5]. However, all too often police do not adhere to these guidelines when conducting interviews with children [6]. One of the key barriers preventing the adoption of these guidelines is the training of front line police officers, making it difficult for them to develop the necessary skills that can assist them when faced with interviewing a child. In the recent 2015 HMIC report entitled 'In Harm's Way', the specialist training of police in the area of child interviewing skills (especially when taking first statements), was considered ineffective with a reliance on simplistic online training [7]. This has resulted in a police problem with disengagement and simplistic understanding by the police of child interviewing techniques and processes.

This paper documents research into the use of Game-Based Learning (GBL) to support police training and engagement to develop a deeper understanding in child interview training. This is sought through the use of a serious game to focus on specific learning aspects (e.g., rapport and emotional recognition), to support and enhance police tacit experiential knowledge. The result is a serious game, Child Interview Simulator (CIS), which can assist front-line police officers in developing a deeper understanding of effective practices and provides a more engaging mode of the training of early career police officers when they interact with a child. The particular focus of this paper is to research how emotional recognition can be used to support the training within rapport building when police officers interact with a child during an interview.

2 Challenges of Child Interviewing

Child interviewing research evidence suggests that child statements should be taken as early as possible after the alleged offence. Interviewers should encourage children to disclose as much information as possible by using open-ended prompts (e.g., 'Tell me what happened'), as opposed to focused (yes/no) questions [8, 9]. Children are capable of providing accurate information about their experiences, but the quality of communication and the types of retrieval methods used need to be carefully considered [10]. Far too often child witnesses are not interviewed by police as their abilities at remembering the events are considered poor. Research has identified various techniques, such as revisiting the context in which the event occurred, or children drawing during interviews to enhance free-recall while avoiding feelings of risk and error [10]. Paine et al. [11] identified that the mode of interaction with children that includes visual prompts can positively impact upon the success of these interviews. Unfortunately, these findings have not effectively been passed through into police practice. Research has revealed that more often suggestive utterances and focused questions were used as a means to obtain accurate information due to limited time and lack of effective training [9, 12].

In policing, practice communication with children can be difficult for police officers, especially for those unfamiliar with dealing with children. Tactic police practices have identified that one of the essential elements in a successful interview is the ability to build good rapport. The onus is for the front line police officer (who arrives first at the scene), to establish good rapport quickly. This can be very challenging, especially when time maybe limited and there are often other witnesses and distractions to deal with. Furthermore, police officers also have to judge the child's cognitive and language abilities, along with assessing their emotional state [3]. As a result, during initial contact police officers often do not allow appropriate time that is needed for rapport building, and so fail to gain good quality statements from a child.

Both academic research and tacit police knowledge have identified the important need for effective training in how to take the first statement from a child, especially for front-line early career police officers. Training of new recruit police officers within the UK combines an intense initial tutor-lead phase, followed by a 2-year community-based probationary period. Although new recruit police officers are given some training in child-interview procedures there is little time to practice these skills, and the online-training courses are limited and deemed inadequate to develop these skills. It is not until police officers have been practicing for a number of years that they may be selected to attend an intensive 2–3 week child interviewing training course that largely consists of role-play. Practice-based learning and training aim to replicate real world interactions to enable a transfer of understanding from the learning activity to real world experiences. For example, inquiry learning suggests learning through doing [13, 14]. Problem-based learning highlights the value of real world problems as a focus for testing learning [15]. Role playing provides a valuable approach to learning through enacting experiences [16]. However, recent findings have identified that often the complexity of real world interactions can distract and reduce the effectiveness of realistic approaches to learning and training [17]. The aim of the CIS serious game is to focus the learners on specific tacit skills that can support them during their 2-year probationary period, prior to attending a more specialist child interviewing course.

3 Representation of Emotions in Games

3.1 Categorizing Emotions

Children, whilst vulnerable have been recognized by the police internationally as witnesses to crime who should not be undervalued and ignored. The ability to assess a child's emotional state during a police interview would be a huge advantage for the interviewer, as they can adapt the interview technique in order to build rapport and aid communication. There are many cues of nonverbal behavior that are used to assist communication. Recognizing and responding to non-verbal behavior is central to building rapport and achieving a successful interview. Communication usually consists of a mix between verbal communication and several types of nonverbal behaviors, such as gestures, body language, tone of voice and facial expression. Sometimes the verbal and nonverbal language conflict with each other, which often results in the nonverbal cues being perceived as being more authentic than the verbal, as these are harder to control [18]. Nonverbal information has been termed as 'leaky' clues, as they can reveal the true feelings or intensions of the speaker [19]. Therefore, it is important for an interviewer to be able to pick up and recognize the nonverbal cues, as this provides insights in the emotional state of an interviewee, and can have big implications that can either have a positive or negative impact as to how well an interview may progress. While technology cannot replicate the full complexity of human interactions, we argue that this maybe an advantage for training purposes. By restricting these cues during police training we could increase the potential for more effective cognition and internalizing of these tacit interviewing behaviors. Furthermore, by restricting and simplifying the cues it could be argued that this may increase awareness of these factors by those being trained. The face, in particular, allows us to express in visual form our feelings and emotions, and plays an invaluable role in social interactions and communications [20]. For example, facial cues have been argued as the most important behavior to focus research on when developing rapport for those with Asperger's syndrome who have problems recognizing emotions [21].

Facial expressions are the most obvious emotional indicators providing initial indications of how a person is feeling at any given time. The visual nature of emotional expressions makes it a very good method for incorporating nonverbal clues into a game design. The study of emotions has been of great interest to various scientific fields, ranging from psychology and neuroscience, to machine learning and computer vision. Emotions have been widely viewed in psychology as categorical, in that there are certain basic emotions that is governed by individual neural networks [22]. Past researchers have suggested different lists of basic emotions, with Ekman and Friesen [23] being in the forefront in the measuring and validation of facial expression. Their theory is based on the premise that emotional expressions are formed by changes in different facial muscle actions that create emotional patterns that can be recognized as different emotions. Many of these patterns of muscle movements within the face have been coded by Ekman and Friesen [23] to form the basis for the Facial Action Coding System (FACS). A database of over 200 facial images of different expressions were created [24], by breaking expressions down into Action Units (AC). Since then, FACS has become one of the most widely used and validated method of measuring, analyzing and describing facial behavior. In a recent paper by Ekman [25], a survey of experts in emotion related research was conducted to identify the most salient emotions. There was a very high agreement (75–90 %) that the top most recognizable emotions were anger, fear, sadness, happiness and disgust. Less salient emotions found were shame, surprise and embarrassment (40–50 %), followed by guilt, contempt, love, pain, envy and compassion, being less recognizable. This is reflected in further literature, where the primary 6 emotions (with the addition of surprise) are identified as being the most recognizable, while the secondary emotions (such as guilt, contempt etc.), being considered more difficult to define [26, 27].

In contrast, the dimensional *Circumplex Model of Affect* (CMA) theory [22] see emotions organized on a two-dimensional level of *valence* and the intensity of *arousal (activation),* which map emotions onto an *Affective Space Model*, (see Fig. 1). Different emotions are understood on each of these two linear dimensions, or varying degrees of valence or arousal. Although the CMA allows for a variety of emotions across a wide spectrum, it does not determine the most (or least) recognizable emotions. We argue, that for police interview training, using the most recognizable emotions (identified by Ekman & Friesen), rather than all the complexities of less salient emotions (provided by the CMA), is valuable for enhancing awareness of rapport. Whilst role-play training cannot restrict and focus on these issues, the CIS can focus on specific key emotions that are relevant to the game storyline, thus assisting the learner in rapport building.

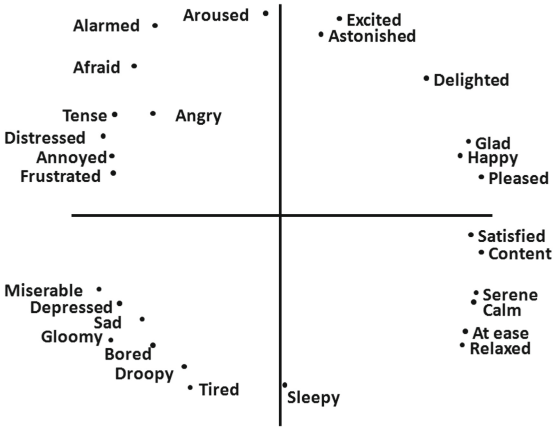

Fig. 1. A graphical representation of the Circumplex Model of Affect showing the horizontal axis (valence), and the vertical axis (arousal)

It has been argued by facial recognition research [26] that the lack of any contextual information (social situation in which the emotion occurred) and any causal information (events that may have caused the emotion) could increase the effective emotion recognition. Again whilst this may not be a true representation of reality, it does provide a way to focus training and increase its effectiveness. By providing an initial awareness of these cues for the police during training it is argued that this would allow an awareness of these basic emotions before they become over-complex and harder to interpret with situational and emotional intensity. For example, the intensity of the emotion has been identified as providing an impact on its effective identification, with some emotions at full intensity (such as anger and disgust) looking very similar, thus causing confusion [28].

The value for the police to enable a more focused route to training cannot be underestimated. The ability to assess a child's emotional state during the interview would offer a huge advantage for the police interviewer. Providing effective and engaging training in this area can allow the police to adapt their interview technique, to build rapport and aid commination, and ultimately increase their potential to solve crimes and bring perpetrators to justice. Enhancing the tacit skills of early police officers to identify the emotional states of a vulnerable witness will enable them to respond appropriately to their needs.

3.2 Emotion Recognition in Games

Emotions' recognition is a basic social skill and is identified as the ability to recognize the major group of human emotions. It is associated not only with effective peer relationships and social development, but also with children's preparation for learning in a formal setting [29]. Emotions conveyed by facial expressions, gestures, words or situations contain critical information for the regulation of social interactions. Significant research has been conducted during the last three decades within the field of serious games, in the development of systems that attempt to mimic human cognitive processes by automatically analyzing and interpreting facial expressions. In order to address the challenges related to this particular field of research, facial expression analysis has been distinguished between two main streams: facial affect analysis and facial muscle motion analysis [23, 30]. Most facial expression analysis systems focus on facial expressions to estimate emotion related activities. In addition, many studies have introduced the interpretation of real-life situations based on the correlation of multiple channels, such as both speech and facial expressions [31].

As humans perceive a lot of emotional information through visual communication, several research projects have investigated the different aspects of affect recognition through facial characteristics [29, 30, 32, 33]. The majority of serious games developed around this scientific field mainly focus on health studies and affect recognition for individuals with Autism Spectrum Disorder (ASD). The use of virtual humans as a way to teach emotion recognition through games enables the contextualization of emotions, as they simulate real conversation without the actual social interaction that people with ASD find difficult [32]. In addition, the review of current literature on emotion recognition in gaming contexts verifies the use of the widely accepted model of Ekman and Friesen [23] which supports the universality of facial expressions (described in previous section).

In the gaming field, the development of embodied conversational agents (ECAs) and talking heads with a focus on accurate gaze targets have been in the center of recent research efforts [34–36]. The use of ECAs in different contexts and purposes in games has revealed the importance of facial expressions and non-manual facial signals in speech and language understanding. Consequently, avatars are required to portray at the same time emotion and facial non-manual signals [37]. Furthermore, there is an emergent need for expressive avatars that will mainly contribute to Collaborative Virtual Environments (CVEs). The use of avatars as simple placeholders doesn't contribute to the communication process and it has been proved that even a single expressive behavior that reflects the conversation can contribute significantly to the perceived quality of communication [38].

4 A Serious Game for UK Police Force

The Child Interview Simulator (CIS) consists of a serious game developed to enable and complement current police training practices in the field of child interviewing, targeting mainly new recruits. The CIS simulates a real-life situation that allows the player to be a police officer whose goal is to obtain a first statement from a child that has witnessed an alleged criminal offence, and then conduct an interview. This serious game bases its structure on dialogue mode and utilizes interview types applied in previous games like "Global Conflicts: World Collections" [39].

The game was co-developed with one UK police force with the context being inspired by an actual real life case that formed the backstory to the CIS. A nine-year old boy is walking on his way back home from school, when he witnesses a man grabbing a lone female from the bushes and attempting to drag her off the common pathway. As the woman screams, the attacker notices the child watching him and in panic, runs away. The gameplay is based on Experimental Learning Theory [40], which uses the learner's experiences in order to facilitate learning. Following Kolb's four stages of learning theory, the player learns about the incident and collects information on the witness through various sources (State 1: Concrete Experience), then reflects on the obtained information (State 2: Reflective Observation), in order to develop his/her own understanding (Stage 3: Abstract Conceptualization), and finally act accordingly by making the correct choices in gameplay (Stage 4: Active Experimentation).

The CIS has two main parts (see Fig. 2), the first begins when the police trainee receives a dispatch call about the incident and visits the child at his home in order to take a first response statement. The second part consists of the police trainee conducting an interview in what is known as Achieving Best Evidence (ABE) suite. Although, in reality a trainee will need to have undertaken specialized child interview training to conduct an ABE suite interview with a child; the experience given by engaging in the 2nd part of the CIS will allow them to experience the importance of gathering effective data from the first response interview, and how this may impact on the success of the ABE interview.

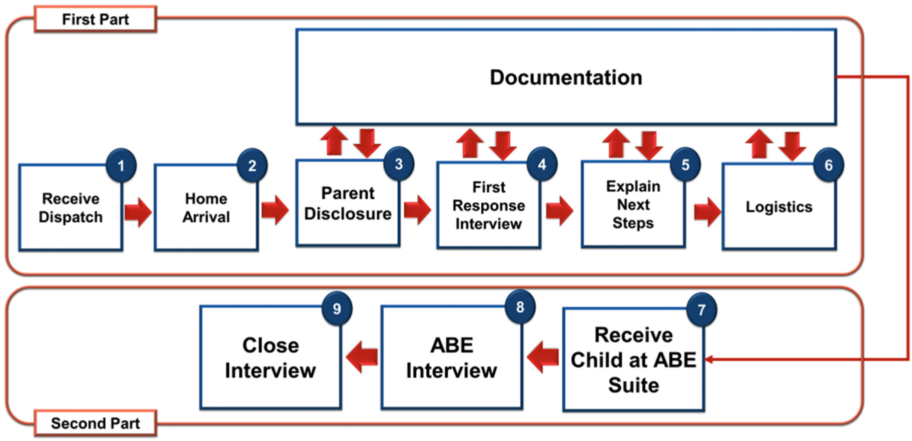

Fig. 2. The Child Interview Simulator (CIS) showing the two parts broken down in episodes

In the first part, the key episodes are the parent disclosure (episode 3) where the police trainee needs to obtain a statement of account from the parent, without the child present, and the first response interview (episode 4) where the police trainee obtains the first account statement of the alleged offence from the child. In the second part, the key episode is documenting the police interview with the child, which is captured on video (episode 8), and used as evidence in court, thus not requiring the child to be present within the judicial court procedure. In all the episodes, it is necessary for the police trainee to engage with the child in verbal communication (see Fig. 3 for a snapshot of the dialogue interaction within episode 4). However, the hard challenge to master is the recognition and interpretation of the non-verbal communication cues, which are complex and difficult to implement in the form of a serious game. The use of 3D was discarded early in the development precisely because believable non-verbal communication would be difficult to support, and consequently 2D was adopted as a credible alternative to representing the emotional state of the characters with whom the police trainee will engage with. To support the trainee further, a ‘Rapport bar’ was conceived to convey how successful the trainee is in building trust, affinity and empathy with each stakeholder (mother and child). The decision of making rapport visually explicit in the form a gauge (top left corner of Fig. 3) was due to the difficulty of capturing the non-verbal subtleties even in 2D.

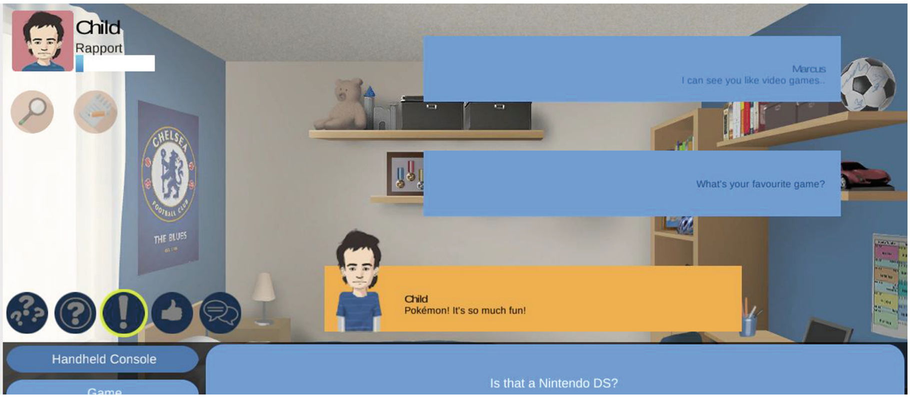

Fig. 3. Partial snapshot of the CIS in the first response interview (episode 4)

The CIS uses the child’s facial expression to make explicit the emotional state of the child, and to convey their mood which provides an indication as to how the interview is proceeding. For example, Fig. 4 illustrates the case when the child changed his emotional state from neutral to angry because the police trainee decided to take by force the gaming device that the child was playing with in order to gain their attention.

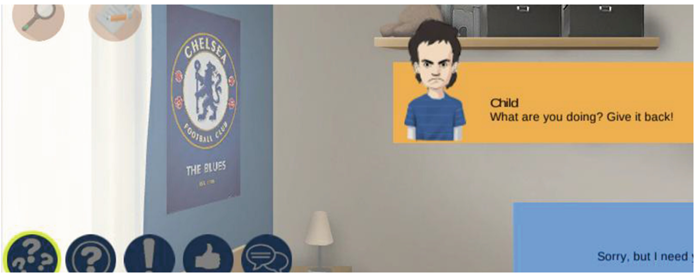

Fig. 4. Partial snapshot of the CIS demonstrating change of child’s emotion

To ensure that the emotions are recognizable, a set of facial expressions were generated for the child-witness character and these were tested with different stakeholders, ranging from experienced police officers to interviewing experts. The initial set of 17 facial expressions included a set of basic emotions validated by relevant literature [25], were used within the evaluation test.

The different emotions were organized into an Emotions Map (Fig. 5) consisting of eight different branches of emotions. The categorization was done based on the intensity of each emotional state. Consequently, the facial expressions marked in dark blue are the most easily recognizable by people (Level 1) and those marked in light blue are less easily recognizable (Level 2). Following this approach, we formed an Emotions Map consisting of eight pairs of emotions (ranging from more to less intense facial expressions) and a neutral one.

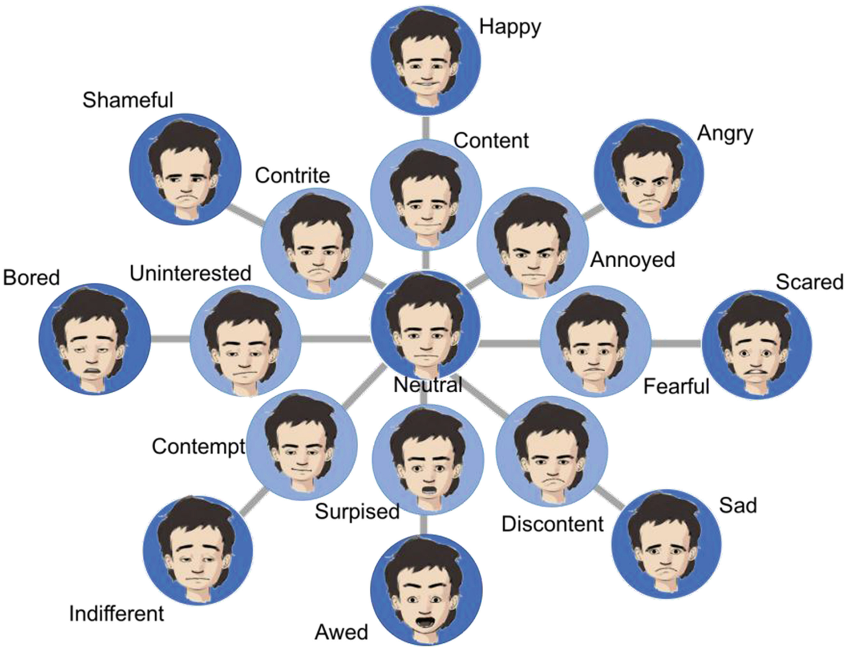

Fig. 5. Emotions Map

5 Methodology and Validation Results

In order to evaluate the emotions map created to support in-game learning, an iterative evaluation process was adopted. The process consisted of two consecutive rounds of evaluation in May 2016, where a set of different facial expressions were tested. The first round was piloted using a digital evaluation method whereby an email was sent to participants, which resulted in a slow response rate. So a paper-based method was adopted for the final evaluation method as it provided a faster response and enabled more control over the quality of participant completion.

The sample of the participants that contributed to the evaluation consisted of two different groups of people: ‘experts’ and ‘non-experts’. The experts consisted of psychologists (recruited from three different UK universities) who were experts in visual expression research, police experts within child interviewing (recruited from one UK police force), and usability experts, (recruited from one UK university). The second group we termed ‘non-experts’ refers to participants recruited from the general public (in this case university staff). The justification for recruiting expert participants was to improve the validation of the results gained from the general public (non-experts). A total of 41 participants took part in the evaluation, with a split between non-experts (56 %) and experts (44 %). Participants’ age ranged from 25−55, with a slightly higher female (59 %) to male (31 %) gender split.

The same paper-based survey was employed in both iterations of the evaluation and it consisted of 17 different 2D graphic images depicting different types of emotional expressions. A predefined multiple choice format was used with the addition of an open-ended response, as depicted in the examples shown in Fig. 6. Participants were given a paper booklet that consisted of 17 different 2D graphical representations of a facial expression that elicited a particular emotion that could be used within the game. Prior to evaluation, participants were asked to spend a few seconds looking at each face and select from the three choices given, which expression best matched the image. The aim was to illicit participants’ initial impression of each expression. They were also given an open-ended response that allowed participants to add any further comments. The results of both rounds were used for the validation, improvement and final choice of the set of facial expressions to be used in the game.

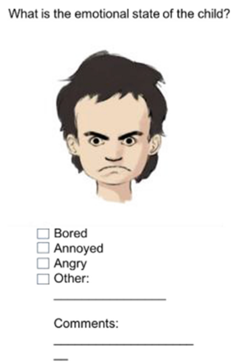

Fig. 6. Facial Expressions Survey

In order to extract the results of the first round of evaluation, the answers of the two different groups of participants were separated. In case of disagreement between the two groups, the experts’ choice was favored above the non-experts’ choice. However, there was 70 % agreement between experts and non-experts, which further validates the results, indicating the innate role of emotion recognition. The result of each round was listed showing the approved, rejected and undefined facial expressions. As approved was considered an expression that either both groups agreed on for more than 50 % each, or that only the experts agreed on for more than 50 % [41]. Rejected expressions didn't manage to collect the 50 % of either group's acceptance and undefined expressions collected only the 50 % of non-experts' acceptance. The results of both rounds indicated that –in accordance to relevant literature (see Sect. 3.1) there is a certain group of facial expressions that are globally recognized by people. Based on the intensity of the emotional state, we observed that all facial expressions in the outer circle of the emotions map (Level 1) –plus neutral emotional state, in the middle of the map- scored high among all participants and were approved. On the other hand, less intense facial expressions – in the inner circle of the emotions map (Level 2)- weren't that easily identified by all the participants and some of them were marked as undefined of were even rejected.

Analytically, the results of each evaluation round are presented together with the final results of the evaluation procedure in colour-code (green-approved, blue-undefined, red-rejected), as shown in Table 1 below.

Table 1. The Emotions Map Validation Results

N	Level	Emotion	Round 0 - Experts	Round 1 – Non-Experts	Round 2 – Non-Experts	FINAL results
1	1	Neutral	100%	78,2%	100%	Approved
2	1	Happy	100%	91,3%	84,6%	Approved
3	2	Content	60%	34,7%	46,1%	Approved
4	1	Angry	60%	56,5%	53,8%	Approved
5	2	Annoyed	60%	52,1%	53,8%	Approved
6	1	Scared	80%	73,9%	76,9%	Approved
7	2	Fearful	40%	56,5%	69,2%	Undefined
8	1	Sad	60%	56,5%	53,8%	Approved
9	2	Discontent	20%	56,5%	53,8%	Undefined
10	1	Surprised	40%	52,1%	53,8%	Undefined
11	2	Awed	40%	56,5%	38,4%	Rejected
12	1	Indifferent	20%	21,7%	15,3%	Rejected
13	2	Contempt	60%	47,8%	38,4%	Approved
14	1	Bored	60%	60,8%	46,1%	Approved
15	2	Uninterested	80%	60,8%	69,2%	Approved
16	1	Shameful	80%	30,4%	30,7%	Approved
17	2	Contrite	0%	0%	23%	Rejected

In detail, 11 out of the 17 facial expressions were approved by the participants, with the *neutral* expression scoring higher than all the rest. In addition, *happy* and *scared* also scored very high among the participants. The complete list of approved emotions is the following: *neutral, happy, content, angry, annoyed, scared, sad, contempt, bored, uninterested* and *shameful*. The facial expressions that were marked as undefined consisted of 3 emotional states; *fearful, discontent* and *surprised*. Finally, there were 3 emotions rejected by both groups of participants: *awed, indifferent* and *contrite*.

6 Conclusions

This paper reports on the development of the CIS serious game that incorporates triggers for emotional recognition to support the training of rapport building of early career front-line police officers when interviewing children. By using a 2D serious game interface the aim is to increase the focus on some of the key learning skills required for conducting a successful interview. Whilst there is ample literature in emotion recognition, the results are not easily applicable within the context of a serious game due to the limitations of representing the subtleties of the human face without encountering the uncanny valley [42]. Some of the attempts of crossing the uncanny valley using computer graphics and photorealistic rendering are discussed in [43], which supports the decision for adopting 2D for the recognition of emotions. This paper reports on the process of designing an ‘emotions map’ for the purpose of developing a child interviewing game-based learning solution. The results of the study support the existing literature in the field of facial emotion recognition, that there are different levels of high and low saliency of emotional recognition. From the 17 facial expressions evaluated, 11 were approved, 3 were marked as undefined and 3 were rejected. Little difference was found between experts and not-experts with a 70 % agreement indicating the innate aspect of emotional recognition It should be noted that even though the whole set of facial expressions was tested and evaluated, only a part of them were included in the game. The selection of these expressions will be based on their relevance to the game’s episodes.

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Health, Well-Being and Accessibility

Using Twine as a Therapeutic Writing Tool for Creating Serious Games

Katryna Starks(✉), Dakoda Barker, and Alayna Cole

University of the Sunshine Coast, Queensland, Australia
{kstarks, dbarker, acole}@usc.edu.au

Abstract. Serious games are understood as games that have a purpose beyond entertainment, and are designed for the educational or behavior-change benefit of those who play them. However, the creation of text-based, choice-driven games presents an opportunity for therapeutic narratives that benefit the game authors as well as potential players. Although the benefits of storytelling for therapy has been previously established, these narratives were often linear in nature; the software program, Twine, enables technologically non-savvy authors to write branching narratives with multiple choices, creating an opportunity for an enhanced experience of cathartic storytelling. This paper includes a brief description of writing therapy models, including cognitive behavioral writing therapy (CWBT) and trauma-focused cognitive behavioral therapy (TF-CBT), and how the thinking involved with creating choice-based narratives mimics those processes. Then, it moves into a brief introduction of Twine and how it is used to create non-linear narratives. Following that, the paper presents three self-reported cases of authors who have experienced catharsis and wellbeing benefits via the use of interactive storytelling with Twine, and how the creation of choice-based narratives enhanced this wellbeing experience. Finally, the paper presents advantages for introducing Twine in a formal therapy process, and practical considerations in doing so.

Keywords: Choice · Narrative · Catharsis · Therapy · Writing · Cognitive behavioral therapy

1 Introduction

Storytelling has been used throughout history to convey information as well as express thought and emotion. However, writing also has a dual therapeutic purpose. One therapeutic purpose is to provoke understanding or catharsis within the reader, while the other provokes a similar response in the writer. Dan McAdams [7] has proposed that people use narrative to express and form identity, and that one can ascertain who they are based on the stories they choose to tell. Furthermore, writing therapy is used successfully to treat both post-traumatic stress disorder and depression, and has been found comparable with other forms of cognitive behavioral therapy in adults [17] and children [16].

Writing therapy rests within cognitive behavioral therapy, and can be presented on its own with cognitive behavioral writing therapy (CWBT) [16], or as part of a larger

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framework, such as the trauma narrative in trauma-focused cognitive behavioral therapy (TF-CBT) [3]. The forms of writing therapy generally involve four steps: (1) writing a story about one's experiences or fears, (2) expanding that story until it is fully detailed, (3) using that story to converse with a therapist and reframe the experience in order to find more effective ways of coping, and finally, (4) sharing that story with others as a sign of completion [16]. This treatment mimics other post-traumatic stress therapies in that it involves exposure, education, cognitive restructuring, and social sharing [16, 17].

Traditionally, these identity-building and therapeutic approaches to writing involved the author conveying a linear story about their experience [14, 15]. However, with the advent of Twine, an interactive narrative writing tool (described further in the next section), authors can easily create branching narratives that once required the aid of a programmer. This has the ability to expand the arenas of narrative identity formation and writing therapy, and possibly allow people to move more efficiently from catharsis to coping. Branching narratives are an innovative way for people to not only write a story and to experience the self-validation of having written their truths, but also to write alternative routes that could be taken should they encounter a similar trauma in the future. These alternative routes can be actions that they can take, or simply educational routes that they can use to help others understand their experiences. The use of variables within Twine expand the branching narratives into fully-fledged games, allowing players to discover how well they are coping by providing reactions to player choices in the form of narrative expansion or the use of a scoring system.

The three works discussed within this paper represent three cases of Twine narratives having provided self-reported cathartic, therapeutic experiences for the authors by allowing them to express themselves and to educate others. While the term "catharsis" was coined by Aristotle as a literary device, in this paper, we refer to Moreno's [9] definition of catharsis in psychodrama, which defines catharsis as a healing and liberation that results in a dual effect: firstly within the author of a work and secondly within the audience. Although these works are not the result of therapy sessions, they provide insights into the potential use of Twine as a tool for writing therapy. These works explore topics such as domestic violence [14], coping with chronic health conditions [2], and understanding queer identities [4]. Each of these works takes the approach of putting the player in the position of authority. They are all written in second-person, referring to the player as "you" and inviting them to experience the life of the traumatized person. For players who have experienced a similar trauma, this can extend the author's catharsis to the player. For others, the experience can induce empathy along with education.

2 Use of Twine

Twine is a free, browser-based writing tool (found at http://twinery.org) [15] that is designed to allow authors to create interactive narratives with very little programming. It uses simple script and a flowchart-type interface to connect passages of text, and publishes the output as an interactive web page. Although both the authoring tool and output require a browser, an active internet is not required after the initial download of the program. The tool is very easy to use, comparable to regular word processing software. Based on the experience of the authors both in learning Twine and teaching it, the program takes about 20 min to learn for ages 10 and up. This includes creating and linking passages to each other to create a story, and including graphics and sound. For more extensive works, users can visit the Twine webpage to find custom templates to change the visual style of their stories, discover more advanced ways of using Twine's simple programming language, or learn HTML, CSS and Javascript in order to add features not available within Twine's core interface.

The potential benefit of using Twine for writing therapy is that it allows clients and therapists to explore various responses and outcomes to one scenario through the use of branching narratives, or choices. Clients and therapists may be unfamiliar with the term "branching narrative", so the term "choice-based narrative" may be preferable within a therapeutic context. Creating "choices" within Twine is simple. Each section of a story within Twine is referred to as a "passage" and contained within its own box (Fig. 1); within a passage, you can put the name of another passage in square brackets to create a link to that passage. Placing multiple links in one passage creates branches or choices that the reader—and also the writer—can make. These branches can be as complex as a writer desires or is capable of producing, with simple narratives being just as potentially effective in producing a therapeutic benefit. While images and audio are not necessary for the creation of a therapeutic Twine narrative, these features can be easily added to passages in Twine (Table 1) Once the Twine story is created, a publish button creates a self-contained HTML file that can be opened and played directly in a browser.

Some of the writing techniques discussed in this paper—such as second-person perspective and looping narration—have a desired impact of fostering empathy in a player, but it is unnecessary for writers using Twine to use techniques that deliberately attempt to evoke a particular emotion in their readers, or for writers to even create Twine narratives with a particular audience beyond themselves in mind. While the authors of the works within this case study chose to publish their final creations for public consumption, any potential positive impact on readers was secondary to the primary cathartic purpose of their creation for the creator. It is not necessary for a game to be hosted publicly after its creation unless this is a recommendation as part of ongoing therapy or a personal desire to share a journey with a wider audience.

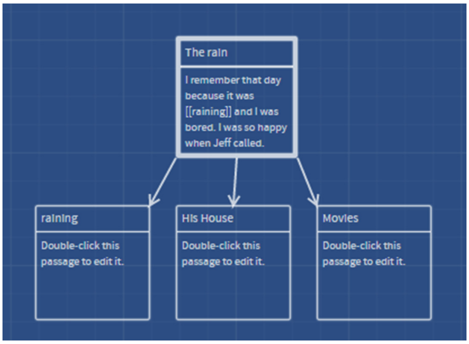

Fig. 1. Twine passages and structure

Table 1. Example of Twine programming syntax with image of layout (see Fig. 1)

```
This is the text of the story. Now,
here is the [[link]] to a different
part. Links can be placed anywhere
within text, or separated out to form
choices, as below:

[[choice 1]]
[[choice 2]]
```

To add a picture:

```
<img
src="ImageFolder\ImageFile.extension>
```

```
Example:
```

```
<img
src="MyStoryFolder\sunnyday.jpg">
```

To add sound or video, simply replace “img” with “audio” or “video” as appropriate.

Twine has an extensive online collection of tutorials [15] that can aid with learning basic and complex functions within the engine. These can help an uncertain Twine user—a writer, client, or therapist—become familiar with the engine quickly and seek assistance for any issues that may arise.

3 Game Discussion

3.1 Technical Overview

Twine is a versatile instrument that can be used to create works of varying complexity, without extensive experience with the tool. Of the three works discussed, *The Icecream Parlour* [4] is approximately 1,500 words in length, *Tuesday* [14] approximately 2,500 words, and *threesixfive* [2] approximately 5,000 words. *The Icecream Parlour* [4] and *threesixfive* [2] were the first Twine games their respective authors have created, who each learned how to use Twine during their creation; *Tuesday* was the second Twine game created by Starks [14]. An average of 20 min was attributed to the process of learning how to perform basic functions in Twine, with *The Icecream Parlour* [4] taking approximately two hours to complete in full, *Tuesday* [14] taking approximately 3 h, and *threesixfive* [2] taking approximately ten hours, with these values being reflective of the number of words each narrative contains.

Images are only used in one of the Twine games discussed in this case study—*The Icecream Parlour* [4]—which uses abstract images to create a tangible link to the metaphors used within the text. Cole [4] chose not to incorporate audio within the text, while *threesixfive* [2] and *Tuesday* [14] use neither images nor audio. Barker [2] made this choice due to a desire to focus on the text of *threesixfive*'s narrative; Starks [14] instead considered the sensitivity of the topic of domestic abuse that *Tuesday* explores and determined that including sound or pictures could traumatize potential players of the game. Both Barker [2] and Starks [14] felt that not including images or audio encourages players to remain focused on the choices and outcomes within the game rather than additional stimuli, such as gory representations of abuse that could have been depicted in *Tuesday*.

3.2 *Tuesday* by Katryna Starks [14]

Introduction. *Tuesday* is a game that explores domestic violence through the mechanism of psychological abuse. Unlike physical abuse, which often leaves outward evidence, psychological abuse often leaves only feelings of low self-esteem and confusion. Indeed, some psychological abuse tactics involve making the victim feel crazy or unsure, leaving them to wonder if the abuse even happened at all. This interactive experience was designed to present psychological abuse in a way that clarifies that abuse is happening, hopefully providing a mechanism for the abused to recognize what is happening and seek assistance.

Motivations. The initial idea for this game came about when I was attempting to demonstrate to my Interactive Narrative students that all choice in games must ultimately have a deeper meaning, even if those choices appear inconsequential at first. In seeking a practical example, I spoke of the everyday decisions a woman might make throughout her day, and how those decisions could have dire consequences within an abusive relationship. After the lesson, I realized that the "walking on eggshells" feeling I was trying to convey to my class was a familiar one, though I hadn't been in a physically violence situation. Upon further study, I came across an abuse model that described the emotional aspects of abuse, and realized that, while not being hit, I had been in an abusive situation, and that the anxiety from it remained. I chose to make the game as a practical example for my students, but also as a way of validating my own feelings as a result of my experience.

Design choices. Tuesday is designed to lead the player through the internally experienced effects of psychological abuse via self-doubt. In this way, players can empathize with an abuse victim, living that experience and making choices in the same mental state she shares. My hope is that this game will help abuse victims understand when abuse is happening even if it isn't physical, and also help friends and loved ones understand the mindset of the victim so they can guide her toward outside help in a way that is loving and non-judgemental.

The game is based on the Duluth Power and Control Model [5, 11], a community-focused education program developed by the Domestic Abuse Intervention

Project (DAIP) of Duluth, Minnesota. This model emphasizes community education and influence on political policies in order to remove blame from domestic violence victims and hold abusers accountable for their actions. DAIP has also developed an internationally recognized curriculum for retraining abusers (theduluthmodel.org) [5]. The Duluth Power and Control Model [5] is represented in a wheel-diagram that shows domestic violence as a multi-pronged activity that includes both physical and psychological abuse [11]. The Power and Control Wheel details various types of psychological abuse, including economic abuse, intimidation, coercion and threats, emotional abuse (insults), minimisation and denial, and using children (theduluthmodel.org) [5, 11].

Tuesday was built in Twine and written in second-person. However, based on the Duluth Model [5] and the cathartic nature of the writing for me, I chose to make the main character female and in a heterosexual relationship, which becomes evident in the choices offered to the player. The game consists of several ordinary decisions that the player makes throughout her day. These decisions include what to wear, what to eat, how to do chores, and whether to meet a friend for coffee. Under normal circumstances, this would be a quite boring experience, as these decisions require very little thought and no reason to ponder their aftermath.

However, in Tuesday, these choices aren't as benign as they seem. Upon choosing, the player sees one of four reactions. Either "he" likes the choice, "she" likes the choice, "he" doesn't like the choice, or "he" hates the choice. If the player makes a choice that he likes or that she likes, the task is complete and the story moves to the next task. However, if the player makes a choice that he doesn't like or that he hates, they see a messages similar to this one, regarding which patterned shirt to wear. In this example, the player has chosen a shirt with stripes as opposed to dots, pink or turquoise.

> He doesn't like stripes.
> You take a moment to reconsider, then decide to go with…

The reaction is followed by the same four choices, allowing the player to either confirm their prior choice or make a different one. Initially, the story doesn't appear to branch, as these choices don't have an immediate effect, however the "branches" are in the mind of the player, who believes that there are correct choices and that making them will affect the outcome. This mimics the heightened anxiety of an abuse victim, and the attempt to control the situation through choices and actions.

One important aspect of the game is that, despite the ever present thoughts about his preferences, the "he" in the game is not actually there. At the end of the game, he returns home, indicating that he was at work while you were making decisions. This highlights the anxiety and self-doubt resulting from abuse, so much so that the player reacts to the abusive situation by internalising it, considering whether to obey all of the rules even when no one is physically there to enforce them. This is consistent with reports from battered women that the psychological and emotional abuse they experience has an effect that is similar in severity as the physical abuse they endure [10].

Domestic violence is a sensitive topic, and the use of sound or pictures could traumatize the players I am trying to reach with the game. For that reason, although Twine enables visuals and sound, the entire game is comprised only of text. This keeps players focused on the choices and outcomes within the game rather than gory representations of abuse.

The end of the game highlights a common fallacy of abuse, and helped move me through my final experience of catharsis. In my initial design, I moderated the level of abuse based on the number of decisions the player made that "he" liked. However, I realized that this approach placed the responsibility for abuse on the victim, as if she could manage her abuse based on her actions. The truth is that the responsibility for abuse lies with the abuser, who will simply change any facts or situation as necessary in order to justify whatever abusive acts they want to perform. In response, I removed the moderation and wrote the game so that the abuser's actions are justified differently based on player choices, but the only way to escape abuse completely is to leave the relationship. I provided real help lines for Australia, America and the UK at the end of the game for players who require assistance.

Although it is important to refrain from blaming abuse victims for the abuse they endure, it's also necessary to note that leaving the situation is voluntary. To convey this, there is another ending in the game in which the player can choose to continue the relationship. At the end of each play-through, the choices are the same: stay or go. I hope that players will understand the cycle and if they are experiencing abuse, they will realize that seeking help is the best way forward.

Tuesday was written with a female protagonist in a heterosexual relationship, however this is not the only way that domestic violence is experienced. Males can also be abuse victims, and for severe abusers, males and females use the same abuse techniques at the same frequencies [6]. Therefore, the structure of this game can be adapted to represent female abuse of males, and abuse within queer unions.

Therapeutic benefits. The making of *Tuesday* has provided both an empathetic experience and catharsis for me. Through the exploration of the subject matter, I was able to reflect on my own anxieties and pinpoint the source to a psychologically abusive relationship. Although I realized that I was treated badly, the lack of physical abuse masked the extent of the abuse that occurred – and that my anxiety and other issues were its aftermath. The process of writing *Tuesday* helped me see the truth of my situation, and that I had choices. As a result, I distanced myself from my abuser. The game also provided an empathetic experience in that I understand more fully why abused people stay in those relationships. The anxiety, doubt, and reduced self-esteem that stems from psychological abuse makes abuse victims doubt themselves and absolve their abusers, keeping them in a cycle of trying to "fix" themselves and their own behaviors instead of placing blame on the abuser, where it belongs.

Although the game is used here as an example of self-induced therapeutic benefit for me as the author, my hope in creating this piece was that people who played it would recognize the anxiety experienced within the game, and use that experience to identify if they were in an abusive relationship. The feeling of anxiety would hopefully be moderated by the inclusion of helpline information at the end, and the understanding that the creation of this experience means that someone understands their situation, and they are not alone. The combination of recognition, empathy and information might be an incentive to seek help.

Although the game has not received official recognition, I did enter it into Indie Cade 2014. It received positive feedback and suggestions for expanding the experience. The game was also played as a demonstration for employees of R4Respect, a local non-profit with a domestic violence prevention program. The R4Respect team reviewed it positively and were interested in the potential of Twine to create these types of experiences. I have also demonstrated the game within a classroom environment as an example of a Twine-based Serious Game, and received positive feedback from my students. These classes happened to be predominantly male, which provided a unique opportunity to test a female-leaning game with a mostly male audience. The students demonstrated empathy and understanding, and even a sense of protectiveness over the protagonist, often making disparaging remarks around the abuser in the story. At the end, there was consistently a unanimous decision to call the hotline. After choosing the hotline, I demonstrated the other ending with the choice to stay. This was followed by a discussion about the design decision of the other ending and placement of responsibility for abuse on the abuser, thus completing the learning experience.

3.3 *threesixfive* by Dakoda Barker [2]

Introduction. Conversations about my struggle with chronic health conditions have rarely left me feeling uplifted. More often than not, the responses I receive indicate a lack of understanding or a dismissal of my chronic health conditions entirely; frequently, relatives whose conditions are similar but manifest in less significant ways are mentioned as evidence that I am simply too fragile and should cease complaining. *threesixfive* is my cathartic response to this; it is an attempt to prevent further harmful, unsupportive comments by allowing players to, through interactive narrative, "experience" the same kinds of challenges that I—and others who have similar struggles with chronic health conditions—must overcome each day.

Motivations. *threesixfive* is an autobiographical text that was born from a panicked exercise: I attempted to chart the activities that were required of me each day in order to manage my chronic health conditions effectively and maintain the appearance of an ordinary, functional adult and found that there were not enough hours in each twenty-four-hour period. In creating *threesixfive*, I wanted to find a way to process this experience—I wanted to find a way to make my life "winnable"—while also creating an interactive narrative that could help to educate people and generate empathy, for others as well as myself.

Design choices. The narrative in *threesixfive* begins at ten pm on an unspecified day. This decision reflects the notion that managing chronic health conditions does not begin from the moment that a person wakes, but can be influenced by a number of factors from the previous day. Forcing the player to be proactive and forward-thinking makes them more accountable for less optimal choices and their outcomes. This also pushes the player towards making decisions under added levels of stress: sleeping takes up many of the limited hours and therefore restricts how many other activities can be completed; however, sleep is vital to ensuring that the player-character can function for the duration of the twenty-four-hour period.

Six attributes are defined for the player-character that help to determine which of the four endings the player receives after the cycle has been completed: energy, fitness, relaxation, socialisation, classwork, and housework. These represent the broad areas that can affect and be affected by the chronic health conditions explored in *threesixfive*. Originally, these attributes and their values were to be hidden from the player in favor of a streamlined focus on the narrative; however, I decided to make these attributes visible in order to give the player a clearer goal. With the visible attributes and an early passage establishing an overarching goal, the player will likely strive to achieve the most optimal outcome. Despite this, the player cannot form a perfect strategy due to the fact that each activity carries equal probability for failure or success—this carries the additional benefit of demonstrating to the player that someone with depression, anxiety, and chronic pain may not be able to achieve their goals even if they can determine the best possible approach to the challenges that lie before them.

Second-person perspective is used to foster a stronger connection between player and protagonist. Though this perspective positions the player as the protagonist, several fourth-wall breaking passages suggest that the narrator—the "character" telling the player the narrative—is the true protagonist; the narrator hints to the player that the experiences contained within *threesixfive* belong to them, and the player exists as an observer. One passage in particular highlights this:

> You are not you. You are me. Or maybe you are you. Who can really say, for sure? You are whoever you want to be: me, you, your neighbor, that one cousin you only see at Christmas.

The effectiveness of second person narration in generating empathy can be undermined if the player is unable to reconcile elements of the player-character that clash with their own perspective; by acknowledging the uncertainty around the owner of the pronoun "you", I attempt to offer the player alternative ways to interpret the protagonist character. The intent here is to prevent players from disengaging from the content if they encounter parts of the character that are not applicable to them as a person and maintain the potential for building empathy and understanding.

Chronic health conditions, by definition, are a recurring problem. This is captured by the title, *threesixfive*, which references the fact that managing chronic health conditions is a challenge every day of the year. This notion is demonstrated through the use of nondescript language and deliberate ambiguity throughout the narrative, which allow the events to be applicable to as many contexts as possible. Each of the four endings concludes with a link to the opening passage; this reinforces the cyclical nature of managing a chronic health condition—there is no true "ending".

Therapeutic benefits. The development of *threesixfive* did not "solve" my chronic health conditions or the issues surrounding them—the same number of hours exist in each day, as do the same number of necessary tasks. However, the process of creating *threesixfive* helped me to externalize the problem, which allowed me to stop fixating on these issues and instead use that time productively and thereby feel better and more accomplished. Designing my life as "winnable"—including some design ideas that did not make it into *threesixfive*—contributed to an improved mindset: I could frame each day as a minor victory worth striving for to minimize the overwhelming feeling, and—paradoxically—attribute wasted or unproductive days as minor setbacks in a large system of continued successes. Indirectly, the process of sharing *threesixfive* online has been met with positive anecdotal comments from players who enjoyed the experience of seeing themselves or their struggles represented; this feedback validates my experiences and allows me to feel understood, thereby reducing some of the baggage associated with living with my chronic health conditions.

3.4 *The Icecream Parlour* by Alayna Cole [4]

Introduction. *The Icecream Parlour* is a satirical exploration of sexuality and people's stereotypical views in response to others who have similar or varied sexualities or gender identities. The interactive narrative was designed to increase understanding of some typical experiences people have in relation to sexuality, not just within the perceived dichotomy between heterosexual identity and queer identity, but also between identities within the queer community.

Motivations. The creation of *The Icecream Parlour* was motivated by the lack of empathy that I have witnessed personally and professionally for the experiences of others in relation to sexuality. The narrative was created so that I might experience catharsis in response to discrimination for people of differing sexualities, with the secondary goal of the narrative acting as a tool that can aid in catharsis for or increase understanding in readers.

Design choices. The player is able to select the icecream flavor they are "attracted to" in the opening passage: vanilla or strawberry. In addition, the player is offered an alternative flavor ("something else"), an option indicating indifference ("any flavour is fine"), and a choice not to eat icecream at all ("no icecream, thanks"). These five options are a simplified representation of the spectrum of diverse sexualities, which becomes clearer in the passages that follow: vanilla symbolizes heterosexuality; strawberry symbolizes gay/lesbian identities; alternative flavors symbolizes attraction to non-binary genders; the 'indifferent' option indicates a person's inability to choose a "favourite" option from those offered and is designed to symbolize plurisexual identities (such as bisexual, pansexual, non-monosexual, and other multi-gender attracted identities); and a dislike or disinterest in icecream symbolizes asexuality.

The narrator of *The Icecream Parlour* refers to the player in second person; however, the narrator also hints that the "you" being addressed is not necessarily the player themselves, but an alternative protagonist whose experiences the player is simply observing. The opening passage indicates this:

> Welcome to my icecream parlour. This is where your story begins.
>
> And yet, it is not your story. It is the story of many, and the story of no one, and the story of somebody else, whose perspective matters just as much as your own.

Second-person perspective allows players to identify with the protagonist if they choose to or are able to, but also allows them to distance themselves from the protagonist and suspend their disbelief if the protagonist's responses and reactions differ from their own. This allows for multiple playthroughs of the interactive narrative, with some acting as cathartic and others acting to increase the player's understanding of the experiences of others.

The Icecream Parlour features nine endings, with different degrees of variation. Each resolution ends with an invitation for the player to return to the opening passage and play through the interactive narrative again, embodying a different identity and thus experiencing an alternative perspective.

The most common resolving sentence is "You're safe here, dear. I don't judge. Have whatever flavors you like and come back any time," which features in five of the nine endings and can be reached by choosing any flavor but "vanilla" in the opening passage. This design choice was made to indicate the judgement and prejudice that all sexualities outside the societal norm can experience. It is important to note that not all discrimination against members of the queer community comes from outside the community; different identities within the queer community can also be prejudiced against one another. This type of discrimination is demonstrated in the following passage:

> Sometimes the whispers even follow you here, among people who are meant to be supportive, but generally this is a safe space. A community.

The positive ending that can be reached after choosing 'vanilla' in the opening passage is resolved with the line, "You're welcome to return when you are in need of another scoop." This line can also be reached after choosing "strawberry" in the first passage. In both cases, the player must agree that there is no point to abusing others for being attracted to a different flavor; this is designed to symbolize an ideal coexistence between those who desire same gender relationships and those who desire other gender relationships. A more negative ending can be reached by choosing to abuse those with different opinions on icecream. Although the narrator adopts a much more aggressive persona in this resolution than the others, it is still not an entirely negative ending as the narrator still offers for the player to return to the icecream parlor if they are more willing to be open-minded about icecream preferences, and therefore sexualities.

An alternative, neutral ending can be reached by choosing "no icecream, thanks" in the first passage. This leads the player to a passage that emphasizes the importance of empathy in *The Icecream Parlour*, as the resolution sentence encourages the player to start the narrative again and become "a friend who has always loved icecream", to see the world from their perspective.

Therapeutic benefits. *The Icecream Parlour* was created as a form of catharsis, both for myself and for readers who share my personal frustration at the triviality of the conflicts between people in response to sexuality and how this sexuality is expressed. This triviality is highlighted in the interactive narrative through the use of an absurd extended metaphor that connects sexuality or sexual attraction to a person's preferred flavors of icecream. The humor within *The Icecream Parlour*, as well as the unapologetically honest narrator, had therapeutic benefits for me as I wrote the narrative, as the process of embodying this character allowed me to express my beliefs and frustrations.

4 Twine's Potential in Writing Therapy

Games have been used for CBT, such as the Triangle of Life game [1] and SPARX [8], and have been effective compared to waitlists and to other types of therapy; however, Twine is not a fully created game to be experienced, but rather a writing tool for non-linear, interactive expression. As such, it can be used to enhance the experience of CBT even when games are present. For instance, after learning about the Cognitive Triangle in Triangle of Life [1] clients can use Twine to create their own story, carefully inserting their own thoughts, feelings and behaviors in response to the events in their lives. Similarly, the authors of the SPARX game supplied clients with a paper journal to record reflections as they played the game [8], introducing a separate written component to the CBT therapy experience.

Writing therapy is included in several forms of CBT, including the Trauma Narrative in Trauma-Focused CBT (TF-CBT) [3] and other journal/narrative interventions such as Online Structured Writing Therapy (OSWT) [13], Narrative Exposure Therapy (NET) [12] and Cognitive Behavioral Writing Therapy (CBWT) [16]. These forms of writing therapy all include: an initial writing of events, thoughts and feelings; a reflection on the thoughts and feelings to ascertain their usefulness and accuracy; and reframing of the thoughts and feelings to more positive ones. Two therapies, OSWT and CBWT, also include a final component of sharing the story with others.

Several writing therapists have noted the non-linear storytelling that naturally occurs during client memory recollections [3, 12], and have included it in the therapy process by having the client write and refine the narrative ad hoc, but rewrite it more cohesively after making connections. Twine can be beneficial for storing non-linear fragments of memory, creating links between thoughts and events, and even expanding on certain words or phrases between memories. Despite the non-linear nature of memory and the tangents that clients write in the moments they have stronger feeling, the Twine narrative will retain cohesiveness at the end, providing the client with full expression of their own thoughts while maintaining an organized document for others to read in the Social Sharing portion of therapy.

As an example, a client may begin a trauma narrative and then talk about noticing a vase in a room of their home. The client may want to expand on their feelings about the vase. Perhaps it was their mother's favorite item, or a special gift they saved up to buy, or they imagined they were a genie who was trapped in it. On paper, this would create an aside that may impact the flow of the story, creating a fractured experience for the client as they reread their work, and for others reading during social sharing. In a paper structure with space and organization constraints, the therapist and client might have trouble deciding where, and if, the details of the vase are included in the final document, especially if they don't directly pertain to the traumatic event. In Twine, however, the client could simply create a link that contains more details about the vase, with another link that returns the reader to the main thread of the story. If readers want to understand the client's thoughts about the vase, they click the vase link and read; if the reader prefers to simply follow the main story thread, they are free to ignore the link and continue on. This separation of non-linear thoughts allows the client to write and think in free-form because they can always add more detail later, and prevents the client from feeling like they have to be good at storytelling and writing. The software organizes the story fragments into a cohesive whole.

The non-linear nature of Twine also supports, and even encourages, multiple story endings. This allows the client to create an end narrative that acknowledges their unhelpful thought patterns and how those thoughts might affect them in a future, imagined reality, while also creating branches in which they successfully change their thoughts and patterns, and the positive future that results in. Upon re-experiencing the narrative, the act of considering the unhelpful thoughts and then choosing the positive thoughts can remind the client that they can choose their own thought path, which gives them control of their future despite the trauma of their past.

5 Implementation Strengths and Weaknesses

Cohen and Mannarino [3] have noted that clients of TF-CBT often choose to write trauma narratives using a computer. In those instances, Twine is easily presented as an alternate writing tool. Cohen and Mannarino [3] also note that TF-CBT clients sometimes use other forms of creative expression to present trauma narratives, such as poetry, drama, song and dance. With the wide variety of expression that TF-CBT in particular provides, Twine should integrate well and be quite easy to implement.

The low cost and time investment required to learn and use Twine makes the software suited as a therapeutic writing tool. The engine's functionality and ease-of-use makes it accessible to people who do not consider themselves game designers or creative writers, thus making the engine inclusive for clients and therapists. It is not necessary for a person to have an understanding of narrative theory or game design principles to create a narrative in Twine that can have therapeutic benefits for the writer; however, if a user of Twine has a background in game design or creative writing—as do the authors of the Twine narratives included in this case study—there is nothing to restrict the use of narrative theory or game design principles as a foundational for the resulting output. Therapy clients may choose to further their skills in these areas to enhance the Social Sharing portion of therapy in which others will read and interact with the work, however the primary therapeutic use of Twine is for the benefit of the client, and the resulting narrative will only be shared with those the client wishes to see it.

A possible weakness of using Twine for writing therapy is the assumption that a client will have access to a computer, either personally or through their psychologist. Another weakness involves the choices about where the narrative will reside. Confidentiality will prevent therapists from being able to share a computer with clients, so one will need to be provided for clients only. The therapist may also choose to use password-protected folders, or external USB drives to store client narratives so they are not accessible to other staff or clientele. Finally, some clients may want to write with pen and paper, or create a linear narrative with a regular word processor; in these cases, Twine can be offered for use after writing in order to reorganize narratives into an interactive format if the client wishes. The authors of this paper are not asserting that Twine should be the only form of writing offered within narrative therapy, only that it presents a choice that can enhance the effects of narrative therapy by helping clients express themselves and their stories more completely.

6 Conclusion

The association between stories and catharsis has been noted since the times of Aristotle and has been subsequently expanded to include the healing and liberating self-response of the author as well as the response of the audience [9]. Furthermore, it has moved beyond the literary realm and into psychology, observed as a way of expressing and discovering identity [7] and as a way of provoking therapeutic response with various forms of cognitive behavioral therapy [3, 12, 13, 16]. The interactive nature of Twine stories, and the ease of use as a choice-based narrative device makes it a possible facilitator in the use of cathartic storytelling both informally and with professional psychological assistance.

For each of the authors in this paper, Twine has provided a way to move through several steps that mimic writing therapy in a way that provides a self-reported therapeutic catharsis. We chose to write stories about our own life experiences, including any details we felt relevant to capture the aspect of the experience that we wanted to focus on. The interactive nature of the Twine writing tool enabled us to provide virtual choices for ourselves, and the process of enabling choice helped us to reframe our experiences and consider alternate ways of handling them. Had we been in therapeutic CBWT sessions, this process may have been strengthened, providing an even greater therapeutic response. Finally, each of these games is publicly hosted [2, 4, 14], allowing us to share our experiences, providing validation and closure. Although these stories contain self-reports of catharsis, these observations offer a basis for further research into the use of Twine in therapeutic situations. Should the use of Twine provide similar outcomes as traditional forms of writing therapy, then creators of serious games can be encouraged to not only make games that focus on educating others, but also to create cathartic experiences that benefit themselves.

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Super Alpha: Arabic Alphabet Learning Serious Game for Children with Learning Disabilities

Jailan Salah[1(✉)], Slim Abdennadher[1], Caroline Sabty[1], and Yomna Abdelrahman[2]

[1] Department of Computer Science, Faculty of Media Engineering and Technology, German University in Cairo, Cairo, Egypt
{jailan.salah,slim.abdennadher,caroline.samy}@guc.edu.eg
[2] Human Computer Interaction, Institute for Visualization and Interactive Systems, University of Stuttgart, Stuttgart, Germany
yomna.abdelrahman@vis.uni-stuttgart.de

Abstract. Children with learning disabilities need dedicated attention to cope with their peers in class. One way to help is using technological assistive learning means as an extra gate to learn different concepts. This study describes the findings of comparative experimental research that questions the effect of using serious games on these children's learning process. The main focus is the design, implementation, and evaluation of an educational platform with different games that are picked based on existing special teaching strategies. It is created to question whether serious games can facilitate the work of the professionals or not by comparing it with a normal instructional method, in the context of an educational activity, which is learning the Arabic alphabet.

Keywords: Learning disabilities · Serious games · Children · Education · Arabic

1 Introduction

The usage of technology for educational purpose is a well-established and growing research area, namely educational systems for children with learning disabilities. One of the main aims of exploring this research field is the involvement of these children in the society development, and utilizing their intelligence in a beneficial way. According to the IQ tests held by CDS,[1] students with learning disabilities have average or above average intelligence levels. However, they struggle with coping with the typical learning process. Hence, it is hard for them to accomplish their academic tasks properly. This leads to a wide gap between their intelligence and academic achievement, which could lead to frustration and other problems.

These children receive and process information differently because they have learning disabilities (LDs), which are hard to diagnose [2]. Learning disabilities exist in a huge part of our societies. Statistics of (NIH[2]) show that 60 % of adults with literacy problems had untreated LDs. Moreover, according to (NCES[3]), 41 % of children

[1] Center on Disability Studies, University of Hawaii.
[2] National Institute of Health, United States.
[3] National Center for Education.

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receiving special education services have LDs. Accordingly, the problem of promoting learning for LD children has attracted much of the interest of research. Studies have revealed that LD children are four to five times more likely to use special learning techniques rather than the normal ones [4]. In some cases, they achieve higher test scores provided that they are taught with the approaches that can cope with their disabilities [3].

In our work, we further investigated the teaching techniques for LD children, with the cooperation of experts working in rehabilitation centers in the field. One of the promising approaches is the usage of games as an assistive teaching technique [5]. We utilized the existing teaching strategies specially made for LD children, taking into consideration their psychological background, to build an engaging platform containing different educational games. The platform is called Super Alpha, and it aims at teaching them the Arabic Alphabet. We conducted a study to analyze and evaluate the effect of the developed platform on the learning process and outcomes. The focus of the study is to experiment the effect of serious games on the learning achievement of LD children compared to other normal teaching means that already exist. The developed platform was evaluated with a number of LD children, and its effect on them was compared to the effect of the normal instructional means they receive, namely the regular presentation slides used in classrooms. The tests were held to compare the effect of using serious games on two aspects: the learning achievement of the children, and their level of engagement during the learning process.

2 Related Work

Many research studies have investigated the potential of serious games. Education is the top field for gamification research with 26 % of attention [8]. According to [1, 2, 5, 6], the evidence provided about the impact of games is mixed. Some studies found positive effects, some found negative effects and some found no effect of using serious games. The studies supporting the positive effects of educational games reasoned this to the presence of the game elements, as games offer some factors that the regular teaching methods lack [5]. An overview of the existing work in this field is presented in order to highlight the points of strength, extract the research gaps and incorporate such aspects in the proposed design.

LeFCA [5] is a game for children with autism that presents basic skills for them in German. The results of the tests showed that having a game in native language for intellectually disabled children is promising. Accordingly, developing similar educational games for developing countries (see footnote 2) is considered to be effective, Super Alpha aims to achieve for the Arab children. CLES [12][4] is another project developing serious games addressing the learning process of persons with cognitive disabilities. Although it is effective, it is mainly designed for adolescents, not children. Moreover, it aims at enhancing the daily life processing skills not the academic achievement of the users. Ecriver Medialexie is an offline tool that addresses dysgraphia. Unlike games, this tool is not engaging and therefore is not helpful for children. Also, it supports

[4] Cognitive and Linguistic Element Stimulation.

the French language only. [13] is a game that aims at teaching Chinese, it tackles language learning in a good way. However, its mechanics are relatively complicated. There are software tools and recommendation systems that provide activities for LD children like Fast ForWord, Learning Works For Kids, and How Difficult Can This Be? However, they do not drive the incentive of the child to play. Finally, there are some existing games that teach Arabic language to children like ALADDIN [7], Salaam Arabic, and Araboh.com. Although they showed success for children, they do not address the LDs nor the intellectual problems. To sum up, the existing work shows the potential of using educational games for children, as well as some useful factors that were harnessed in our design. Some shortcomings exist, among which: addressing LD children, the rarity of the Arabic content, and the interactivity factor. This raises a need for having a game that utilizes all aspects together (children, learning disabilities and Arabic language) professionally.

3 Platform Design

LDs come in many forms, Hogan and Jones defined different deficit areas of LD including memory, organizational, attention, and many other deficits [2]. An LD child might experience one or many of them. Each deficit area has its own teaching strategies and guidelines. Super Alpha aims at tackling seven of the deficit areas and their recommended teaching methods. It includes different games, each targeting one deficit area, aiming to cover most of the common symptoms of LDs among children. This will add a customization and personalization element to the developed platform, to be tailored for the needs of the child.

3.1 Material and Theme

Deciding the curriculum to be taught was based on the input of the experts. An interview was conducted with a board of LD teachers from an early intervention center specialized in promoting the learning process of intellectually disabled children. The curriculum chosen is learning the Arabic Alphabet and words using the Montessori syllabus[5]. Learning through the platform, the LD child should be able to recognize the sound and the shape of each Arabic alphabet letter, along with distinguishing between the three different diacritic signs[6] of each letter. This curriculum was chosen because no prior knowledge is needed from the child. Additionally, it tackles the recognition not production of the language. Production needs extra observation from the teacher. Moreover, this curriculum could be efficiently assessed [7], which enhances the control and correctness of the study. Although LDs come in many forms, they share some symptoms like having difficulties in reading, recalling information, spelling words, and receiving language (known as dyslexia) [2]. That is why the platform built has stressed on the reading goals more than others.

5 An educational method based on self-directed activity and collaborative play.
6 Short vowel marks used as phonetic guides.

The main theme of the platform is a super hero who tries to save a city. In order to achieve that, the hero has to win seven different battles. A battle is represented by a game. Each game targets a certain learning skill that helps a certain deficit area in LDs. In order to win a battle, all the alphabet letters must be accomplished successfully in the game. Accordingly, the child has to pass all stages that contain different questions on the alphabet in order to save the city.

3.2 Games Description

Super Alpha contains seven different games, each game addresses a certain deficit area of LDs. The deficit areas are: memory, organizational, attention, visual, auditory, language processing, and writing deficits. Each game was chosen such that its design and mechanics serve the recommended methods of dealing with each deficit. [2] presents the characteristics of the LD deficit areas and their symptoms along with the teaching strategies applied for each deficit area. The game mechanics of our platform are based on these guidelines.

Each game in the platform has different levels that represent the five learning stages needed for the child to learn a certain letter in the alphabet. According to the Montessorri syllabus, and based on the interviews held with the experts in the field, these stages can be translated into five different levels in each of the seven games included in the platform as follows:

- Level 1: matching two identical objects and their names.
- Level 2: recognizing a word of an object given its image.
- Level 3: matching the letter with the words it starts with.
- Level 4: matching the letter with the images of the objects it starts with.
- Level 5: distinguishing between different words starting with the same letter but with different diacritics.

Regarding the game design, reviews were made such that the mechanics of the different games become suitable for the needs of the target group. According to [1, 5, 7] there are key components for successful computer games for children like: multiple exemplars, variety in methods used to teach concepts, on-repetitive trials, and customization. These factors were considered while building Super Alpha, our Arabic learning platform. Based on the previous work and the input of the experts in the field (given the children's preferences and psychological background), the main pillars of the game design in this platform are: using clear auditory material, giving encouraging and extra praise means, avoiding numbers and verbal instructions, using hints, and avoiding score deduction when answering wrongly. The games available in the platform along with the area deficit that each one tackles are listed below:

Hangman. This game is a typical Hangman game, where the player is asked to fill in the gaps of the missing letters of a certain word. The deficit area it handles the language deficit. Hangman was picked to handle this deficit because it depends mainly on introducing key vocabulary in context, stressing on the spelling exercises, and modeling slow and easy speech processing [2].

Maze with MCQs. In this game the player is asked to go through a maze to reach a final destination. Additionally, we added some obstacles along the way, represented as MCQs. In order to pass an obstacle, the corresponding question has to be answered correctly. The game handles the auditory deficit. This deficit's solving strategy depends on having a lot of auditory components, emphasizing word endings, giving instructions in non-verbal manner (we used arrows to guide the child through the maze), and avoiding spelling activities [2].

Memory Flipping Cards. This game asks the player to match two identical cards that are flipped down on the table after seeking the whole board for a short span of time. It handles is the memory deficit because it makes the players practice remembering the letters and their corresponding words, which enhances their short term memory performance. Memory deficit learning methodology depends on having repetitive memory exercises, keeping number of cards of vocab in hands, using simple questions like matching, and providing examples [2].

Puzzle. A puzzle game where the player gets to re-organize the scattered parts of the letter's image along with the images of the objects that start with this letter. Exceptionally, the child has first to pick the correct image that will be solved as a puzzle. This will come along with a preview image as an example for the child to imitate. The game handles the organizational deficit. The organizational deficit learning methodology depends on enhancing the structured way of thinking of the child, following clear directions, providing questions with organizational skills (like MCQ), giving examples, and the ability of putting things at their place [2].

Painting Letters. This game targets the writing skills of the player by having the Arabic letter on the screen, and asking the players to trace it with their fingers, without going outside the letter nor filling a small part of it. This game handles the writing deficit. It only aims at teaching the letter's shape to the player, unlike the rest of the games that teach three different words per letter. Hence, the difficulty levels of this game are different from the those of the remaining games included in the platform. The levels depend on making the task harder for the child. This is achieved by making the letter thinner for the child to paint and requiring a higher percentage of accuracy. It is designed for the writing deficit because it depends on providing practice in writing, following directions, knowing the shapes of the letters, using activities of visual aids, along with avoiding complicated hand tasks [2].

Drag and Drop. The classical matching game using the drag and drop gesture. It includes a set of empty cards with Arabic words or letters, and below them a collection of images that the child is required to drag and drop in the correct slot. The deficit area it targets is the visual deficit. Since children with visual deficits are highly recommended to avoid tasks or activities that include complicated visual components, this game (including empty cards that need to be filled) is considered to be suitable for them [2].

Shooting. The idea of this game is to shoot the correct components out of a group of moving objects on a board (e.g.: shoot all the words that start with a certain letter). The deficit area it handles is the attention deficit. This deficit needs introducing tasks that use signals to draw the attention of the child (the moving objects that the child is asked to shoot will be these signals), along with providing visual examples and steps, and giving extra praise to the child [2].

There are common guidelines to follow in all games like giving extra time for the child to finish the task (in the range of one and a half amount of time of the regular timings made for normal children) [2]. Moreover, giving constant hints to the children while playing, and providing them with detailed instant feedback in any game. Figure 1 represents all the games in Super Alpha along with the home and the choosing letter pages.

Fig. 1. Super alpha games: overview for the seven games in the platform in addition to the home and choosing letter pages

4 Methodology and Experimental Design

This work experiments the effect of specially designed serious games for LD children on their learning process, compared to other normal teaching means that already exist. This was achieved through implementing Super Alpha, and testing it with a sample of LD children. The null hypothesis states that there is no statistically significant difference in LD children's achievement when they receive two different instructional treatments: traditional computer assisted instructions (presentation slides); and serious games. The first hypothesis(H1) claims that LD children achieve worse academic results when they play a serious game rather than a computer based instructional methods. The second hypothesis(H2) claims that LD children are less engaged in the serious games rather than computer instructional methods. The Methodology presented by [9] to evaluate the gamification effect was used as follows:

4.1 Model Planning

It is a between-group design that has a control and treatment group, they resembled the computer assisted instruction and the gamified version users respectively. Participants were divided into two independent sub-groups of the same number of LD children. The first subgroup used the presentation slides teaching approach, while the second used Super Alpha.

In order to make sure that that the computer assisted mean had an equivalent content comparing to the one presented by the platform, the presentation slides were designed to be identical to the games' structure, following the Montessori syllabus as well. The platform consists of six content-identical games presenting three words with different diacritic signs for each letter, in addition to a writing game (each game has 5 levels). Accordingly, the presentation slides for each letter contain five different slides representing the stages of learning the Montessori way. The slides are repeated six times in order to make sure the children in different groups get the same amount of material repetition, to make the only changing factor the gamification one. As for the writing game, it was equated by including a slide with the shape of the letter and asking the child to trace it in order to learn how to write the letter.

4.2 Material Preparation

This phase includes defining the facilitators, environment, and task scenarios. There were two facilitators. A tester who sits at the back of the classroom observing and helping with any technical details, and a teacher who is right next to the child helping him/her if needed. The experiments were held in the children's classrooms. The device used was a touch-pad (9.7-inch iPad Pro). Paper-based tests for the evaluation as well as consent forms for the parents were used.

4.3 Sample Selection

Participants reflecting the characteristics of the target audience were selected from different early intervention centers specialized in the field. The selection was based on the academic level reached in the curriculum, as they were required to have minor background about the Arabic alphabet. Their age ranged from 6–9 years old. However, age did not matter as much as the academic phase of the child, as different levels of severeness can be found across LD children [4].

5 Test Conduction

A target population of 36 officially diagnosed LD children were randomly assigned into two groups (control group: $n = 18$, and experimental group: $n = 18$). Most of them shared the same LD symptoms of having problems in reading, recalling information and distinguishing between words. Each group was exposed to its respective learning mean during the experimental sessions. Participants in the experimental group played the 5 levels of the seven games consecutively, while participants of the control group were left with the equivalently designed presentation slides for the same amount of time. A session's duration of both groups ranged between 25 to 30 min, with arranged breaks in between.

In order to perform the comparison of the learning process between the two groups, learning gain as well as the engagement level of both were measured after using the corresponding learning instructional mean.

5.1 Learning Gain Test

Before using their respective version of educational software, each participant had a pre-test in the material embedded in the game or slides. An identical copy of the same test was given after using the perspective instructional mean. Participants were asked to answer the test with no help from the teacher unless there was a problem understanding the question itself. To ensure the homogeneity level of the experiment, the structure of the test was compatible with the material embedded in both means. It is a paper-based MCQ exam on a single letter of the Arabic alphabet (the letter to be presented either on the game or on the slides). It consists of five sections, each section examines one of the five stages of the Montessorri syllabus mentioned previously. Learning gain was calculated by subtracting the number of correct answers that the participant got in the pre-test from the number of correct answers received in the post-test. By comparing the learning gain of both groups, conclusions were drawn about the educational effectiveness of the serious game versus the presentation slides.

5.2 Engagement Test

Another test was held for the participants in order to draw conclusions about the difference between the engagement level of the two different means of learning.

It is a 5-likert scale standardized questionnaire inherited from [10], it consists of 9 items that measure the overall flow of any activity through measuring two factors: control, and enjoyment. A hard copy of he questionnaire with the 9 questions and 5 possible likert scale answers for each question was handed to the tutors right after the session. They were asked to fill it according to their observations for the children while interacting with the respective learning means. By comparing the results of both groups, conclusions were drawn about the engagement level of the platform versus the presentation slides.

5.3 Flow Test

According to [11], flow is defined as "The holistic sensation that people feel when they can act with total involvement". Csikszentmihalyi's model represents flow as a channel between the skill and the challenge the user finds in any activity. Flow is present in an activity where there exists a balance between skill and challenge levels. If the challenge is higher than the skill, the user will experience anxiety. If the skill is higher than the challenge, the user will suffer from boredom. According to [10], flow is considered to be more of a continuous process rather than a final state. Thus, another test was held for the group exposed to Super Alpha. This test's aim was measuring the flow of the different games in the platform according to the participants' skill and challenge measurements in each different level. Two five likert scale questions were presented to the tutor of the child to answer during the session. They rate the challenge level and the skill level the child felt going through the same activity, respectively. This was done after each of the five levels in each game of the seven games. This gives a total of thirty five items to answer per participant.

6 Results

Data was collected to be analysed on SPSS (Statistical Package for the Social Sciences) in order to have an understanding about the effectiveness of the platform. An independent t-test was held between the two groups in order to compare between the learning gain as well as the engagement level for the different instructional means.

6.1 Learning Gain Results

The results of the test between the two groups revealed that the learning gain was normally distributed for both groups and that there was homogeneity of variance as assessed by Levene's test for equality of variances ($p = 0.67$). It was found that after the two interventions, the learning gain resulting from using the game as the educational mean ($M = 3.00$, $SD = 1.36$) was significantly higher than the gain of the other group which used the presentation slides ($M = 0.67$, $SD = 1.28$) ($t(18) = 6.077$, $p = 0.00$) with a difference of 1.977, standard error difference of 0.4673 and 95 % confidence interval from 1.95 to 3.92. This rejects the hypothesis stating that LD Children achieve worse academic results when they play a serious game rather than normal instructional methods (H1).

6.2 Engagement Test Results

The results of the independent t-test between the two groups revealed that the ratings representing the engagement level of the group of children who used the game as an educational mean ($M = 4.28$, $SD = 0.47$) were significantly higher than the ratings of the engagement level of the other group that used the presentation slides ($M = 2.35$, $SD = 0.66$) ($t(18) = 9.95$, $p = 0.00$). This was reported with a difference of 1.92, standard error difference of 0.192 and 95 % confidence interval from 1.51 to 2.31. This rejects the hypothesis stating that LD Children are less engaged in the serious games rather than normal instructional methods when it comes to carrying out an educational activity (H2).

6.3 Flow Test Results

For the flow test, Fig. 2 shows the skill versus challenge rates for each game separately, while Fig. 3 shows how far each game was from the desired flow level. This distance was inherited from [10] and calculated using the form:

$$\text{FromFlowDistance} = 0.25\text{x}(\text{Skill} - \text{Challenge})$$

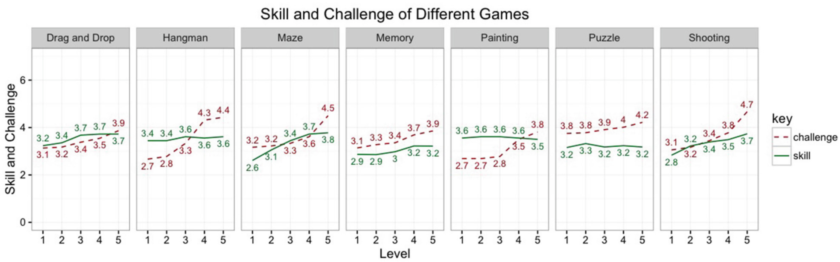

Fig. 2. Skill-challenge results for each game in the platform

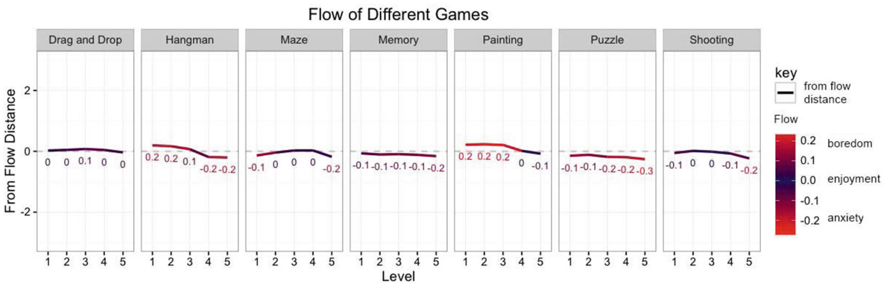

Fig. 3. Far from flow distance for each game in the platform

Some games reflected good flow rate and enjoyability throughout the sessions like Shooting, Maze, and Drag and Drop games. Other games were easier than the expected, where the children passed the earlier levels easily and did not suffer from the challenge like Hangman and Painting Letters games (skill > challenge). The rest were more challenging for the children where they experienced some anxiety trying to pass their different levels successfully like the Puzzle and the Memory Flipping Card games(skill < challenge). Another common observation is that all the games have ascending challenge level as designed by the Montessorri syllabus. Additionally, level 5 in all games had the highest challenge ratings, as it represents the hardest stage which is distinguishing between the three different diacritic signs of each letter. This indicates consistency in the design of the five levels for each game. To sum up, the overall flow of Super Alpha is acceptable, the results show that the participants had an enjoyable experience going through the different levels of the different games in the platform.

7 Discussion

The results show a statistically significant difference between the two instructional means used to teach the Arabic alphabet for LD children (presentation slides and serious games). This difference exists in both aspects: the learning gains and the engagement level, rejecting the null hypothesis stating that there is no difference in the children's achievement when they receive different instructional treatments.

The statistical analysis shows that using the educational gaming platform Super Alpha is more effective than using the presentation slides for the learning achievement as well as the engagement and enjoyment levels of the participants. This might get back to the presence of the different game elements in Super Alpha. These factors offer a more amusing teaching fashion compared to that of conventional computer assisted mean they are used to.

8 Conclusion and Future Work

Promoting learning for LD children is a growing research area. In addition to trying to hold an experiment that claims that serious games are beneficial for LD children, this study tries to describe the properties of a successful game design that is suitable for their needs. Super Alpha; an educational platform that was built based on the strategies applied for LD children; was implemented, tested, and compared with a normal instructional teaching mean. Data analysis showed significant differences in the learning achievement as well as the engagement level of the participants between the two instructional methods. Participants who played the game achieved higher scores and showed more motivation compared to those who were exposed to the presentation slides on the same content. This might be due to the existence of the game elements that affect the enjoyment level of the children, and accordingly their learning gain.

Further investigations need to be done on each game element in the platform in order to know which one affects the learning achievement the most for the LD children. Moreover, we can test the game with the non LD children to see the difference between them and their LD peers receiving the same games for learning. Super Alpha can be tested to support deeper curriculum (i.e. production not only recognizing of the Arabic language). Finally, a concrete test of the correlation between the usability and the learning achievement of the children, and an experiment that examines the effect of the different age ranges on the gaming preferences are needed.

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Building Social Awareness for Teens and Young Adults with Autism via Gamification

Valerie Gay(✉), Peter Leijdekkers, and Allan Pooley

Faculty of Engineering and IT, University of Technology Sydney, PO box 123, Ultimo, NSW 2007, Australia
Valerie.Gay@uts.edu.au

Abstract. Teens and young adults are in one of the most challenging phases of their life in terms of discovering new and complex emotions and situations. This is particularly the case for a demographic diagnosed with conditions commonly referred to as Autistic Spectrum Disorders, which is inclusive of Asperger's Syndrome. Through a video game medium, it is possible to place the players in virtual situations that explore these the intricacies of social interaction and relationships. This could be powerful for communicating such concepts: players can be explained to, practice and given feedback in a comfortable, non-threatening, and perhaps even familiar environment.

Our objective is to build such a game by modifying an already popular video game. Through modification, a game's already existing mechanisms and resources may be repurposed for *serious* functions. In the case of our team, this is to allow the player to have conversations that dynamically change depending on their input. Characters in the game can be manipulated to communicate verbally and non-verbally, delivering emotive lines recorded by voice actors whilst projecting certain facial expressions and body language.

We created a tangible video game learning resource that can be trialed to investigate its value to build social awareness.

Keywords: Game-based learning · Autism · Role-play · Social awareness

1 Introduction

Autism Spectrum Disorders (ASD) describe a range of conditions typically characterized by social deficits, communication difficulties, stereotyped or repetitive behaviours and interests, and in some cases, cognitive delays. A Survey of Disability, Ageing and Carers (SDAC) conducted in 2012 by the Australian Bureau of Statistics (ABS) [1] found that approximately 1 in 200 people within the Australian population, had an Autism Spectrum Disorder.

A commonly observed trait among children and adults with Autism Spectrum Disorders (ASD) is an often-impairing difference in their ability to connect socially, perceiving the emotions of others and communicating effectively. Serious games designed to address these challenges may significantly increase their understanding of emotions, social norms and complex relationships, bridging differences in communication between them and

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typically developing peers. Observing and recording the behavior of players interacting and making decisions of a social nature within a virtual environment could also potentially be of use to carers or educators in order to better understand an individual, and then make better informed decisions.

Our research team has identified a gap in serious game offerings available for high functioning autistic teens and young adults. They commonly have been observed to have an affinity with video games, technology and apps, they do not suffer extremely narrow interest and are less prone to be overwhelmed by complex multimedia material. Subsequently, our efforts are directed to modifying a popular video game to fulfill an education purpose: to train the social competence in youths and adults with ASDs. This may lead to both better understanding in the effectiveness in the medium of video games as educational tools, and also a means of discussing the situation for parents and carers. Modification, rather than development, also presents a potentially more accessible and feasible method for research teams to develop a Serious Game. Additional, by presenting educational content within a popular game, it allows the player to be immersed within a fantasy universe they may already be familiar with.

First, this paper reviews the current apps and serious games for training and treating the social, behavioural and communicative impairments that are commonly associated with autism with a focus on video games designed as Social Skills Training (SST) programs, which closely relate to our project. This paper then explains our approach to building our own tool, our experience modifying The Elder Scrolls V: Skyrim and the attempts to adapt it into a SST video game. It then presents the different aspects of the building the game and concludes with a discussion.

2 Serious Games and Apps for People with ASDs

Social Skills Training (SST) or Social Competence Intervention (SCI) programs are designed to specifically address the impairments in verbal and non-verbal interpersonal communication and social behaviours associated with Asperger's or High Functioning Autism [2]. With the prolificacy of technology, ICT tools are increasingly experimentally integrated into such programs.

At the time of writing there are more than 660 apps contained within a recommended list maintained by Autism service provider Autism Speaks [3], many of them purpose-built for users with ASDs. Observably, apps are the most prolific assistive technology available for ASDs at this point in time. This is can be attributed to the ubiquity, feasibility and social acceptance of smart device technology [4]. In a review of available apps for users with ASD [5], it was identified that most commonly applications focused on academic skills (literacy and numeracy), communication skills and emotional expression and recognition.

However, whilst apps are a widely accepted and growing avenue of software, people with ASDs have a particular affinity with video games. A study observing video game activity amongst 141 autistic, attention deficit (ADHD) and typical adolescent boys found that on average autistic boys spent more than 40 % more time on a day-by-day basis than their typical counter parts [6]. It is presumable that this interest would have a negative impact on social competence, as it is an activity that is typically done in isolation. However, there are both anecdotal and evidence based research [7] to suggest otherwise. The efficacy of popular, commercial video games to teach skills has also been investigated in a research based setting. The capability of video games to teach the social concept of sportsmanship, which included the practice of skills such as complimenting, turn taking, and being a good sport was trialed in [8]. In a Social Skills Training (SST) style program, they integrated the use of sports games on the Nintendo Wii to model and practice these desired social behavioural skills and they found that video games were an effective stimulus for teaching sportsmanship, with each of the trial participants showing significant improvements during post-treatment assessments and in generalisation.

Video games can possess certain attributes and mechanisms that are particularly indicative of supporting the development of social skills. Two of these include the creation of 'Social Stimulation' and the use of a 'Pedagogical Agent'.

The phrase 'Social Simulation' is used to describe the capacity in which a game can depict believable social interactions, creating engaging conversation between the player and characters in the game, or between two or more characters in the game observed by the player [9, 10].

The use of a 'Pedagogical Agent' refers to having a virtual tutor to fill the void of a live instructor. There are several ways to implement these agents: having them embedded within a game environment, which involves them actually having them immersed into the story and events unfolding in the game, or having them separate from the game. Goldberg et al. of the US Army Research Labs [11] investigated the use different types of 'Pedagogical Agents' in the context of the serious games they use to facilitate military training. Their research found that there was little difference between tutors being embedded and separate from the game, however there was significant benefit in the presence of a 'Pedagogical Agent'. The agent appearance, communication and discourse need to being aligned to the players of the game, as it helps stimulate aspects such as motivation.

In addition to integrating the use of commercial games into treatments and intervention, there is also existing research and development that considers the possibility of creating video games that are designed purely for players on the Autistic Spectrum. Video games that would contain content that intended to develop and improve skills that autistic people experience difficulty with, including cognition, communication and/or social behaviour and interaction. Two examples of such games include TeachTown [12] and Secret Agent Society [13]. The difficulty of creating such a game is that it often requires the significant effort of a multidisciplinary team. This approach can either simply be infeasible for a research team, or impact on the end quality of the game.

An alternative to creating a video game is rectifying an already popular game to meet your own needs, using the game and its resources (models, environment, gameplay mechanisms) to create additional content. Video game content created in this fashion is commonly known as a 'mod', short for modification. Morshirnia [14] makes strong arguments as to why makers of educational video games should consider making a mod instead of developing a game from the ground-up. It is of Morshirnia's opinion that educational games are commonly perceived as developed at an amateur level, with outdated technology and quality, and lacking entertainment. In order to successfully appeal to the gamer in students, a game must be capable of matching commercial game quality that players have come to expect. Many games are now released with game editors included, a feasible way of developing an education game might be creating a mod through the utilisation of these editors.

3 Encounters Skyrim – Game Development

This section will discuss how we approached modifying The Elder Scrolls V: Skyrim to create an interactive Social Skills Training (SST) tool. The Elder Scrolls V: Skyrim is considered an action role-playing game, as it allows the player to create their own character which becomes the central figure in an immersive story. Time spent playing Skyrim typically results in the development of the player's character, by learning new skills and/or acquiring new equipment. The content of the game is delivered into segments of objective driven story, known as 'quests'. Players find these quests by speaking to characters dispersed throughout the world, and most quests involve combat.

A survey conducted by Mazurek [8] collected the perspective of 58 adults on their preferences and perspectives of video games. Role-playing games were identified as the favored genre, Skyrim [15] being specifically listed as a commonly considered 'all-time favourite game'. It is a particularly strong candidate for implementing an SST because of the wide variety of mechanisms that can be utilised to support social simulation, specifically it has a detailed dialogue system. In this dialogue system characters can communicate verbally and non-verbally through the manipulation of their facial expression, the tone of their voices and performed gestures. In addition, Skyrim includes an editor for community members to create mods, which means making content for this game is very achievable. It was therefore decided that The Elder Scrolls V: Skyrim was the most suitable game to modify for our project.

We used the design methodology proposed by Tang et al. [16] and this paper focuses on the 8 first phases of the design

1. Define learning objectives and design goals
2. Understand learners
3. Identify learning activities for learning objectives defined in activity 1
4. Sequence learning activities in increasing complexity order
5. design the story to set the scene and link learning activities defined in activity 3;
6. Design game mechanics for learning activities defined in activity 3,
7. Design game components and associated behaviours,
8. Design scenarios and game-play for learning activities defined in activity 3 using activity 4 and activity 5,
9. Prototype game level,
10. Evaluate prototype against learning objectives,
11. Refine the game level;
12. Finalise educational game and
13. Quality assurance test on educational game.

Table 1. How social challenges corresponded to the story within our game.

Social challenge being addressed	Origin of social challenge	How it is represented within the scenario	Feedback within the scenario
Initiating a conversation	Aspect Autism Launchpad [17] 'Preparing for Life', [18]	The player is placed in a situation where they need to introduce themselves and meet entire crew of a pirate ship	How the character appears to respond to the approach in the scenario (tone of voice, facial expression, body language) Feedback in top left hand corner (text feedback indicates whether character approves, disapproves, etc)
Engaging in a conversation – taking interest in what another person has to say, their interests and their accomplishments	Aspect Meet [19] Aspect Autism Launchpad [17] 'Preparing for Life', [18]	The player needs to establish trust and a relationship with each of the crew members of the pirate ship. In order to achieve this the player must use the interests observed when first speaking to the crew member to engage in a conversation	How the character appears to respond to the approach in the scenario (tone of voice, facial expression, body language) Feedback in top left hand corner (text feedback indicates whether character approves, disapproves, etc) Reward given to player, quality of reward indicates how well they have conversed with a particular character

Following a discussion of the project with Aspect (Autism Spectrum Australia), we decided the initial release of the game should be focused on the fundamentals of social interaction. The two main skills that were agreed upon were 1. Initiating conversation with a stranger and 2. Engaging in a reciprocating conversation, one that is mutually engaging and enjoyable. Before starting development, we also required a story that would be natural within the Skyrim universe, but could also present opportunities that would allow the player to practice these two particular targeted skills. It was decided that the player would be placed in a situation where they were held captive on a ship and must escape through means atypical to conventional Skyrim gameplay. The player would be directed meet each of the crew members on the ship, getting an idea of each crew members' personalities and interests. After meeting each of the crew members, the player then must use this information to develop trust with each of the crew members. It is necessary for the player to establish trust with each of the crew members in order to subtly acquire an item that will help them escape the ship.

Table 1 and Fig. 1 explain how the scenario can be broken down in terms of story and social challenges targeted. Figure 1 illustrates how each stage of the conversation the player has within the scenario is aligned with particular social competencies. Competencies are gradually introduced and added throughout the course of the scenario.

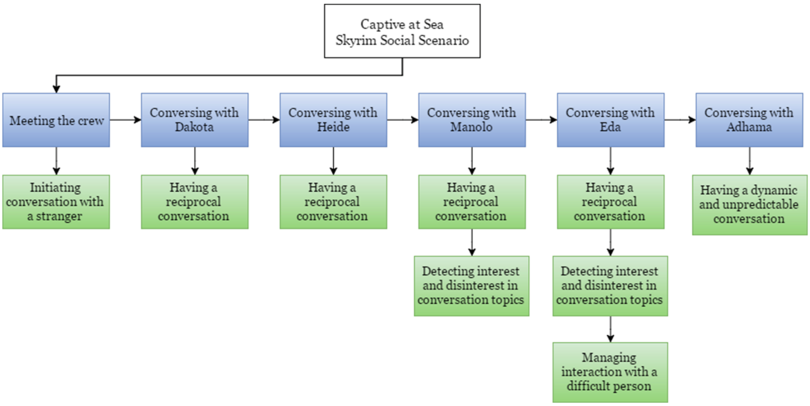

Fig. 1. Scenario and social competencies addressed

Dialogue options are presented to the player when they approach and then choose to interact with a character in the scenario. Conversation with a character is back and forth, with the player choosing from a range of prompts or responses throughout the conversation. These choices are presented within a dialogue menu as seen in Fig. 2,

Fig. 2. The player can choose from a range of dialogue choices with 'Manolo'. (Color figure online)

amongst the choices are those that represent desired and also avoided behavior. For the purpose of explanation these have been outlined in Fig. 2: Green outlined options indicate good choices, blue for neutral choices and red for bad choices.

Through the course of the scenario, the player first initiates a conversation with each of the crew mate on the ship, of which are five. Each of these characters possess a different attitude, demeanor and interests that should be identified by the player and taken into account for the current and future conversation. This is the first phase of the scenario.

The next phase involves the player engaging in a reciprocal conversation, using the information they have gathered in the first phase about the character's personality to start a conversations interest to the character they are speaking to or mutually shared. Once the conversation has begun, they must actively seek ways to maintain and engage in the conversation. In one such conversation, a character may ask a question, or for the opinion of the player. They can respond to these prompts with a dialogue option that shows their interest in the conversation, or an option that indicates disinterest.

Whilst for characters Dakota and Heide, encountered in the scenario, any type of discourse would result in a positive change in their disposition, for Manolo and Eda, later encountered characters, the player will have to intermittently decide during discourse whether to encourage the character to continue speaking on a certain topic or whether they should change the topic. The correct decision is ideally identified based on the character's verbal (tone of voice, choice of words) and non-verbal communication (facial expressions, gestures) whilst initially speaking about the topic.

These attitudes, techniques and concepts are advised and reflected on throughout scenario with the player through dialogue with Fobahn, the character acting as the player's 'pedagogical agent', an in-game coach. Dialogue between Fobahn and the character is strategically placed between each segment of the scenario.

4 Encounters Skyrim – Key Game Mechanics

Branching Dialogues: All conversation within the scenario is achieved through branching dialogues. This is the mechanism that makes discourse between the player and character change depending on the dialogue option chosen by the player. Conversation topics and lines are grouped and structured into branches to achieve this.

Character Disposition: In order to simulate the development or disintegration of relationships, our mod tracks a value representing the disposition of each character towards the player. Disposition can be increased by favorable choices made by the player in dialogue with the character, likewise disposition can decrease when unfavorable choices are made. The disposition of a character towards the player is observable through the way characters initially greet the player. For example, if the player has a negative disposition with Manolo, he might greet them by saying 'I'm a little busy at the moment', but if the player increases their disposition and speaks to him again he might greet the player by saying 'It's good to see you friend'.

Fig. 3. Example of in game rewarding, here the player acquired food supplies from Heide.

A character's disposition towards the player also impacts how willing they are to help the player. During the scenario it is the player's objective to acquire items of crew members that are necessary in order to escape (As seen in Fig. 3). When a crew member offers to help the player, their disposition will govern the quality or magnitude of this help. If disposition is low enough there are some characters who are entirely unwilling to help the player at all. Analysing the final numerical value of disposition the player possesses with each character at the end of the scenario is also useful for evaluating how effectively they have interacted throughout the scenario.

Voices, Facial Expressions and Body Language: In Skyrim, characters' facial expression can be manipulated to depict neutrality, anger, sadness, happiness, fear, disgust or surprise to varying degrees (Fig. 4).

Fig. 4. The five different emotions depicted through facial modelling in Skyrim.

Additionally, whilst voices were being recorded for each of the characters, voice artists were instructed on the context of each line they delivered. This allowed voice artists to apply expressive intonations suited to the context of each line. These mechanisms allow characters to communicate through both verbal and non-verbal means to the player.

In-Game Mentor: Fobahn, the wizard locked inside of the cage with the player acts inexplicitly as their mentor. Fobahn guides the player through their escape plan, can give advice on how to effectively communicate and offer feedback on the player's interactions with the crew. In the story, Fobahn explains that he is qualified to give the player feedback on the premise that he is secretly using magic extend his natural hearing to listen to the player as they converse with the crew (Fig. 5).

Fig. 5. Fobahn, the in game mentor, offering the player advice and feedback

Fobahn was purposely modelled, scripted and casted (voice actor) to emanate the personality of a non-judgmental, easy going and approachable teenager. This was in response to Goldberg and Cannon-Bowers [14] observation that if the appearance, communication and discourse of an in-game pedagogical agent aligns to its player base stimulate aspects such as motivation.

Fobahn's dialogue can alter depending on the actions performed by the player while conversing with other characters. In each segment of the game there is both undesired behaviour, that if performed Fobahn will comment on; and desired behaviour that Fobahn will congratulate the player on.

Personalisation: Aside from decisions made in dialogue, each player's gameplay experience can be differing in two aspects, the mode in which they choose to play and through the appearance of the character the player controls.

Fig. 6. How 'Guided Mode' is activated (left) and an example of prompts it enables (right).

There are two modes offered in the mod, guided mode and normal mode. In guided mode when the player selects a dialogue option that has changed the disposition of the character they are interaction with they are made aware through textual prompts in the top left hand corner. For example, in image to the right of Fig. 6, the player has chosen a dialogue option that has improved his disposition in Manolo, so a prompt explaining this appears in the left hand corner of the user interface. All prompts are written in the first person as though they are the thoughts of the player, this is done to maximize player immersion in the game. The player can also customise their character's gender, race and appearance through a menu (Fig. 7).

Fig. 7. Initiating customisation (left) and the character customisation menu (right).

This was done such that the player felt more connected to their character, and subsequently that the decisions they had to choose between were considered with greater weight because they would impact their character.

5 Discussions

This paper proposes a more accessible development pathway for research teams designing serious games and provides contribution to an ongoing discussion of how games might communicate concepts pertaining to the complex dance of social interaction. In this project we were able to identify the possible game mechanics for a game for communicating such concepts to the player. This included the implementation of an in game mentor that could encourage, correct, advise and guide the player, having characters either favor or disfavor the player based on past decisions they made and exploring how animated characters could express emotions both verbally and non-verbally. A preview video of the game can be found online [20].

Continued work on this project would involve testing gameplay with group of players in an experimental environment, a mix of players with and without high functioning ASDs. A trial, with both pre and post-test evaluation will be done to reveal the tool's capability to improve our players' understanding of social concepts theoretically and in practice. The trial would also assess the quality of the gameplay encasing our educational content, whether it is entertaining to the players, how obvious it is that it is intended for educational purposes. This would pertain to how well this tool has made use of a video game medium to deliver our content.

Two reviews conducted by Knight et al. [21] and Ploog et al. [22] assessed the state of assistive technology in 2013 concluded that there was a lack of empirical evidence to prove the efficacy of assistive technology in the intervention and treatment of Autism Spectrum Disorders. It was recommended that assistive technologies are used in conjunction with evidence based practices, not in substitution of. And it could be hypothesized that this is a likely case for the tool we have developed. It is acknowledged that technology can play a beneficial role in encouraging and stimulating the acquisition and improvement of skills, but at this stage cannot be relied on as a sole source of treatment. The content we created throughout the project so far spans for roughly 40 min of gameplay, which in terms of duration and reinforcement is of a far smaller magnitude that traditional SST.

Whether a popular video game can be modified to effectively evolve into a tool used to teach social competencies still remains to be proven. Our modification of Skyrim allowed us to illustrate the complexity involved in creating such a tool, conflicting with a balance between covering a curriculum, making it clear enough, and ensuring the entertainment of the player.

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Using Mobile-Based Games as a Means for the Self-treatment of Depression and Anxiety in Youth

Scott Cabot and Brett Wilkinson(✉)

Flinders University, Adelaide, Australia
{cabo0005,brett.wilkinson}@flinders.edu.au

Abstract. Long term cases of mental health conditions in Australians generally manifest before the age of 14 years old. Due to this statistic it is important to design cost effective approaches to allow young people the opportunity to self-treat the symptoms of their depression or anxiety. Furthermore, this paper aims to determine if providing these solutions in an age appropriate medium, through serious games on a mobile device, enhances the effectiveness of their treatment. A pilot study was performed to determine if playing serious games on a tablet device improved general mood and decreased heart rate in young Australians.

Keywords: Serious game · Depression · Anxiety · Young people · Mobile applications

1 Introduction

Depression and anxiety are a growing mental health concern. The World Health Organisation [1] cites that worldwide more than 350 million people of all ages suffer from depression. Half of all long term mental health disorders in Australia begin before the age of 14 while three quarters begin before the age of 24 [2]. It is because of these statistics that young people should be afforded the opportunity to access cost effective approaches to help them self-treat the symptoms of their depression or anxiety. One such cost effective method that is familiar to young people is video games. Video games developed specifically for purposes other than entertainment are known as Serious Games, *"The term 'serious game' is used in the games industry to describe games that have a useful outcome or that model real-life situations."* [3].

Russoniello et al. [4] tested the effect of playing casual video games to help improve mood and decrease stress. They found EEG patterns supported the belief that casual video games did have a calming effect on players. Rodriguez et al. [5] found that when using a Virtual Reality based serious game adolescents were able to effectively train and evaluate their emotional regulation strategies in order to maintain healthy behaviours. This study also reflects similar results of an experiment aimed at using Augmented Reality as a substitution for in vivo exposure to help combat the effects of cockroach phobia [6]. In many cases the games do not need to be digital in order for them to be effective as Fitzgerald and Kirk [3] demonstrated when they studied the effectiveness of the board game Snakes and Ladders on patient engagement in the rehabilitation process.

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It is important to look at traditional coping mechanisms and determine how they can best be "digitized" and moved into a format that youth are comfortable with. There are a large number of frameworks that already exist for treating the symptoms of depression and anxiety that are derived from the field of cognitive behavioural therapy. These frameworks include (but are not limited to): Acceptance and Commitment Therapy (ACT) [7]; Emotion Regulation (ER) [8]; and Mindfulness [9].

This paper looks at how mobile devices, along with an appropriate mental health framework can be used to deliver content appropriate serious games to youth. The games should allow them to help self-treat the symptoms of their depression or anxiety as a supplement to their normal treatment therapies.

Information collected from prior research indicated that Acceptance and Commitment Therapy would be a suitable framework to drive core gameplay experiences. Based on these results ACT was chosen as the mental health framework to digitize.

Acceptance and Commitment Therapy is a framework that extends well to game play because many of its subsets (or core principles) can be applied to the activities generally undertaken in play. Out of the six ACT subsets cognitive defusion and contact with the present moment were picked as the two focus subsets.

2 Mobile Application Design

As mentioned the subsets of Acceptance and Commitment Therapy currently used in regular "offline" sessions translate well to the digital space. In particular Mindfulness theory and the action of being present in the moment.

Using the ACT framework, a suite of four mini games was built, namely:

- Spaceman – In this game a lone spaceman is lost is space and does not know which way is up. The user has to rotate the device around and try and line the space man's head up to a randomly generated arrow.
- Avatar Meditation – Players help a popular children's cartoon character meditate. They are prompted to breathe in as the character floats down the screen then lightly press on the screen and breathe out as he floats back up.
- Stickers – Based on the ACT subset of cognitive defusion the player is prompted to write a negative thought about themselves. For example, this phrase could read "I am not good enough". Once complete the user picks one of four different themes, such as circus, beach, city or zoo. The goal of this game is much more self-directed, where possible the player uses digital stickers that match their chosen theme to make a vibrant pretty picture.
- Camera Painting – The Camera game was designed to be about mindfulness but also promote slight physical activity through light movement of walking. This was chosen because there is also a body of research that suggests exercise provides positive benefits to mental health conditions such as depression and anxiety [10–12]. The aim of this game is to fill in animal silhouettes with a randomly generated colour using only the objects available in the users' environment.

3 Method

This study was designed to gather both quantitative and qualitative measures. Specifically, user heart rate was to be collected as anxiety can often manifest physically with a common symptom being elevated heart rate. To add to this, users were asked to provide answers to pre and post-game in-application surveys. These surveys were presented to the user via a Lickert Scale represented via happy and sad faces. Users were asked to evaluate their current mood compared to how they would normally feel before the game and then re-assess it after a given play session.

In order to make other observations from game play experiences the mobile application stored two sets of data. The first is a log file that includes participant age, gender and games played. The other log related purely to each individual game play instance. For example, the gyroscope position of the tablet is recorded each second. Additionally, all touches to the screen including start point, end point and touch type are recorded along with specific gameplay conditions, such as how many animals are coloured in with the camera for the Camera Painting game.

The experiment was held over one session in Adelaide, Australia at Southern Vales Christian College Aldinga campus in a quiet space in their library. Participants that arrived with the appropriate consent forms were provided a Fitbit Charge HR device, a wrist based health wearable that has built in heart rate monitoring, a tablet with the installed application, forms to fill out heart rate and an instruction manual. After hearing about this experiment a further three young people approached the researcher to participate in the study so another session was run at a later date.

After an initial introduction and instructions the users placed a heart rate monitor on their wrist and sat down at a table. Upon entering their age and gender into the app the main menu screen of the application was shown. Before starting the user would note their heart rate and record it on the piece of paper. The user would then open the game, fill in the in-game survey asking them about their mood and then proceed to play the game. Once the game was finished the same mood survey was presented to the user. The user would then note down their new heart rate based on the previous game play session, they would also answer two general usability questions from the System Usability Scale questionnaire [13]. These questions were to help facilitate and clarify the qualitative data gathered from the participant on the device. For example, a user who has a lower post-game mood than pre-game mood may also have noted that the application was hard to use.

4 Results

All participants were aged between 9 and 16 years with no specific age being over-represented in the sample. Males made up 66 % percent of the sample, this result was slightly higher than the national average as noted in the Digital Australia 2016 report that stated 51 % of all gamers were female while this sample only contained 33 % [14].

Each of the participants were asked to record their pre and post-game heart rates in order to determine if playing appropriate games had a physically soothing effect.

The researchers' initial hypothesis was that playing appropriate games would provide a positive physical outcome. Due to the limited number of participants, making a strong correlation between the results and the previous hypothesis was difficult. There seemed to be no strong trend between playing games and a lower heart rate and the results seemed to vary significantly from participant to participant.

Due to the light physical activity involved in the Camera Animals game, heart rate may have been elevated due to moving around their physical environment. Therefore, the results were reanalyzed with the camera game omitted to determine if trends could be seen with the three games that all shared the same trait of being stationary while playing as seen in Fig. 1.

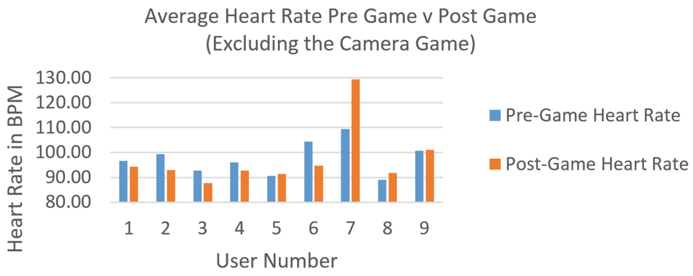

Fig. 1. Average heart rates without the camera animals game

Removing the Camera Animals game does show a stronger trend between lowered heart rate for games that do not require physical activity. As an average, there was an insignificant heart rate change of +2.58 beats per minute (bpm) for participants playing all the games. Excluding the Camera Animals game resulted in an even smaller average heart rate change of −0.33 bpm. If we consider user 7 as an outlier given the vast heart rate change compared to the rest of the participant pool, there is only −2.88 bpm change excluding the Camera Animals game. Both of these results are still quite marginally low considering a healthy resting heart rate in humans is quite broad ranging 60–110 bpm [15].

While there was no strong trend to suggest that playing appropriate video games did lower heart rate there was a much stronger trend that it improved mood. Of the nine participants, only two had a lower average finishing mood for their session than when they started. As can be seen from Fig. 2 no participant had an average starting mood less than three meaning that all felt 'neutral' or better. On average users within the experiment experienced a change in mood over each game of +0.24 using the arbitrary Likert Scale to make this calculation. While this was the average over all the games, many participants had their mood change only ±1 for each individual game.

The experiment also asked participants two post-game usability questions to try and determine if usability played a role in mood change. There was no evidence that usability played a major role in changing mood. The two SUS statements presented to the participants were: I think I would use this system frequently; and I thought the system was easy to use. Participants were asked to respond on a Likert Scale from 1–5 where one was totally disagree and five was totally agree. Although many of the games scored

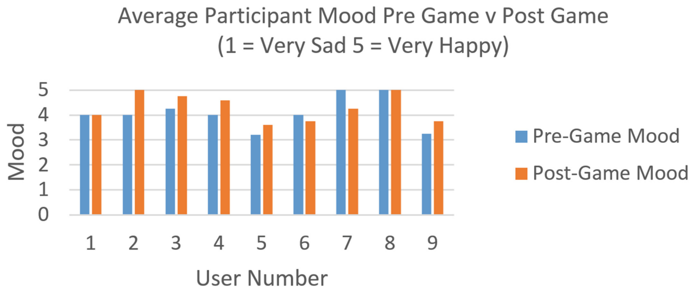

Fig. 2. Likert scale responses for average participant mood

strong usability ratings, and users said they would also likely use some of the games again, their mood would sometimes decrease over the play session. As an example Avatar Meditation had the majority of responses stating the game was easy to use however the majority of users also said they were unlikely to use it frequently.

There is no correlation between ease of use for any game and the frequency of use for those games. For example, Stickers has a strong ease of use component and would likely be used frequently. Conversely Avatar Meditation also has a strong ease of use component however would likely be used infrequently.

5 Conclusion

Due to the small sample size it is hard to draw strong conclusions from the experiment data. Nielsen [16, 17] suggests that usability testing can be done with as little as 5 participants as the number of unique problems they find account for over 75 % of the total problems found by larger groups. However, these results only hold true for the usability testing portion of the results and may not provide the same level of fidelity for the quantitative and qualitative feedback analyzed based on mood and heart rate.

The results above show some evidence that playing mobile games in a stationary position can provide both lowered heart rate and an increase in mood even if both of these changes are only small. This information however is only accurate for the sample population and this population did not necessarily identify with having either depression or anxiety. Although it could be argued that games need to be fun in order to be relaxing there is no research that suggests this is the only contributing factor. Rather entertainment can still be a worthwhile experience even if the experience itself is not purely hedonic (pleasure-seeking) [18].

Overall, many of the mini-games evaluated for the purposes of usability returned positive results. All games had more responses that were neutral or higher for ease of use than below. This does indicate to a small extent that users are comfortable with the device architecture and the controls used on that device. Again, a limiting factor to these results are both participant size and the lack of data with alternative architectures. While these games proved easy to use, and in some cases participants said they would use them frequently, there was no comparison between the efficacy of the games on desktop computers or laptops to provide contrasting results.

There is some evidence to suggest that playing appropriately designed mobile games does have positive effect on mood and heart rate. However, due to the limited participant size, target audience not suffering from depression or anxiety and the lack of more qualitative data more research would have to be conducted to verify these results. The data provides a strong platform for further study and highlights the depth of the problem being researched.

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Design for Happiness - Positive Psychology Through Social Media Games

Dale Patterson(✉)

Griffith University, Gold Coast, Australia
d.patterson@griffith.edu.au

Abstract. This project targeted the concept of happiness and the development of an intelligent social media game to utilize positive psychology techniques to enhance user happiness. The HeHa (Happiness Enhancing Helper Application) was built around the principles of positive psychology, including the identification and active pursuit of signature strengths. It functioned as a social media application and worked by encouraging, through gameplay and active suggestions, social media interactions that support the users personal signature strengths. A randomized control trial of sixty users was carried out to ascertain the effectiveness of the HeHa in enhancing interaction, satisfaction and happiness. The findings showed that users of the HeHa enhanced social media game demonstrated increased happiness levels using the tool.

Keywords: Positive psychology · Social media · Computer game · Happiness

1 Introduction

The pursuit of happiness is something that has engaged the scientific community for many years. A variety of approaches have been successfully identified as providing improved happiness levels. One of the most successful techniques is the use of positive psychology [1, 2]. Positive psychology developed from an initial body of work on overcoming learned helplessness [3]. From the initial techniques, that had successfully raised the wellbeing of depressed individuals, the positive psychology field developed to target a broader audience. Its objective was, not to simply treat those with an existing condition, but instead to offer methods to enhance the wellbeing of those who did not have any underlying psychological issue. Initial results from this positive psychology approach demonstrated significant improvements in reported levels of wellbeing and happiness [2]. Positive psychology moved from a single research project into an entire field of psychological research that has been applied, with success, in both face-to-face and online environments [1, 2, 4, 5]. The positive psychology approach involves the participant engaging in a series of questionnaires to identify "signature strengths". These signature strengths are unique to each individual and fall into a broad set of categories. The key to this approach is to identify the individuals' signature strengths, and then to actively enhance the participants' involvement in those areas of strength, thus leading to enhanced "authentic happiness" [2]. A number of experimental studies, including those involving face-to-face interventions as well as those involving online interventions

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have been undertaken to measure the effectiveness of positive psychology techniques, and these indicate significant improvements in wellbeing and happiness following the positive psychology interventions [5–8]. In the same time period, as the developing success of the positive psychology movement, social media tools have been a rapidly expanding sector of the software market and represent a significant communication mechanism for broader society. The recent work of Manicavasagar et al., has demonstrated the use of online computing technology and social media as a mechanism for engaging in positive psychology approaches. The direct application of the social media tool Facebook was also demonstrated in the work of Victoria Sosik and Dan Cosley, where the social media tool becomes the communication mechanism between the patient and psychologist with demonstrated positive effect [9]. The success of these systems is largely dependent on how effectively the participant pursues their signature strengths. As with many interventions the effectiveness of the technique drops away over time if the participant is not actively reminded to engage.

2 HeHa Game - An Intelligent Happiness Application

The objective of the HeHa game was to enhance user happiness through a combination of an expert system based on positive psychology techniques and a social media game interface to engage with the user. In simple terms the HeHa application sits between the social media tool and the user, adding a game element that encourages the player to interact with items that are related to their personal signature strengths. In terms of the interface that is presented to the user, the HeHa aimed to be as unobtrusive as possible. The key interface differences are the additions of the players' game progress and successes (shown when player runs up game interface, see Fig. 1) as well as highlighted "signature" events (these are the events that the application has identified as linked to signature strengths and are highlighted in the players normal social media tool interface). Highlighted events would be shown at the top of the page (as new posts highlighting possible interactions, see Fig. 2), as well in the form of notifications. The game is played primarily as a single user game. Initially involving the setup of the players' character; this involved the player answering an extensive series of questions (based on questionnaires used in Seligman's' work [1, 2]). These answers are then stored and analyzed to generate a set of "signature strengths" specific to this player. These are then displayed to the user as a set of treasure chests, one for each of the players' signature strengths (see Fig. 1). The fundamental visual style and game interaction is based on the 3D flow based interfaces, utilizing diegetic and transient components, as described in the works of Patterson [10–14].

Following setup, the player is then walked through an introduction where they are shown how the application of signature strengths (bonuses for multiple) in a time period (e.g. 1 day or week) gives them bonus treasure (essentially each time they interact with a different strength they get treasure & a piece of a map, and when they have pieces for all of their strengths they get a bonus treasure item).

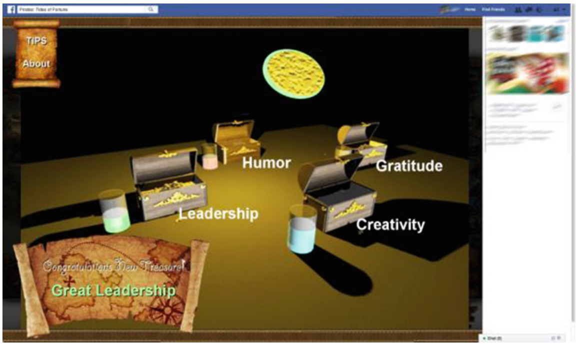

Fig. 1. Example game interface (showing "signature strength" chests)

The game moves into Phase 2, where the players normal social media interface and interactions are used. The game analyzes every social media interaction (including incoming and outgoing news/comments) and for those that are related to "signature strengths" they are highlighted/suggested to the player (using comments in main news timeline and notifications, see Fig. 2). If the player engages in the suggestion, they then receive a reward, in the form of treasure towards the relevant "signature strength" treasure chest (see Fig. 1).

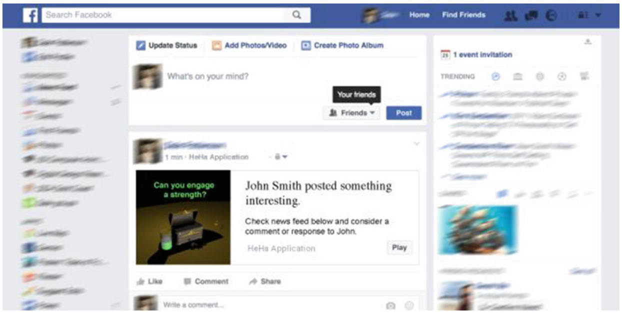

Fig. 2. Social Media news/comment feed example

2.1 Intercepting Social Media Interactions

The HeHa game works by intercepting the Graph API changes that occur for this specific users social media public feed (i.e. news, notices, posts). It receives any interactions, both inputs and output, that the social media tool receives and based on those interactions then presents the information to the user in an interactive gameplay based form. Analysis of each specific social media interaction is based on parsing the textual content and searching for particular items or terms. Depending on the nature of the users identified signature strengths the HeHa application then either enhances the interface presence of an interaction or diminishes/ignores its presence. This enables the tool to bring "signature" items to the forefront as key game elements. The HeHa application also gives acknowledgment through game points/rewards and makes suggestions. For example a user who associates with leadership they receive a suggestion to initiate conversation with others or initiate new groups. This suggestion seeks to generate new interactions that are led by the user and thus enables them to actively engage with their signature strength in leadership.

2.2 Implementing HeHa

The Facebook social media tool was selected (following a study identifying that 85 % of participants actively used this tool). The study also showed that the most active form of interaction was in the form of "likes" of other members posts, followed by "comments" on others posts, then initiation of new posts. The game application itself was developed as a Facebook app in JavaScript, that accessed the Facebook public feed and graph APIs to intercept public information on posts, comments, likes and notifications. These interactions were then parsed for key terms identified as being associated with signature strengths. The set of identified key terms was then sent to the Happiness Expert System for analysis. Following that analysis posts/comments/notifications were generated (to suggest and prompt interactions) and presented to the user through the Graph API (writing them into the users normal social media page content).

2.3 The HES (Happiness Expert System)

The Happiness Expert System included three key elements, firstly the questionnaire linked to the "signature strength identifier", secondly the database of key terms with potential actions, and finally the happiness knowledge system that uses a conditional rule based system to take the incoming key terms in conjunction with the stored signature strengths and to link them to appropriate actions (enhancing, generating or diminishing an interaction in the users game/view). The expert system itself is comparatively simple and involves rules that lookup tables of key terms (these tables are pre-created, and filled with synonyms of relevant terms, for each of the signature strengths). Where a term is found in both an incoming interaction and in the stored set of terms for a signature strength of the user, then the incoming interaction is highlighted for in game enhancement. If an interaction contains more than one matching "key term" then its highlight level was raised. After full analysis of all terms from an interaction the event is then reformatted for a gameplay based presentation to the user.

3 The Experimental Study, Results and Analysis

Measuring the effectiveness of the Happiness Enhancing Helper Application (HeHa game) was carried out through a randomized control trial of sixty users (N = 60) over a six-month timeframe. At the start of the trial the users were randomly allocated into either the control (n = 30) or happiness enhanced group (n = 30). Participants independently used the application for six-months, during that time users were surveyed at four points (start, 1, 3 and 6 months) regarding their satisfaction and happiness. Results from the study showed that members of the HappinessEnhanced group rated their happiness levels on average (across the four sample points at 0, 1, 3 and 6 months) at 5.8 (on a 7 point Likert scale), as compared to 4.9 for the Control group (see Fig. 3 chart showing mean values and 95 % confidence intervals). As Fig. 3 demonstrates these levels varied throughout the trial with the control group levels rising at the initial measurement point (1 month) but falling after the initial rise. The HappinessEnhanced group showed a larger initial rise, followed by a less significant decline in the same time period, leading to a statistically significant difference in happiness levels at the 6-month point.

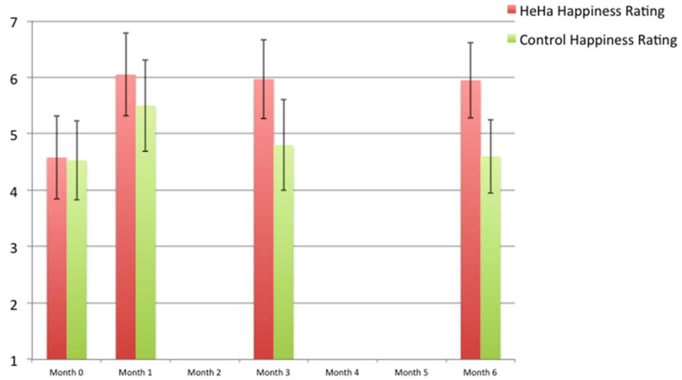

Fig. 3. User Happiness ratings at 0, 1, 3 and 6 months

A key result relates to the change in happiness level from start of trial to the end for users of the two systems. This result involved comparing the same user at each point to see how, and in which direction, they had changed their happiness rating. This was intended to remove the subjective nature of happiness reporting simplifying it to a directional change (either better, unchanged or worse). Overall 52 % of the control groups members changed their recorded happiness level in a positive direction, 30 % a negative direction and 18 % unchanged. In contrast 94 % of the members of the HappinessEnhanced group changed their happiness level in a positive direction.

4 Conclusions

The results from the study indicate that a computationally based intelligent social media game application, that makes use of positive psychology techniques can be effective in enhancing users level of happiness as self reported. The results also indicated that the HeHa application had been successful in maintaining raised happiness levels at the 6 month mark (where the control group had fallen after 1 month).

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Competitive vs Affiliative Design of Immersive VR Exergames

Kiran Ijaz(✉), Yifan Wang, David Milne, and Rafael A. Calvo

School of Electrical and Information Engineering,
University of Sydney, Sydney, NSW 2006, Australia
{Kiran.ijaz,Yifan.Wang,David.Milne,Rafael.Calvo}@sydney.edu.au

Abstract. Virtual reality (VR) can provide compelling experiences which might enhance users' engagement with physical activity. Despite the known health benefits of exergaming, there is a limited understanding of how various game designs impact user experience. This work proposes VR Rides, a virtual reality exergaming platform that combines a recumbent tricycle, real-world panoramic images, an Oculus Rift headset and a Microsoft Kinect camera, where the player can navigate real locations in a safe virtual environment. We further compare two game designs: a competitive guessing game and affiliative tour. This pilot study with both young and older adults indicates that task enjoyment ($r = 0.721$, $p = 0.000$), motivation ($r = 0.565$, $p = 0.009$) and connectedness ($r = 0.697$, $p = 0.001$) is higher in the competitive variant. Participants in both variants were highly engaged, likely due to the use of immersive VR. Descriptive analysis suggests that participants showed similar connectedness in affiliative tour (63 %) and competitive design (62 %).

Keywords: Virtual reality · Immersive VR games · Exergames · Game design

1 Introduction

Physical activity is widely recognized as key for reducing risk of many health issues and to improve overall wellbeing. According to World Health Organization's report, lack of physical activity is the fourth leading risk factor for mortality causing an estimated 3.2 million deaths worldwide [1]. An active life style is particularly vital to control rising medical costs for those suffering various cognitive and physical problems who often have great difficulty navigating and recognizing familiar locations [2]. There is also alarming obesity rates among children, teenagers and adults globally [3]. In addition, age has a profound effect on mobility and can turn a simple walk around the neighborhood into a frustrating and frightening experience. Many seniors live an understandably sedentary life.

Exergames—games that encourage physical motion have grown in popularity recently. Health professionals use them as an alternative form of treatment and to promote an active lifestyle [4]. Some of these games were initially designed for entertainment [5], while others were specifically designed to motive people to change their sedentary behavior [6]. Lieberman [7] describes exergames as highly appealing,

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motivating and fun; and that provides exciting game challenges, a way to perform athletic or expressive activity and to socialize.

Over the last few years, virtual reality technology has been attracting a lot of interest in academia and industry alike. VR headsets such as the Oculus Rift can provide extremely rich and immersive virtual environments. This could be combined with exergames that already aim to capture natural motions [8], to create experiences that are vastly more engaging than traditional desktop or console games [9].

In this study, we compare two different strategies for motivating players to play a VR exergame: a competitive design that motivates players by competing against others to achieve certain goal, and affiliative design in which the motivational driver is to provide new ways for the player to connect with family/friends (e.g. sharing the game experience with them). Most games predominantly follow a competitive design approach [10–12] and although this might be effective for a young audience, it might not work for an older one. Age Invaders is one of the few exergames that involve affiliation rather than competition [13]. Nevertheless, the effectiveness of affiliative game designs requires further investigation.

In this paper, we present VR Rides, a combination of technologies that allows the user to safely cycle around almost any real-world location in an immersive virtual reality environment. We aim to compare competitive and affiliative game designs through a pilot study with both young and old adults. Moreover, we intend to collect feedback about VR Rides and how immersive virtual reality environment is perceived among various demographic groups.

2 Related Work

This project fits into an area of game design that seeks to engage and improve the health of both young and older players. Most games that encourage physical exercise are built around the Nintendo Wii [5], Microsoft Kinect [8] and Dance Pads [14]. When paired with careful game design, these sensors allow players to use natural body movements to safely simulate familiar real-world activities. Exergames for the elderly are most successful and acceptable when they allow players to operate at their own pace; i.e. Wii bowling is a better choice than tennis or boxing [15]. Ijsselsteijn et al. [16] argue that perceived health benefits of the underlying exergame should be clear in addition to good usability while designing for group such as older adults. Similarly, Sinclair and colleagues [17] emphasized that a good balance between factors such as game's attractiveness and effectiveness is important to design successful exergames.

Several other researchers have used a stationary cycle as a game controller [6, 10–12]. In these studies, players were able to navigate a landscape, compete with an avatar or play a puzzle game through pedaling. Authors in these studies report use of existing video games [11], competing virtual tours [6] and used uncomfortable cycle as game controller in a way that raise the safety concerns for groups such as old adults [10]. These studies have used display screen or monitors to interact with game environment and to display physical activity data. McCallum [18] divides health games into three broad categories: games for physical health (that require movement), cognitive health (that require reasoning) and social/emotional health (that encourage connectedness). Existing cycling based exergames facilitate physical and cognitive health, but largely ignore social aspects.

There are many factors that influence whether a game is engaging. Among younger players, the primary themes appear to be emotional arousal, challenge, competition, diversion, social interaction and fantasy [19]. However, it is not clear to what extent these motivations translate to older audiences. For example, authors in [15] outline that overly challenging an older player may be harmful, that social interaction should be limited to people that are already well known, and that simplicity and intuitiveness is key. Lindley et al. [20] suggest that the social interaction should be deeply personal rather than lightweight.

Przybylski et al. [21] show that self-determination theory explains the strong appeal of video games. The theory states that one's motivation to perform an activity depends on whether it satisfies three basic needs: competence (one's sense of skill), autonomy (one's sense of personal agency) and relatedness (one's sense of connection to others). VR Rides has been designed with these needs in mind. For example, the affiliative mode allows players with limited mobility to confidently navigate a city (competence), leaves them free to decide the direction and content of a tour (autonomy), and helps them to share significant locations and memories with loved ones (relatedness).

3 The VR Rides Platform

The main components of the VR Rides platform are shown in Fig. 1. It starts with a recumbent tricycle, which provides a safe, stable platform for physical exercise, and exerts minimal strain on the user's back. The rear (driving) wheel is suspended to keep the bike stationary.

A smartphone is attached to the handlebars, so that its internal compass captures the steering angle. The phone also communicates with a sensor attached to the rear wheel,

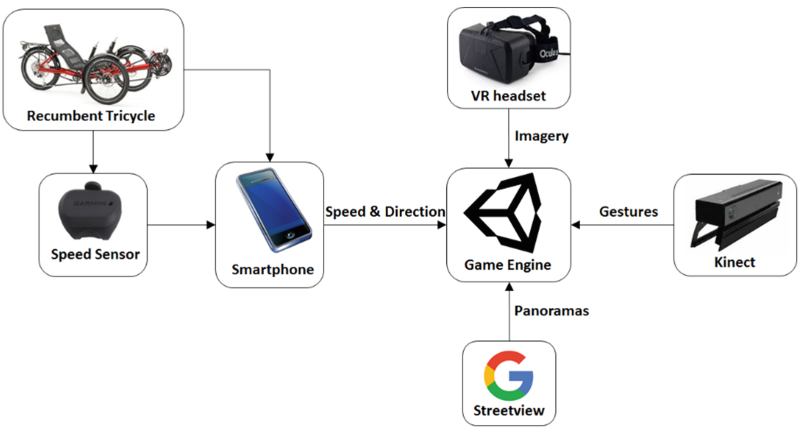

Fig. 1. VR Rides architecture

to capture speed. The user's speed and direction are sent to a laptop computer running the VR Rides game, which we developed in Unity. This game communicates with Google's streetview service, to fetch full 360^{o} panorama images of real-world locations.

This imagery is presented to the user via an Oculus Rift VR headset, which allows them to freely look around their environment. We also track the user's gestures via a Microsoft Kinect IR camera, so they can point at landmarks within the game.

4 The VR Rides Games

Having established the platform described above, the key challenge is to translate it into an experience that players with various age groups will find appealing. Young and old adults who do not have competitive mindset are unlikely to engage with technology simply for technologies sake, and may not respond well to traditional game mechanics. Consequently, we developed two distinct game modes:

4.1 A Competitive Guess Game

At the beginning of a level, the player is teleported to an unknown location within an unknown city. An onscreen compass and map point out locations of various landmarks they can cycle to, which might give them an idea of where they are. The level ends when they successfully guess the name of the city. This game has four levels, which increase in difficulty as the landmarks become less well-known and more distant from each other. The game starts with an in-game tutorial which describes the different game components. As shown in Fig. 2, players are assisted by a compass bar across the top of the screen, and a large map that can be viewed simply by looking down. There are also audio cues that indicate when landmark is nearby and when a wrong guess is made.

We need to be careful that players do not over-exert themselves, so the contest is not a race. It is instead a strategic guess game that requires players to predict where the nearby landmarks are located, and plan an efficient route between them. The player is asked to make verbal guess during the game and if the answer is correct it unlocks the next level and gains high points as per distance travelled. The score degrades with each unnecessary location (s)he visits.

To foster a sense of competition, the player can see their score directly compared against two other opponents. These opponents may be real or virtual, or even the "ghost"

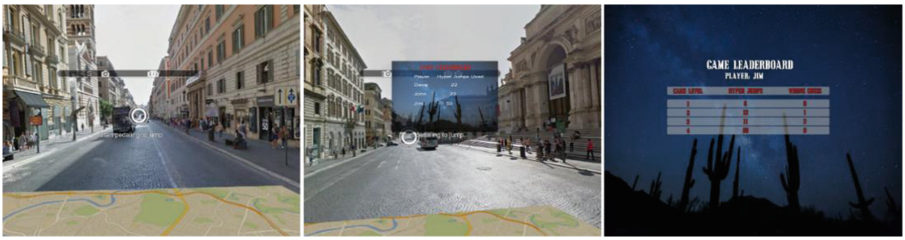

Fig. 2. Competitive game environment and leaderboards

of the player's previous performance. For the study described in Sect. 4, all players were aware that they were competing with virtual opponents. A leaderboard is presented on each level and before the game is exited, to reinforce the player's sense of competition and personal accomplishment.

4.2 An Affiliative Virtual Tour

In the affiliative design, players take a bike tour by cycling in different cities, listening to the introduction audio of major landmarks and taking photos of the views. This virtual tour game has three cities for players to choose from (Fig. 3), and three places of interest within each city. The tour starts with an in-game tutorial that describes the different game components. As shown in Fig. 3, players can use the compass bar and map to orient themselves and locate the landmarks. As they cycle towards a landmark, the distance and time taken are shown above the compass bar. When they get close to a landmark, an audio clip plays automatically to describe it. With the help of Kinect, players can also take snapshots by using right hand to point to the red camera icon. The green circle shows the position of hand.

Fig. 3. Affiliative virtual tour

The affiliative virtual tour gives the players same feeling as a sightseeing bus tour in a famous city: the virtual tourist can visit different landmarks, listen to historical information, and take pictures as a memento, all while exercising by cycling. The photo album generated during the tour can later be shared with family and friends. In contrast to the competitive design, this affiliative tour does not require players to achieve any particular goal, compete with others or improve performance during game play.

5 A Preliminary Evaluation of VR-Rides

5.1 Participants

Forty-three male and female participants of age between 18 to 92 years (21 females and 20 males, 21 = competitive group, 20 = affiliative group M = 47.29, SD = 22.8) registered for pilot study over period of two weeks. The recruitment was conducted in two separate locations; older participants (all aged over 60) were recruited from a local community center, while younger participants were recruited from undergraduates at the authors' university. One older participant had to be excluded after they experienced discomfort with the VR headset, and a young participant was excluded due to a technical issue. The remaining 41 participants were stratified by age group and then randomly assigned to the affiliative and competitive groups. Each game condition was allocated approximately ten older and ten younger participants.

5.2 Method

Each participant was allocated a time slot of 30 min to complete the study. On arrival, participants were briefed about the study and were requested to provide informed consent. They filled out screening and personality information in pre-test section of the questionnaire. Data was collected through a Likert scale questionnaire that included multiple questions for personality preferences, task enjoyment, motivation, and willingness to participate in future sessions. Participants were assisted into the recumbent trike and the VR headset, and given two minutes to become accustomed to them. Following this, players engaged with an interactive tutorial that explained the basic mechanics of the game variant they were assigned to, and were then left to play the game.

5.3 Results

Participants' Competitiveness Preference. Competitiveness index [22] (pre-test) and psychological (post-test) responses were collected through a questionnaire. This competitiveness index measures both enjoyment of the competition and contentiousness (diligence and being thorough). Investigating competitive nature of the participant's personality may help us find potential bias towards a particular game design. Based on the participants' responses, independent samples median test revealed that younger adults were significantly more competitive than older adults (p = 0.002, M = 3.25, N = 40). However, both young and old age groups shown no significant difference for contentiousness or conflicting situations (p > 0.05). Findings suggest that younger participants were more competitive in nature. Therefore, we might expect that traditional

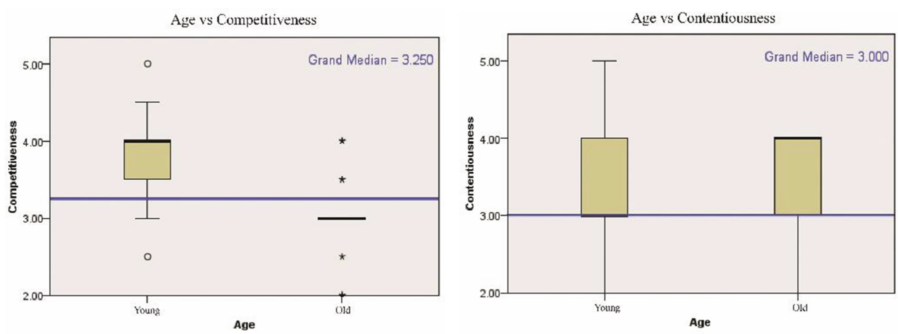

Fig. 4. Competitiveness index across the age groups

competitive game mechanics (scores, leaderboards etc.) could be less effective for seniors. Figure 4 shows the boxplots of competitiveness index across the age groups.

An aggregate frequency of participants' responses was calculated (see Table 1.). For each psychological factor (task enjoyment, motivation, performance measure, competence and connectedness), post-test responses were combined within category. Generally, participants rated agreed (50 %, 46 %, 44 %) and strongly agreed (34 %, 16 %, 13 %) for task enjoyment, motivation and performance measure respectively. In terms of connectedness, participants in affiliative design felt more connected (agree = 50 % and strongly agree = 13 %) in contrast to the competitive design (agree = 38 % and strongly agree = 24 %).

Table 1. Frequency of participants' responses

Factors	Strongly disagree (%)	Disagree (%) n (%)	Neutral (%)	Agree (%)	Strongly agree (%)
Task enjoyment	0(0)	2(5)	5(11)	21(50)	14(34)
Motivation	0(0)	4(10)	12(28)	19(46)	7(16)
Performance measure	0(1)	3(7)	15(36)	18(44)	5(13)
Competence	0(1)	6(14)	14(35)	16(38)	5(12)
Connectedness(Comp.)	0(0)	3(14)	5(24)	8(38)	5(24)
Connectedness(Aff.)	0(0)	1(3)	7(35)	10(50)	3(13)

* numbers be added to greater than 100 % of the sample due to rounding.

Most (80.5 %) participants showed interest in participating in future sessions in contrast to 18.1 % who reported unwillingness. Similarly, 55 % participants both young and old were interested to pay for the affiliative game. Whereas, fewer (33.33 %) in the competitive game group mentioned their willingness or interest to pay money to play. In competitive design, young adults were more open to pay than old adults (young = 6, old = 1). Box plots of two age groups with respect to psychological factors are shown in Fig. 5.

Game preference. Pearson correlation method shows that in both game designs (competitive, affiliative), competitiveness was positively correlated with participants' enjoyment, motivation and connectedness. In competitive game design, task enjoyment ($r = 0.721$, $p = 0.000$), motivation ($r = 0.565$, $p = 0.009$) and connectedness ($r = 0.697$, $p = 0.001$) were strongly correlated with competitiveness. In contrast, although there was a strong correlation, competitiveness of affiliative game design group was only marginally statistically significantly correlated with task enjoyment ($r = 0.402$, $p = 0.08$) and connectedness ($r = 0.402$, $p = 0.08$) and significantly correlated with motivation ($r = 0.459$, $p = 0.04$). Participants with competitive personality were substantially more biased towards the competitive than affiliative game design as shown in Table 2 Competitiveness was also correlated with age in both the competitive ($r = -0.544$,

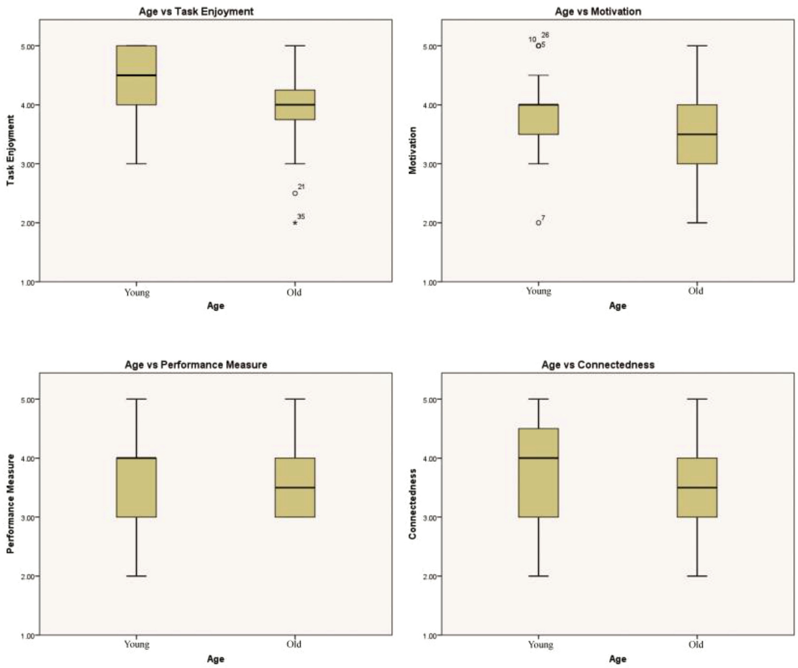

Fig. 5. Participants' behavior in different age groups

p = 0.01) and affiliative design groups (r = 0.739, p < 0.001). However, it was not associated with participant ratings of task enjoyment, motivation or connectedness.

Table 2. Role of competitiveness for game preference

	Competitive (*r*)	Affiliative (*r*)
Task enjoyment	0.721	0.402
Motivation	0.565	0.459
Performance measure	0.125	0.092
Connectedness	0.697	0.402
Age	−0.544	−0.739

There was small to medium negative correlation of age with task enjoyment, motivation and connectedness that suggest young participants reported slightly more task enjoyment, motivation, and connectedness in both games as shown in Table 3. Nevertheless, there was apparently small difference in relationship among these variable with respect to age for both game designs.

Mann-Whitney U test revealed no significant difference between the two game designs with respect to task enjoyment, motivation, performance, competence and connectedness. However, there was significant difference between young as opposed to old adults for task enjoyment (U = 122.5, $p = 0.015$).

Table 3. Preference of two game designs w.r.t age

	Competitive (r)	Affiliative (r)
Task enjoyment	−0.394	−0.286
Motivation	−0.146	−0.276
Performance measure	0.107	−0.105
Connectedness	−0.37	−0.198

5.4 Discussion and Study Limitations

This study compared two game designs (competitive and affiliative) for virtual reality exergames. VR Rides bridges all three categories of health game (physical, cognitive and social), but the emphasis differs between the two game modes. The competitive mode requires planning and spatial skills, and is focused more on cognitive than social health. The affiliative mode has a strong focus on social interaction, but also requires players to use their memory and language skills. Both modes require physical effort to move about the environment, but neither punish players for taking a relaxed pace.

Results indicate high task enjoyment and motivation levels for both age groups. We also aim to gather feedback about the VR-Rides platform that was well perceived by both young and old adults. In both game designs, participants showed equivalent interest. In contrast, it was observed that older adults connected really well during the affiliative tour which brought back personal memories. One participant mentioned, "I have never been this close to statue of liberty" while another said "Oh, I have been here but I forgot the name of this building". In this study, we mainly focus on comparing two game modes in relation to engagement, motivation, competitiveness etc. But impact of specific designs in terms of physical activity may reveal interesting behaviors. Participants of both designs showed positive response in terms of psychological factors. Nonetheless, bigger sample size would provide stronger results and much visible variance between the two game designs.

6 Conclusion and Future Work

This paper has presented VR Rides, an immersive virtual reality game that encourages both young and older adults to engage in physical and cognitive exercise. The game employs real-world imagery to provide a competitive guess game that challenges players to navigate environments, and an affiliative virtual tour that allows players to share memories and locations that are of personal significance. We deployed VR Rides into community center to evaluate in a realistic setting with wider audience. The primary measures of this study focus on motivation, connectedness, and engagement: e.g. whether players voluntarily register for future sessions with the bike. Findings suggests that VR-Rides was equally well perceived among young and old adults. Moreover, results shown that players with different personality type have different preferences in terms of game designs i.e. competitive and affiliative. However, in future we would also ideally measure whether access to these games has a lasting effect on one's motivation to adapt active life style and spatial skills.

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Science, Nature and Heritage

Exploring the Value of Simulations in Plant Health in the Developing World

Michael Thompson[1(✉)], Philip Taylor[1], Robert Reeder[1], Ulrich Kuhlmann[1], Cara Nolan[2], Jonathan Mason[3], and Joshua Hall[2]

[1] CABI, Surrey, UK
Michael.Thompson@cabi.org
[2] Bondi Labs, Brisbane, Australia
[3] University of Sunshine Coast, Buderim, Australia

Abstract. There is a growing opportunity to deliver mobile technology-based training on the diagnosis of plant health problems and to explore experiential learning through simulation in the developing world. Solving knowledge problems in plant health en masse would have a vast impact on global food security. "Plant Doctor Simulator" is an android tablet-mounted 3D modelling simulation to enhance and measure the diagnostic skills of plant health workers. The 3D models simulate symptoms of plant pest and disease problems on a variety of crop plants, and the game play data is stored in a web portal for analysis. Early stage testing results indicate that plant health advisors in the developing world are receptive to tablet-based simulation as part of a learning and teaching program. When evaluated as a diagnostic competency assessment tool, performance in Plant Doctor Simulator was found to be correlated to performance on a traditional written exam; however, further study is required to better understand the reliability and validity of the tool. Learning effects of the simulation are not yet conclusively investigated.

Keywords: Simulation · Plant health · Extension · Diagnosis · Competency · Assessment

1 Introduction

It is estimated that globally 30–40 % of potential crop yields are lost each year to pests and diseases [6]. Reducing these crop losses by even a small margin has the potential to feed significantly more people, especially if the effects are targeted at smallholder farmers in developing countries. Plantwise is a global programme led by the Centre for Agriculture and Bioscience International (www.cabi.org) that works to help farmers lose

Plant Doctor Simulator app GooglePlay: https://play.google.com/store/apps/details?id=com.BondiLabs.PD&hl=en.
Plant Doctor Simulator promotional video on YouTube: https://www.youtube.com/watch?v=yh8GOp57FOo.

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less of what they grow to plant health problems. Working closely with national agricultural advisory services, Plantwise establishes and supports sustainable networks of plant clinics run by trained "plant doctors", who are national extension workers that give farmers practical plant health advice. Plantwise currently operates in 34 developing countries, with over 1500 plant clinics, and has trained over 3500 plant doctors who in turn have influenced over 3,500,000 farmers.

Diagnosis of pests and diseases is a critical skill for extension workers (3); before giving useful advice to farmers, they need to first identify the problem. Like all development NGOs, Plantwise faces challenges conducting face to face training. Providing training for plant doctors is expensive due to the number and geographic spread of plant doctors, and the breadth of plant health problems that are required to be taught. There is also the additional challenge of being unable to carry infected plant material to the training, as travelling with infected live plant samples is often not allowed by national quarantine authorities.

What is required is a training and assessment tool that can scale out to thousands of users, effectively simulate the symptoms of the infected plant material on the screen, and allow users to practice diagnosing those issues whilst receiving feedback. Simulations can be seen as ideal tools for these kinds of situations as they have been found to be useful when aiming to improve and assess knowledge, skills and changes in behavior [2]. Ideally these tools should be designed to focus on integrating gameplay around core skills and knowledge. This ensures the tight coupling of learning and assessment with the most engaging parts of the application [3, 4].

1.1 Description of the Plant Doctor Simulator

The Plant Doctor Simulator is an android tablet-based plant inspection and diagnosis app that complements the face to face training modules of the Plantwise program. Plant Doctor Simulator was built by subject matter experts (SMEs) from CABI, with software developers at Bondi Labs. Real plants were scanned and pests and diseases rendered accurately to build models that can be rotated and magnified to reflect how diagnosticians investigate a damaged plant in real life. The combination of plant health expertise, simulation techniques and artwork has produced a tool that is designed to be engaging, scientifically accurate and credible.

The application was designed to infuse core learning/assessment outcomes with the interaction mechanics of the application [5]. This design process meant that core knowledge and skills required to be a competent Plant Doctor could potentially be learned and assessed through gameplay in an engaging way i.e. learning/assessing the skills and knowledge required diagnose plant health problems in the field and accurately reporting the findings. A core skillset required to be a Plant Doctor is to inspect a crop specimen with an unknown problem, and competently (a) find visual symptoms, (b) describe the found symptom, and (c) determine a likely problem cause. An example of this would be, the Plant Doctor is given a leaf with yellow spots on it. They should be able to identify the location of the spots, describe them as "Yellowed", "Spotted", "Necrotic". In some cases more than one crop specimen is investigated e.g. stem, roots. They should then be able to use that information to eliminate all known problems (for example virus, nematodes, bacteria, water moulds, nutritional) until a likely problem is selected (for example fungus).

Plant Doctor Simulator is unique at this time: there appear to be no other simulation-based apps used in agricultural extension training and competency assessment, and especially not in a developing country context. There are many apps used in agricultural extension, such as John Deere's Mobile Farm Manager, and the Kenyan Agricultural Commodity Exchange Limited (KACE) market information app. However, existing apps such as these largely focus upon providing market information to farmers or enabling data collection and farm monitoring, rather than training and assessment through simulation.

Users of the Plant Doctor Simulator are provided with over 20 engaging simulation scenarios of plant inspection and diagnosis, covering a range of pest and disease problems in globally relevant crops: tomato, cassava, maize and cabbage. Each simulation scenario allows users to visually investigate and describe realistic plant parts and symptoms.

Each scenario progresses in the following format 1: (Crop Information Screen) exposed the user to relevant cropping history and weather information for consideration during the diagnosis. 2: (Crop Investigation Screen) This screen presents the user with plant parts (leaves, stem, roots and fruit); see right edge of Fig. 1 below, and allows them to inspect and identify symptoms. This can be achieved by selecting on a visual symptom as well as making use of tools (zoom to real life still image of feature, cut, and tag). Interacting with a visual symptom will reveal the symptom descriptor menu, allowing them to accurately describe what it is they are seeing (see Fig. 2.).

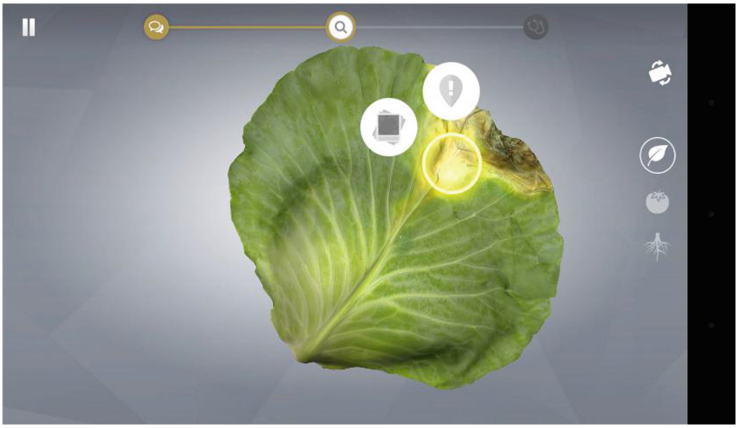

Fig. 1. Plant Doctors observe 3D symptoms and tag them as part of problem diagnosis (Source: Plant Doctor Simulator)

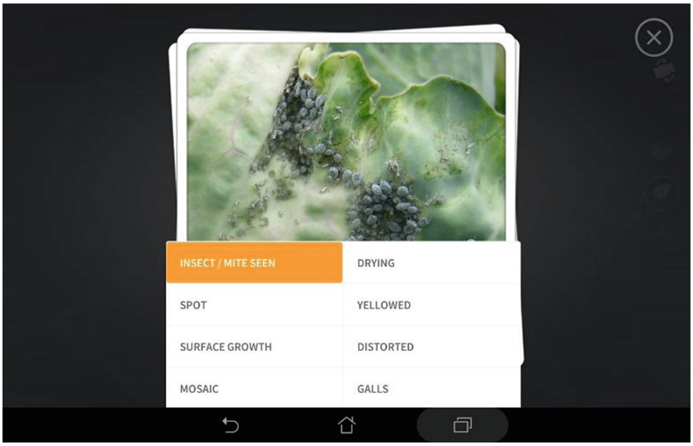

Fig. 2. After tagging symptoms, Plant Doctors observe real life pop-up images for labelling, as part of problem diagnosis (Source: Plant Doctor Simulator)

3: (Problem Diagnosis Screen) Once the user has tagged symptoms (see Fig. 2, above), they progress to the diagnosis screen (see Fig. 3). On the diagnosis screen users associate specific symptoms with possible diagnosis, which are represented by the hexagons below for bacterial, fungal, nematodes, phytoplasmas, nutritional, insects or water moulds (see Fig. 3). By having the user associate symptoms with their diagnosis, the Plant Doctor Simulator is recording how well they understand their decision. This mechanism of labelling symptoms and associating symptoms also reflects the real life decision-making process that plant health workers face every day. Real-time and contextualised feedback ensures users learn from their simulation experiences.

Fig. 3. Plant Doctors associate symptoms with problems as part of the diagnosis mechanism (Source: Plant Doctor Simulator)

4: (Scenario Feedback Screen) Following completion of a scenario, users receive a detailed overview of their performance. Key performance metrics such as symptom finding, symptom description, issue finding, symptom association and problem accuracy are fed back to the users in a detailed manner so they can improve their scores with repeated play. These scores are also recorded on national and global leaderboards available for other players to see, which can invoke a sense of healthy competition. All scenario data is saved to an online database.

Plant Doctor Simulator is an android simulation delivered through the Google Play store as well as Chinese app store, Baidu. Android was chosen as the delivery platform due its prevalence in the developing world generally, and the planned rollout of android tablets in the Plantwise programme for digital data collection and information delivery through a series of apps. Aside from English, can also be played in French, Spanish, Swahili and Chinese.

2 Methods and Results

Testing of the Plant Doctor Simulator is aimed at exploring the validity of the plant health diagnosis scores recorded by the simulation. With confidence in the validity of the simulation, Plantwise can draw usable and realistic conclusions regarding the competency of plant doctors from data gathered.

A hypothesis was initially explored aimed to determine if the Plant Doctor Simulator could be a valid substitute for more traditional paper based assessments:

H1: There is a positive correlation between plant doctor scores generated in the Plant Doctor Simulator and existing assessment methods.

The level of uptake and user engagement of Plant Doctor Simulator was also explored to determine the practical value of the training tool.

2.1 Study Design

The study used a repeated measure design to determine if there was any correlation between user scores generated from the Plant Doctor Simulator and a traditional assessment. Participants in the study were 21 individual plant health extension workers (plant doctors) from Rwanda (N = 11) and Sri Lanka (N = 10) who were part of the Plantwise program. There was a wide spread in the level of existing plant health knowledge: participants ranged from newly-enrolled plant doctors to experienced plant health experts doing a refresher course.

The study involved completing two activities; firstly an online assessment (traditional multiple choice exam), then playing the Plant Doctor Simulator. The online assessment was written by Plantwise experts, and tested content from existing Plantwise training material and included 25 questions covering the diagnosis of key crop problems and symptom observation based on real images. The types of crops, complexity and range of problems was matched to the scenarios in the simulation and took approximately 50 min to complete.

Following the online exam, plant doctors played the Plant Doctor Simulator. Plant doctors were introduced to the simulator verbally, and proceeded to register, sign in and play the tutorial in the simulation. Plant doctors then played the simulator, attempting every level at least once. Plant Doctors from both countries played identical versions of the simulator, as the crop and disease scenarios are relevant in both locations. Gameplay data was captured and examined in an online web portal.

Performance in the Plant Doctor Simulator is based on the scoring system based upon a weighted sum, which is designed to reflect the real life diagnostic process (outlined in Table 1 below). The primary and so most heavily weighted metric is "Problem Accuracy", which measures whether or not the user made the correct diagnosis on any given turn in the simulation. Describing symptoms (Symptom Description Accuracy) and associating them with a diagnosis (Symptom Association) is also key to making a well informed and thought out diagnosis, which is also reflected in the weightings. These two metrics also give insight into user understanding of their diagnostic process; the data can show well the user is connecting the symptoms they are observing with the final diagnosis they make. This information can then be used by Plantwise trainers to address knowledge gaps.

Table 1. Metrics as part of "investigation" and "diagnosis" in the Plant Doctor Simulator, and their weightings

Investigation	Percentage of total score
Issue Finding Accuracy	7.50%
Symptom Description Accuracy	17.50%
Total Investigative Efficiency	5%
Diagnosis	**Percentage of total score**
Problem Accuracy	40%
Symptom Association	25%
Total Diagnosis Efficiency	5%

Engagement and usage of the tool was also explored through field observations recorded during the Plantwise program. Individual user play time was captured to determine how long users were spending in the Simulator outside of the structured training Plantwise training workshops.

2.2 Results

In Rwanda (N = 11) and Sri Lanka (N = 10) the study (total N = 21) examined whether plant doctor competency as measured by the Plant Doctor Simulator was associated with plant doctor competency as measured by traditional multiple choice exam. Based on the results, it was found that plant doctors scored well on the Plant Doctor Simulator also scored well on the exam, with a Kendall's tau correlation coefficient of r t = 0.547 ($p = < 0.001$). These results indicate a moderate positive association between the two measures of competency, supporting our H1. This association between scores in the Plant Doctor Simulator and the traditional measure of competency suggests that the simulator may be a valid measure of plant doctor competency. In addition to this, multiple experts from both CABI and the wider plant health community reviewed content of the Plant Doctor Simulator at regular intervals during development of the project. These expert evaluations indicated it does possess some degree of construct validity.

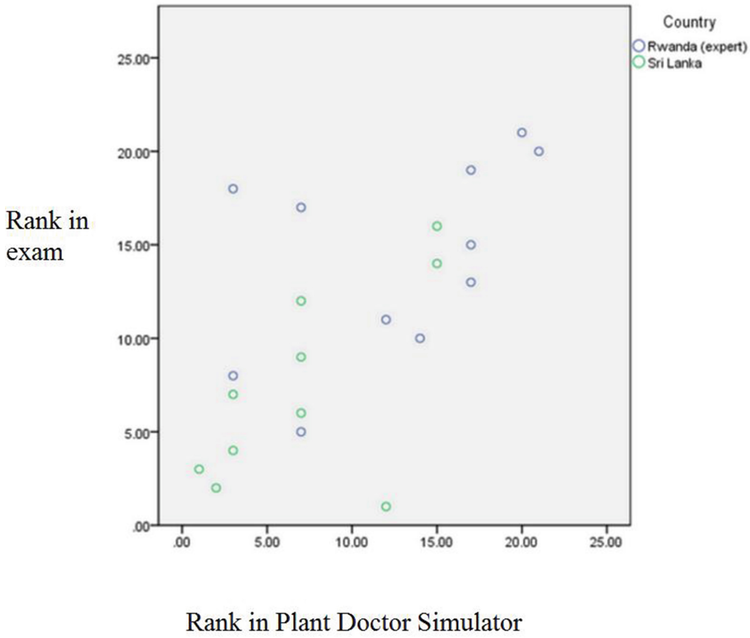

Fig. 4. Scatter plot showing the correlation between rankings of performance in the traditional measure of competency, and rankings based on performance in the Plant Doctor Simulator

Field observations of plant doctors using the Plant Doctor Simulator suggest that they were comfortable downloading it (from the Google Play store), signing up and logging in. Outside of the 21 users in this study, there are over 150 active users of the Plant Doctor Simulator in Plantwise in Ghana, Kenya, Vietnam, and Cambodia. Examination of usage of the simulation shows that most users play for around 7 h, in some cases users were found to play for over 20 h.

Based on findings that suggest the Plant Doctor Simulator has value as a competency measurement tool, it is possible for Plantwise to investigate plant doctor user groups. Demonstrating further value in using an application like this, the simulation data is queryable by Plantwise administrators. This allows them to assess the competency of plant doctors, allowing them to respond to training gaps and to measure the effectiveness of the Plantwise training program. The example query below in Fig. 5 shows the relative diagnostic accuracy of Kenyan, Sri Lankan and Rwandan plant doctors on each of the 21 levels, over a defined time period. It is evident that each group has different strengths and weaknesses, but all groups have a weakness on level 10, which focuses on the diagnosis of water mould on tomato. As a group, it is clear that Sri Lankan plant doctors are able to diagnose problems more accurately than those in Kenya and Rwanda. This difference may be due to the level of experience of plant doctors; with Sri Lankan plant doctors having higher levels of tertiary education, and having been in the Plantwise program for longer. Kenyan and Rwandan plant doctors were new to the Plantwise program.

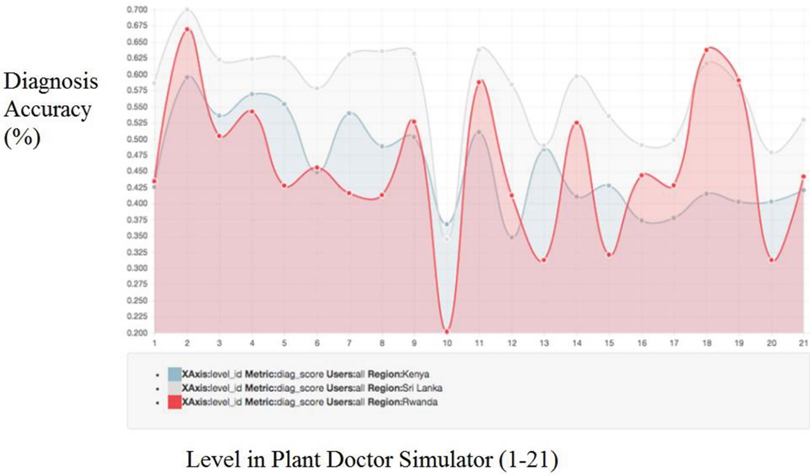

Fig. 5. Plant Doctor competency is examined by displaying the results of detailed queries; this query shows percentage diagnosis accuracy on the y axis, and the 21 levels in the simulation on the x axis of Kenyan (blue), Sri Lankan (grey) and Rwandan (red) plant doctors. (Color figure online) (Source: Plant Doctor Simulator web portal)

Based upon field observations, a number of factors were identified as critical to the success of the simulator's implementation. These learnings are generalizable to similar apps and contexts, and have informed further developments of the Plant Doctor Simulator. The following are examples of some of the generalizable learnings found.

Familiarity with technology: Not all users were familiar with basic touch device and email login systems, resulting in delays in the exercise progression. It is recommended that in initial stages of simulation development, assumptions regarding ownership of suitable devices and familiarity with technology should be tested before rolling out into a training group. Additional face-to-face training modules on basic usage of touch devices (such as tap, swipe, drag, and email login processes), and provision of devices for ongoing usage of the simulation, would increase the success of adoption of the simulator.

Relevance of Training Content: Some users commented that plant scenarios were not relevant to their local area, and as a result the value of the simulator was slightly diminished. It is recommended that further plant species are explored that are more relevant to the geographic location of specific training groups. It is also recommended that during the workshops it is clearly outlined that the skills demonstrated with these plant scenarios are fairly universal and can be applied to many other plant diagnostic situations.

Localisation: Some users found the text in the simulator difficult to understand as English was not their primary language. It is highly recommended that local language is used for key text areas of the simulator such as the tutorial, symptom descriptors, and diagnosis problem text. To complement this, a face-to-face trainer who speaks the local language is required during the initial interactions with the simulator.

3 Discussion and Conclusion

The positive correlation found between users performance on the traditional measure of competency, and in the Plant Doctor Simulator, suggests that the simulation may be a valid measure of plant health worker diagnostic competency. This, and anecdotal reports of construct validity from various plant health experts, suggests that simulation for measuring competency does have merit.

However, there are limitations to this design, including the small number of participants. The correlation design could be expanded using more participants and made more rigorous by introducing a control group. There is also opportunity to explore the reliability of the application by measuring repeated usage over time. With a change in study design, additional variables could be investigated such as learning outcomes, both immediate and longitudinal.

Whilst there is no delivery of new learning content in Plant Doctor Simulator, as the application was designed to test competency rather than deliver new information, there is the potential to learn from this application due to the feedback given. Synergies with Plantwise training have been reported anecdotally, so further investigation is underway to determine whether or not Plant Doctor Simulator use enhances plant doctor learning outcomes. Michael and Chen [1] state that when evaluating simulations, the study must be able to show that the necessary learning has occurred. In the case of Plant Doctor Simulator, the necessary learning outcomes would be plant doctors better identifying symptoms and making diagnosis of plant health problems. These outcomes were not investigated in this study, but will need to be in the future.

It should also be noted that the Plant Doctor Simulator is generally completed in no less than 2 h, by expert plant health personnel. The bloated usage times reported (7 h), suggest that most users had lower skills and needed to repeat levels to gain understanding, often consulting with their peers and teachers. This could also be due to user inexperience with tablet technology. Examination of a wider range of user skill sets may yield more meaningful insight into simulation value.

Following the encouraging results of early trials, CABI is continuing to implement and test Plant Doctor Simulator in the Plantwise program. It is clear that further testing is needed to fully investigate the reliability, validity and efficacy of the tool. Future testing is investigating the use of the tool with plant doctors in Ghana, Malawi, Kenya, Myanmar, Sri Lanka, Afghanistan and Pakistan in 2016. CABI is also investigating new ways to deliver Integrated Pest Management (IPM) training to plant health workers in the developing world with simulation. A new simulation, to be delivered on smartphones, will aim to teach and measure the principles of IPM. This will be achieved by simulating the farm environment and encouraging the user to make decisions on how to deliver constructive messages to farmers, again with data capture and analysis capability.

It is hoped that the application of the lessons learned designing, building and testing Plant Doctor simulator to solve problems can be applied to other areas of plant health. In particular, there will be value in areas where observation and detection skills are central, such as biosecurity and invasive species management. It is possible that the costs and benefits of simulation are still becoming clear to stakeholders in plant health and food security. With further examination of the value and impact of simulation as a competency measurement tool and as a training tool, we may see further investment and innovation in simulations and simulation to solve problems in plant health in the developing world.

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Game Science or Games and Science? Towards an Epistemological Understanding of Use of Games in Scientific Fields

Moozhan Shakeri(✉), Richard Kingston, and Nuno Pinto

School of Environment, Education and Development,
University of Manchester, Manchester, UK
{moozhan.shakeri,richard.kingston,
nuno.pinto}@manchester.ac.uk

Abstract. Recent years have seen a tidal wave of interest in the use of computer games in fields as diverse as urban planning, health, education and business studies. Despite the reported success in the use of games for pedagogy and communication purposes, the lack of critical understanding of games as a medium, their capabilities and limitations, the sorts of knowledge they produce and the types of data they can deal with has led to the limited use of games in scientific fields. In this study by conceptualizing games as artifacts with embedded information systems, a better recognition of artistic values of games is called for. It is explained how understanding the various ways in which data flow happens between the real world and the imaginary world can help us better situate games within scientific fields.

Keywords: Game science · Simulation and gaming · Serious games

1 Introduction

The very root of what is now known as game science can be found in the ancient war games [1]. Games were historically been used for creating simulated interaction environment for exploration, planning, testing and training of military operations. In 1940s and 1950s, particularly after the World War II, war gaming was transferred to simulation gaming as a rational and analytical method of public policy making. The work of Morgenstern and Neumann on 'Theory of Games and Economic Behavior', emergence of decision sciences (i.e. operational research) and the wide range of studies done by RAND corporations were very influential on the then-emerging discipline of gaming simulation for public policy making.

In the context of the then dominant fascination with modeling and simulation, games started to be conceptualized as systems rather than playful activities. This turn in conception of games in 1970s left its mark on the way games were and are being used in contexts other than pure entertainment. In 1970 a group of game designers got together in the first International Conference on Simulation and Gaming [2] which was later marked as the start of 'simulation and gaming' as a discipline. The main topic at hand

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in this gathering was the use of games in urban planning context. The choice of urban planning context did not come as a surprise; in 1960s urban simulation models had gained their momentum and by the late 1960s arguments were raised on limitations of large-scale models in dealing with social complexities. To better understand and deal with complexity and uncertainty, the use of gaming, interactive simulation and computer simulations were then called for. The use of games for pedagogic and communication purposes in serious contexts was already tried-and-succeeded case. However the use of games for research purposes was not yet explored to that date and therefore it raised many arguments in the conference of 1970. As Klabbers reports, the matter left unsolved. As the final decision members suggested "labeling the [use of games for] pedagogic objectives as gaming and the [use of games for] research objectives as simulation" [2]. In the same year, Clark Abt [3], one of the main organizers of that conference, suggested the term 'serious game' for talking about games that "have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" [3]. The idea was that contrary to the mainstream games that are solely designed for entertainment purposes, games for policy making need to be based on scientifically valid and policy-relevant theories.

In the 21st century however, the emergence of new forms of games such as 'Massively Multiplayer Online Games' (MMOG), pervasive games and social networking games have shifted the emphasis from the procedural capacity of games to their participatory and pedagogic values. The new types of games such as social network gaming are considered to be products of the contemporary techno-culture which seeks and makes use of totally different kinds of knowledge compared to the ones in modeling paradigm of 1970s. As a result of the changes in the types of knowledge that are taken for granted in different scientific fields, the role of 'serious games' have changed as well. For fields such as physics and math which are highly reliant on positivist rationality the use of games still follows the traditional frameworks; games are mainly used in these fields for educational purposes. However other scientific fields such as urban planning and public policy analysis which have gone through different paradigm shifts since 1970s are facing a challenge to situate games within their set of tools and approaches. These fields successfully make use of pedagogical values of game, but the use of games for research purposes in these fields has not yet managed to distance itself from the simulation tradition. For example, in urban planning field, the serious games that are designed for research purposes are mainly in form of a detailed simulation of the neighborhood in which the player can move around freely and is asked to comment on different proposed/current developments.

2 Game Science and the Evolving Definition of Games

To better situate games within scientific fields it is crucial to understand the significance of the shift in conception of games in 1970s from playful activities to systems and the impacts this shift can have on the perceived use of games. With the dominance of system thinking in the end of 1960s, defining the main properties of games through defining their 'sufficient and necessary conditions' became very appealing to gaming scholars.

To date, many studies [3–9] have defined games using this approach. While these studies are commonly referenced in studies about serious games, the mainstream game designers argue for more descriptive approaches to game design and often refer to the earlier works of scholars like Huizinga and Caillois [10]. According to Calleja [11] the arguments between advocates of descriptive and definitive frameworks are indications of a bigger problem; the widening gap between games as a mean to entertain and games as a mean for problem solving; or as Waern [9] puts it the gap between games as playful activities and games as systems. Advocates of conceptualizing games through defining their main properties believe that the process of game design should not be just a trial and error. In this sense by defining the main attributes of games one can design games (systems) which are productive (ensures a certain outcome) and repeatable. On the contrary, advocates of descriptive approaches believe that games at best can be studied for identifying the factors involved in the success or failure of the game in a certain context; no one can provide game designers with prescribed methods which ensure success. Definitive view of games, inspired by system thinking approach, is essentially an attempt to produce repeatable patterns for games which ensure achieving certain outcomes while descriptive approach tries to promote creativity and artistic aspects of games and ensuring the fun quality of games.

Adopting any of these two approaches has some implications not only on the specification of the games that are produced but also on the types of data that can be produced in the game. The very early definitions of game (such as the ones provided by Huizinga and Caillois) were mainly the product of works of scholars in anthropology and psychology fields. In their approach rather than reviewing existing games, these scholars focused on the concept of play. In their work the separation of the real world and the game world was very central. In defining play, Huizinga argued that all play moves take place in a "play-ground marked off beforehand either materially or ideally, deliberately or as a matter of course… All are temporary worlds within the ordinary world, dedicated to the performance of an act apart" [12]. He then defines play as: "a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding; having its aim in itself and accompanied by a feeling of tension, joy, and the consciousness that it is 'different' from 'ordinary life" [12]. When system thinking and simulations build in popularity, games were conceptualized as complex systems rather than culturally defined phenomenon. As a system then games could not be a free form of play; rather it needs to have rules and quantifiable planned outcomes.

In effect the separation of the real world and the imaginary world of games also was revisited. Salen and Zimmerman [8] argue that "the pleasure of a media experience lies in its ability to sensually transport the participant into an illusory, simulated reality". Harteveled [13] also emphasizes the importance of achieving balance between the worlds of meaning and reality in designing serious games. However majority of the serious game designers assert the difficulty of achieving this balance and sensually transporting the participant into an illusory reality. The main premise in the use of games in scientific field for research purposes is that the acquired knowledge and experiences from one system needs to be translatable to another. The extent to which this translation will be successful depends, among other things, on the degree to which the game is a valid representation of the reference system. The importance of ensuring ‘validity of games’ in scientific field (i.e. expecting scientific outcomes from an artifact) is the reason why the so called ‘serious games’ cannot distance themselves from simulation tradition when they are used as research purposes.

3 Games as an Artifact with Embedded Information Systems

The emphasis on conceptualizing games as systems with predictable outcomes has led to limited use of games in scientific fields. Exploring the types of data that can be used in the design of the game world and the data flow between the real world and the imaginary world of games can provide game designers with new insights on the ways in which games can be used for research purposes. In an attempt to do so, we made use of Cook’s model [14]. His model is one of the few that illustrates how the internal elements of the game interact with the players and the external resources. According to his model the loop starts with the player having a mental model (he thinks that he has an idea on how things work in the game world) and through the loop the mental model of the player is updated. Having the four main elements of this loop in mind, the ways in which the real world data can be used to create the game world and the types of data that can be produced through the game are identified (Fig. 1).

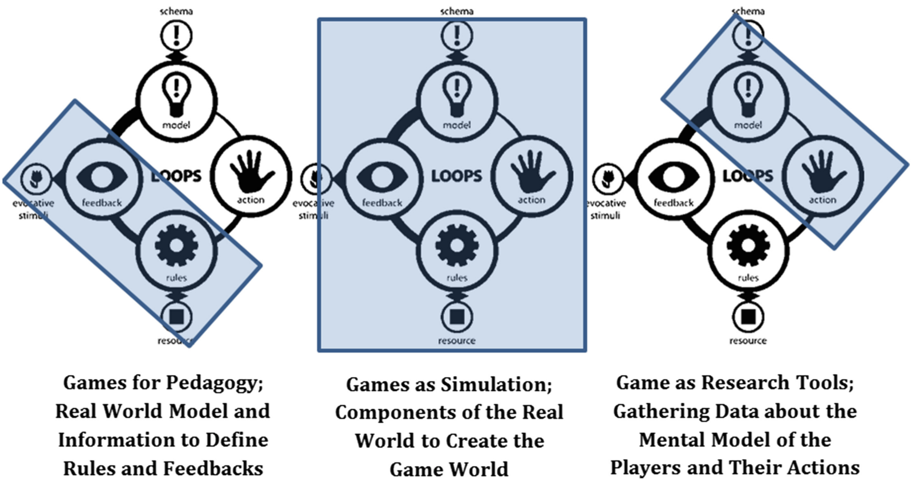

Fig. 1. Data flow between the real world and the imaginary world of games in different types of games

When the game is used as a pedagogic tool, the focus is on rules; the ‘right mental model’ or accepted facts in that field (which are conclusions drawn from real worlds observations and studies) are incorporated into the rules of the game. The ultimate aim of these games is to bring the mental model of player closer to the right mental model incorporated into rules of the game. In the case of serious games as media also the same applies. The message that is supposed to be conveyed is used to define the rules.

The rules can take different shapes. In some cases rules are mathematical equations so you want the player to deductively learn about the model. In other cases, the rules reflect the mental model or the worldview and you want the player to become familiar with that. In all these cases since the focus is on the rules of the game, it is not required for the game world to be the true representation of the real world in its totality; only the logic and rules need to resemble the ones in the real world. In this sense, depending on what the game needs to focus on, a small set of real world data are represented or abstracted in the game world.

When the games are used for research purposes, the main aim is to monitor the mental model or the actions of the players throughout the game. In fields such as economy and business, that make use of tacit and behavioral knowledge of the public, games become very useful tools for research purposes. There exists breadth of studies on how people spend their virtual money/resources in online games. In this model this will be monitoring players' actions; commonly known as game analytics which make use of various techniques including heat maps and built-in action monitoring techniques in games. However in fields such as urban planning and public policy which are still struggling to find meaningful ways to incorporate the tacit and behavioral knowledge of public into their traditionally scientific positivist approaches, the value of capturing player's mental model and the way it changes through the loops have not yet been fully explored. Given the importance of the game's validity in the case of fields such as urban planning, the real world data, models and information are simulated in the real world to ensure that the monitored actions in the game will be the right representation of the player's actions in the real world.

4 Conclusion

Despite the pervasiveness and the widespread use of serious games, a better understanding of the game as a medium is required to situate games within different scientific fields' toolboxes. Exploring the ways in which the data flow happens between the real world and the imaginary world of the game to a large extent determines how games can be used in different scientific fields. This is specifically crucial for fields such as public policy and urban planning that have gone through major paradigm shifts since the introduction of serious games in the peak of modeling and simulation era. The use of games for research purposes in these fields have not yet managed to distance itself from the legacy of simulation and gaming and in these fields games are still being conceptualized through the lens of system thinking. The strong emphasis on the use of traditional concepts of game validity which were constructed based on scientific measures in these fields has limited the use of games and has ceased the opportunity to explore the value of artistic aspects of digital games in scientific fields. To better situate and use games as artifacts within scientific fields on one hand a better understanding of games as medium is required and on the other hand scientific fields need to reflect on the types of knowledge that are taken for granted and the ways in which games can have an added value for dealing with new types of knowledge.

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Reality Reaching into Games - Weather as a Dynamic Link to Real-World Streams of Information

Dale Patterson(✉) and Scott Roberts

Griffith University, Gold Coast, Australia
{d.patterson,scott.roberts}@griffith.edu.au

Abstract. This paper describes the design and applied use of in-game weather systems to convey streaming real-world information to the game player. Weather systems were selected as the form of ambient in-game information due to their visual presence and limited involvement in gameplay. This allows change to the weather, based on real-world data, without negatively effecting gameplay. This mechanism provided an ambient in-game source of information that kept the player informed regarding a source of streaming information from the real world, while also allowing for the immersive game experience to be maintained. Results from the experimental trial (n = 35) showed that the weather simulation, linked to real-world information stream, enhanced reported levels of information engagement, without negative effect in terms of player sense of immersion and realism. These results indicate the potential for in-game weather to be used as an effective, time varying form of immersive information transfer.

Keywords: Computer game · Weather simulation · Visualization · Game design · 3D user interface · Information system · Human computer interface · Randomized control trial

1 Introduction

Computer game based weather systems continue to become visually richer, more realistic and dynamic, yet, with the exception of specialized simulation systems/games, in-game weather is fundamentally a visual enhancement rather than a key gameplay element [1–3]. In many ways weather is an ambient feature, visually enhancing the spatial environment, but not playing a key role in the interactive gameplay itself. Although it may not affect gameplay, the in-game weather is directly aimed, with great success, at creating more realistic and immersive experience for the player [1, 4–6].

Recent developments in game design, including stepping towards the combination of more diegetic in-game elements to convey in-game information [7–9], minimal game interfaces (NUI (Natural User Interfaces) [10, 11] & transient interfaces [12]) and richer spatial (from biological models for trees, swarms and flocks to fractal design for structures [13, 14]) and weather based systems [15, 16], all aim to immerse the player in the virtual world of the game, with more realistic spaces, less artificial overlays and visible user interface componentry.

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From an interaction perspective, these design steps provide greater realism and immersion, but also limit the games ability to break into the "immersive space" and force the player to address an external factor, without breaking the illusion of the virtual reality. This issue presents an interesting challenge for game designers, particularly in terms of sending information to the player without breaking their sense of immersion. In essence, it raises the key interaction question of how can the game itself tell the player something important, and something that isn't part of the immersive game world? A good example of this would be the use of battery powered mobile devices for gameplay. In such a scenario the player would, in most cases, want to be made aware of the fact that the battery is running low on the device, but in an immersion sense this isn't relevant to the "virtual gamespace". The game could use classic user interface methods, for example a dialog box to tell the user, but this very directly breaks the players sense of immersion. It could also insert some form of diegetic game element (e.g. a battery bar/item associated with the character) and this would work, but would use up valuable visual/spatial/screen real-estate for an item that is not directly game associated. The option that this research project proposed, and explored, was the applied use of the interactive in-game weather systems as a means of conveying information from the real world into the immersive game. In the example of the battery, the game weather system could be used to reflect battery levels. Bright and sunny for high battery levels, as compared to dark and stormy for low levels, with interactive change being made during gameplay, thus allowing the player to "see the storm coming", and hopefully, in this example, plug into power.

Of course the technique could be applied to other real world information flows, including more serious health systems such as heart, blood sugar and baby monitors, as well as other information such as stock market volatility or even social media engagement. At its core the concept was to use the in-game weather system to allow the real world to reach into the immersive game, without breaking the players sense of immersion. To achieve this it is important that the weather is an ambient feature that can be changed without effecting gameplay.

2 Ambient Information

Ambient information can be thought of as information that is present around us, yet does not demand our attention. Examples of such information systems in the real, or natural world, might include sunlight through a window, telling us the time of day, or the background hum of road noise, telling us traffic information. This information is always there and available for focus, if desired, but is also passive and non intrusive on our primary activities. This information can flow to us through a range of human sensory systems including sight, sound or touch.

Our ability to understand the ambient information, without giving it detailed focus, is based in human evolution and our sensory systems. As an example, being aware of our surroundings was important to early humans, in case a predator was to jump from the forest. Although this fundamental human sensory capability is founded in basic evolution, our capacity to keep track of peripheral information/environments is a powerful human skill. A skill that is sometimes underutilized in the design of games and interaction.

Looking at this from a less evolutionary (survival of the fittest) perspective, these skills are still widely used in everyday life. The cocktail party effect is an excellent example of the applied use of ambient information [17, 18]. The cocktail party effect essentially describes our ability to be at an event, a cocktail party, and while standing in one location being able to keep track of several nearby conversations at the same time, and when prompted by something relevant, for example our name, we are able to engage in that conversation. Although we aren't initially actively engaged with any one conversation, we are able to keep track of several peripheral conversations and when necessary directly engage in the conversation of choice. While doing this we are also able to gauge the overall event, and its level of activity through broader peripheral information such as the overall audio buzz and visual movement. Most people apply these skills without any planning or pre-thought [17]. The fact that these skills are so fundamental, and universal, makes them an ideal target for communication or information transfer. This raises the question of whether such ambient communication systems could be utilized from within game environments.

3 Ambient Information Interfaces and Calm Technology

The concept of digitally based "ambient information interfaces" is not a new one, and has been explored in a number of fields. It is often referred to as "calm technology", a name that was initially developed, in 1995, by Mark Weiser and John Brown at Xerox PARC [19, 20]. The key concept to the ambient interface, or calm technology, is the link between a digital information source, and an ambient visualization technique.

The techniques that have been developed range from highly abstract, physical and sculptural artworks, to immersive virtual reality and on screen human computer interfaces [21]. In the physical realm, ambient systems, such as those developed through the ambientROOM experiments at MIT media labs, were designed to take data sources and visualize their changing values through physical mechanisms such as water ripples (controlled by the data source), mixed with lights to produce projected shadows and colour effects in the physical space [22]. Many of these systems are artistic and experimental at heart, with limited practical application, beyond information as an experience. Other systems are very practical, such as the work on the "Power-Aware Cord" by Gustafsson and Gyllenswärd [23], where the ambient interface is a physical power cord that shows power flowing (to highlight devices that are drawing power). In terms of the data, it simply uses the power flow within the cord for its source data and then visualizes this through "dynamic glowing patterns produced by electroluminescent wires molded into the transparent electrical cord" [23]. The effect, for the user, is a power cord that glows with colour based on how much power it is consuming (see Fig. 1). This hidden, or peripheral, source of "calm information" demonstrates an effective form of information transfer through the physical real world.

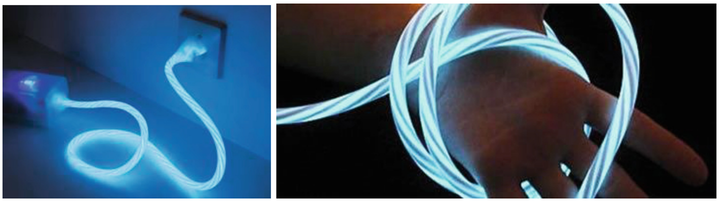

Fig. 1. "Power Aware Cord" [23] (Color figure online)

In the virtual and screen based realm, a similar broad spectrum of ambient systems exists, from practical to artistic. Screen based ambient systems have been developed taking data sources and visualizing them as dynamically changing visuals and flows [24–26]. These screen systems utilize animation and change over time to visualize the changing data. One example, at the artistic end of this range, is the bus departure system designed by Skog et al. [24]. In this system the data was based on the departure times of buses from the local stops. This data is visualized through an animated artwork, in the form of an abstract painting based on the style of Piet Mondrian. With the coloured non-representational forms (rectangles and squares, based on Mondrians neo-plasticism) representing bus departures (see Fig. 2).

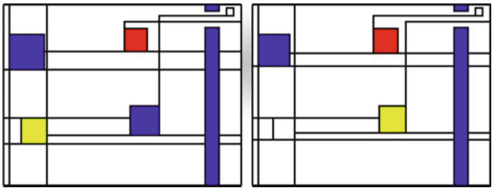

Fig. 2. Mondrian like bus departures [24] (Color figure online)

These forms were then animated (changing size based on how far away from departure the bus was). For the viewer the display presents as an aesthetically pleasing animated artwork, but if they know the relationship to the buses, it also provides information that can assist in knowing when the next bus will leave a particular stop.

The abstract (non representational) nature of the visualization used for the bus departure system makes it difficult for the user to immediately understand that there is a relationship to buses, and this highlights a key factor for the design of "ambient information interfaces". On one level the interface needs to be on the users periphery, without demanding attention, but there also must be a way for the user to make the link between the ambient visual/experience and the information contained within. One approach to providing this link is to use more representational visuals, for example instead of an abstract artwork, one involving buses may be subtle enough to provide the information or make the link for the viewer.

Systems of this type, showing representative items, have been demonstrated with positive effect, including the use of flow based three-dimensional visuals in the game and VR based visualization of blood sugar and web based search data by Patterson (see Fig. 3) [25, 26].

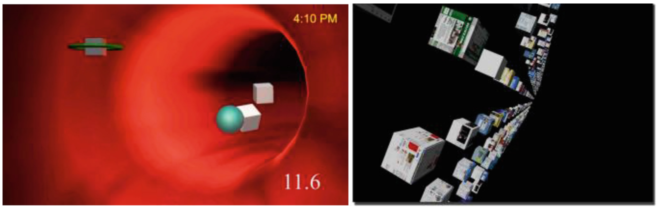

Fig. 3. Blood sugar visualization (left) and web search visualization (right) [25, 26].

More representational visuals are not the only approach. It is also possible to simply inform the user/viewer that there is a link. In a game scenario this could be through the initial "pre-game" setup (letting them know that the art/visual means something, or even better letting them choose what information it is displaying. Thus making it more relevant to the individuals needs).

At the heart of all of these systems is the data itself, in most cases a single varying element. In analyzing the selection of existing ambient information interfaces it is clear that any one of the datasets could have been visualized (with minor adaptations) in any of the other visualization techniques. This highlights the fact that there is the potential to develop visualization techniques, in both physical and screen based worlds that could be used for a range of possible sources of data.

3.1 Potential for In-Game Ambient Information

Being immersed in a world of big data, where streams of information are constantly available, makes it comparatively easy to access streaming data sources of a range of types. From healthcare and medical information (such as streaming blood sugar, heart rate and other monitor based feedback) to more personal data such as social media interactions (comments, posts, likes) it is possible for the modern user to access a broad range of streaming data, that could be visualized, using ambient information displays. Despite the potential, only limited use of in-game ambient information has been utilized, with advertising currently being the main active use [27].

Modern game systems are capable of producing highly realistic virtual environments, and from within these virtual environments all of the techniques described above could be utilized (even the Mondrian like artworks could be placed on the virtual walls) to display ambient information interfaces. By placing ambient information interfaces throughout virtual game worlds it would be possible to provide a collection of links to real-world data. Yet, for many players, the reason to enter the game world is to escape from the real world (if only briefly) and enjoy a space without the pressures of reality [1, 2, 4]. This is an important consideration for designers of game spaces and ambient information interfaces. Although diegetic ambient interface components, like Mondrian artworks, 3D sliders, bubbles and spirals can be effectively used (to display information) in multi-user 3D spaces, they are essentially just an immersive version of the GUI based controls that have previously been used for games, and, depending on use, can be quite intrusive [9].

For an ambient information source to be most effective it should not stand out in the space, but should instead be on the periphery, providing useful information (much like the weather out the window does in the real world). When considering games, this is particularly relevant as there is a strong desire to create an immersive experience, and anything that breaks the illusion of immersion is potentially damaging.

4 The WAII (Weather Ambient Information Interface)

Game spaces are, in many ways, rich environments where the possibilities for items, interactions and experiences are very open to a range of possibilities. Having said that, it is also true that games are an escape where players can enter a different world and play out different stories. The ability to insert "real world" information into these game worlds offers potential but also risk. To do it effectively there is a need to understand the parts of the immersive game space that can be altered without breaking the players sense of immersion or experience. Previous work in ambient interfaces has utilized in-game lighting levels to effectively convey information [28]. Unfortunately this impacts on the games playability (especially when lighting levels are low, or where lighting is used to direct story or flow).

Weather systems also represent an option for in-game ambient information as they are visually rich, can be dynamic, are throughout the play space (something that individual diegetic items may not be) and are rarely directly involved in gameplay, making them a potential area for application in ambient interfaces. In fact if we consider game design, many designers already utilize in-game weather for ambient information. The classic example of the bad/boss character coming onto screen with additional peripherals including dark clouds, lightning bolts, raised music effects/volume and intensity are all subtle uses of these ambient techniques to enhance the story.

This project explored the use of these dynamic in-game weather systems as a link to streaming real-world data. Essentially taking the information from a real-world data source (just like another i/o input device) and adjusting the weather to reflect the dynamically changing values provided by that data source (see Fig. 4).

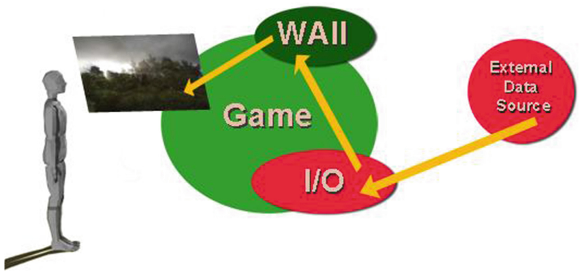

Fig. 4. The WAII (Weather Ambient Information Interface)

In this project the weather system was used in an outdoor environment, allowing for rain, wind and storm features, but it could also be applied indoors with "indoor weather" being represented by fog, smoke and lights/effects (much like the ambientROOM experiments [22]).

5 Experimental Trials

Measuring the effectiveness of the weather based ambient information interface (WAII) was carried out through a randomized control trial of 40 users (N = 40) each engaging with the game systems over a 90-minute timeframe. At the start of the trial the users were randomly allocated into either the control game group (nControl = 20) or the ambient information interface (WAII) game group (nWAII = 20).

Both groups were aware they were involved in the study (as active participants), but they were unaware of the studies specific purpose. Participant ages ranged between eighteen and forty-three years (25.6 year average). The ratio of female to male participants was 40 % female (16 of 40) and 60 % male (24 of 40). There were five participants that initiated the trial but failed to complete, giving only thirty-five, N = 35 (nControl = 17, nWAII = 18), completed experimental trial results.

The core purpose of the experimental trial was to measure whether the insertion of the ambient information interface (via WAII – as in-game weather) was effective in presenting real-world information, and in doing so, if that change had an effect on the users sense of immersion within the virtual game space. To achieve this, following completion of the consent process, participants were allocated into one of the two groups.

Those in the control group were then presented with the game. It was a three dimensional, first person perspective game using a realistic spatial environment.

The game itself was made up as two distinct levels, the first level with "simple weather" made up of blue and unchanging skies and the second level with "rich weather" made up of cloudy skies, rain, wind and visual environmental effects (splashes, lightning, trees blowing – see Fig. 5).

Fig. 5. "Simple Weather" (left) and "Rich Weather" (right) (Color figure online)

The two levels were designed to provide the player with an experience of both simple weather and complex weather systems, and in doing so to measure if the "richness" of the weather itself played a role or biased the results. The users were then given 45-minutes (for each game level) to explore the game spaces, and when finished (each separate level) they were then asked to complete a questionnaire regarding their experience.

Participants allocated to the WAII group were presented with the game (the same two-level game as for the control group (see Fig. 5). Containing the same spatial layout/ items and characters, as well as the same hardware, graphics, levels and qualities. The difference between the two groups was that the WAII group were informed that they were using the dynamic weather system that was linked to a real world information feed (the information chosen was a baby breathing monitor), and that the in-game weather was dynamically changing based on the real world information from a baby in the next room, for whom they were responsible (with clear weather representing clear breathing and cloudy/stormy weather representing breathing difficulties). This, quite serious scenario, was chosen to provide something that participants would take seriously (much as they would if it were an important piece of data they had chosen themselves). Following their introduction to the situation they were then given 45-minutes with each level (completing the questionnaire at the end of each).

To ensure that each participant had a similar "weather" experience, the weather system was pre-recorded (based on dynamic information) and played through for each new participant. This enabled each player to experience the same game space, players, system and weather. The experiment was designed to have a single changing variable between groups, that being the players' knowledge of the link to the "real live" data for those in the WAII group, thus enabling the ability to link any differences between groups to the use of the ambient information interface.

6 Results and Analysis from Experimental Trials

The results from the experimental trial include both statistical analysis of the numerical answers given to the survey questions, as well as qualitative analysis of the observational findings from the study. Statistical results from the experimental trial are presented as data and charts showing average result values with the addition of error bars showing the 95 % confidence intervals for those results. The statistical results are based on the users responses to questions as rated on a 7 point Likert scale, where 1 represented extremely poor and 7 represented extremely good. The result analysis sought to find areas of both large effect size (difference between averages) and statistical significance (where 95 % confidence intervals do not cross) [29].

The first key question related to the users perception of the effectiveness of the weather as a form of external information (note that control group did not have link to real world information so were not asked this question). When users of the WAII group were asked "How well does the in game weather function as a means to communicate real world information?" their average response was 5.9 on the 7 point Likert scale, with more than 90 % of players rating it above the mid point (indicating strong positive sentiment on the Likert scale).

The follow-up question then asked "How likely are you to use real world information if it was embedded into game weather?". Users responses to this were still positive (with more than 80 % of responses above the mid point on the Likert scale) but there was a notable group of respondents who rated this at a lower level (all rating it as 1's (the lowest possible level) on the Likert scale). When asked why, in an open follow up question, members of this (1's) group strongly indicated a desire to be "in-game and separate to the real world". This highlights the point raised earlier regarding the use of games as an escape from reality. For players seeking to escape from the real world (around 20 % of the users in this study) the concept of a real world feed is undesirable. Given this situation it is clear that to be effective such ambient information systems would need to be optional, and under the control of the user to be effective. For those players who like the idea of keeping a link back to reality (the 80 %), the tool is useful, but for those wanting an escape (the 20 %), the tool needs to be able to be disabled.

The second key topic in the survey focused on the users sense of immersion in the game. Keeping in mind that one of the objectives of the ambient system is that it does not intrude into the users experience, but is more passively available, and as such aims to be present without having a negative effect on immersion. Results from this question are shown in Fig. 6.

These results indicate that although there was a notable effect size (mostly indicating a preference for richer weather) there was no statistically significant difference between the groups in relation to the users reported level of immersion.

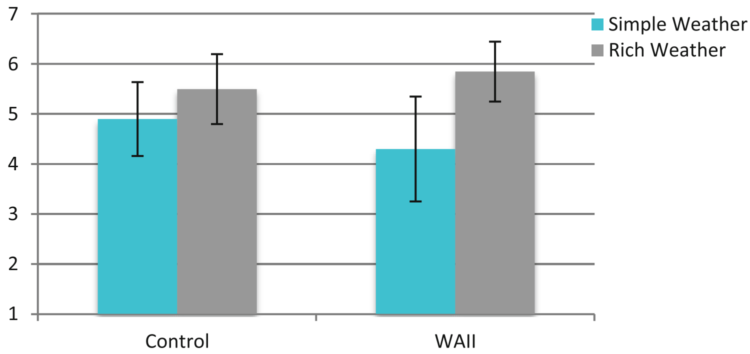

Fig. 6. How immersive was your game experience?

This indicates that the addition of the WAII (weather ambient information interface) did not adversely affect the users sense of immersion. Looking in greater detail highlights several key points. Firstly that the "Rich Weather" system for the WAII group was actually more immersive than the control groups "Rich Weather", yet the "Simple Weather" system for the WAII was less immersive than its Control equivalent. This effect is most likely due to the fact that participants were focusing on the weather and thus expecting it to be dynamic and changing (as it was linked to reality), so when the control groups weather was calm (and relatively static) they rated it lower. Overall this tells us that by highlighting the weather (through the WAII), we are actually drawing greater attention to it. When the weather is rich and interesting, users find it more immersive, but when it is simple they find it less immersive. Given this fact it would be valuable to consider the base level of the weather to be richer (rather than a neutral input giving “fine and sunny” if it were to give “slight, rain and clouds” then the user may find this more satisfying). It would also allow for the tool to have the option of changing the weather in both an upward and downward direction (from the base level starting at a mid point in the weather range).

The observational study also highlighted a similar finding, in that the users reported that they were looking for “change” in the weather more than an absolute value. This works to support the theory that a higher base level with options both up and down, would make the tool more capable of engaging the user, by providing more options in terms of directional change.

From an overall analysis perspective, the fact that the ambient information was dynamically part of the game world, it was rated as useful by players, they indicated they would use it in future and their was no statistically significant difference in immersion indicates that game weather has the potential to be used as an effective information communication mechanism without breaking the players sense of immersion in the virtual game space.

7 Conclusions and Future Potential

The results from the study indicate that an in-game dynamic weather system can be effectively used to convey real world information to the player, without needing to break their immersive experience. The experimental study found that the majority of players (greater than 90 %) found the idea of linking streaming real world data to the dynamic in-game weather to be useful. Having utilized the trial system more than 80 % of players also indicated that linking in external real world information was a feature they would use in future gameplay. Weather systems by their very nature, are an ambient system, they are all around us, yet not intrusive. This study shows that the concept of ambient information applies as effectively for in-game weather systems as it does for real world weather. The advantage for the in-game system is that the weather can be dynamically linked to data sources of varying kinds, thus allowing the player to have an ambient feed of real world information while still being immersed in the virtual game experience.

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Augmented Reality and Gamification in Heritage Museums

Ramy Hammady(✉), Minhua Ma, and Nicholas Temple

University of Huddersfield, Huddersfield, UK
{Ramy.Hammady,m.ma,n.temple}@hud.ac.uk

Abstract. Augmented Reality (AR) technology is one of the fastest growing areas in the computing field and it has pervaded many applications in the market including museums. However, there is a need for a survey exploring the effectiveness of augmented reality as a communication medium in museums. This paper reviews the development of Augmented Reality as a mass communication [1] tool in museums. We introduce a communication model which would work as a roadmap building AR guidance system with ensuring this system will be a successful method of communication with users. Besides, we propose a novel way to enhance the visitors' experience and learning by combining AR with games in museums.

Keywords: Augmented Reality · Gamification · Museums · Communication methods · Visualisation · Interactions

1 Introduction

Augmented Reality (AR) was introduced to the heritage sector in the last decade as a technology that has the potential to assist visitors inside museums [2, 4]. As the technology kept evolving, acoustical tools were combined with AR tools to enhance visualisation especially in archaeology and cultural heritage sites [3]. *LIFEPLUS* in 2003 was considered a good example of the AR development that occurred to be capitalized in indoor and outdoor guided tours in cultural sites and museums [4]. In the following year, the augmented visualisation using the technology of mixed reality [5] engaged visitors by immersing them in a virtual world and stimulating them for long discussions after the visit. Another system in 2004 named *ARCO* [6] enriched the interaction in museums and offer the chance to use AR outside museums as well.

Mobile multimedia guide on handheld devices started to appear widely with some revolutionary features especially used in museums and cultural heritage sites. A good example was in 2007 [7] when the level of interaction became higher and the geolocalisation prospects became accessible via mobile devices. In 2008 Damala, Cubaud [8] argued that the multimedia guided system which functions by AR techniques could be altered by the experience gained from museum visitors by observing and monitoring the visiting patterns and the real-time communications including pre and post visit [9]. In 2010, Naemura, Kakehi [9] built an inclusive system that could create augmentation using optical displays without mediums, navigations system, and diverse ways to let

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visitors express their feelings and a chance for visitors to contribute in order to develop the system.

Based on the literature, this paper proposes communication models that can be applied to multimedia guiding systems, which use augmented reality technologies. The last section introduces ideas for combining serious games with AR in museums in order to engage and educate visitors about the history and culture of ancient Egypt.

2 Communication Mix and the 'Noise' Concept

In this section we discuss the position of AR guiding tools in Hooper-Greenhill [1] communication categories. They might be considered as *direct communication* or *mass communication*. Hooper-Greenhill's *communication mix* is a key concept in museums settings as it captures a wide variety of museum communication methods, which has shifted over the decades, and exploits their benefits.

Figure 1 demonstrates the communication processes that involve all parties of the communication in AR methods. The model starts with the sender which could be the person who is responsible to prepare the content that needed to be delivered. That person might be an archaeologist or a curator or a tour guide in the context of heritage museums. This person carefully delivers the information and interpretations which could be textual, visual or auditory. In addition to that, this person should construct a coherent scenario for the whole visit based on a sensible route that he suggests. Furthermore, a part of the sender's role is to give all of the sufficient information needed for the augmented reality developer/designer. The role of AR developer/designer is to choose the most suitable devices, which do not burden or distract visitors during the tour, and to encode the message and ensure that the technology and tools are reliable to deliver the narratives associated with the exhibited objects and collections, taking user experience into consideration. The Internet/Servers are channel through which the data is conveyed. This project focuses on the collaboration between the archaeologist/curator and the AR developer.

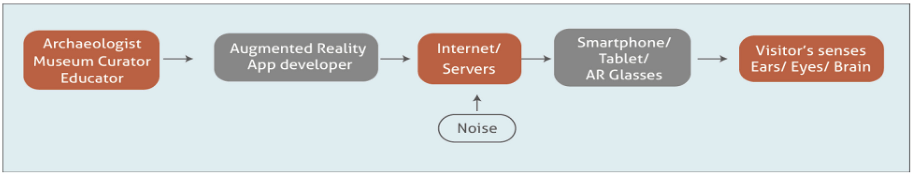

Fig. 1. The communication model of Augmented Reality guided tools in museums settings

'Noise' is defined as any internal or external source that may interrupt the communication or confuse the receiver [10]. External noise could occur for various reasons, for instances, overcrowded museum when visitors use the AR guide, insufficient lighting especially when the system is based on visual tracking. Internal noises could relate to functionality, usability of the system and other aspects.

In Fig. 2 we categorize internal noise that users may experience during their tour in museums using AR guide. Internal noise may occur due to tracking technologies, interaction and UI, and display techniques. Sensor-based tracking is very sensitive to noise. It may be disturbed by an ambient magnetic field. Vision based tracking can be feature-based or model-based. Feature-based tracking could be a problematic if the marker is occluded. Model-based tracking might be a problem if the 3D model is lack of distinguished edges or poor textures. Finally, hybrid tracking is a combination of several sensing technologies including the vision-based tracking. Regarding the vision-based tracking, there are some possibilities of low speed of the tracking process. Moreover, the outlines could be happened and the speedy motions might lose the tracking process and the attempts to recover will take considerable time [11].

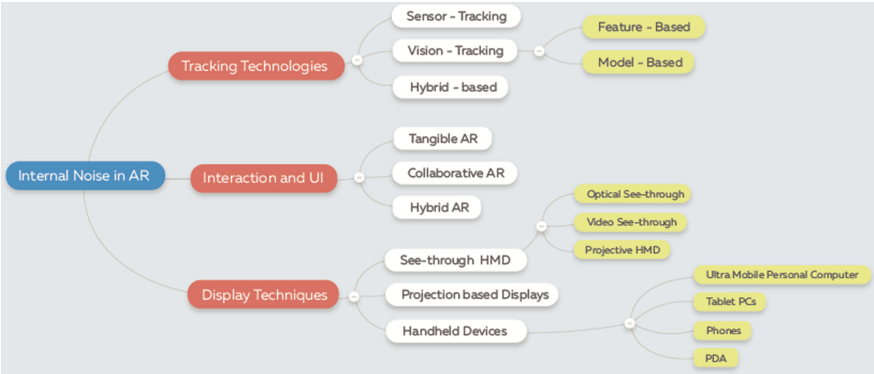

Fig. 2. Internal noise could occur from a structure of Augmented Reality technologies and devices

The second category of internal noise is due to AR interaction and user interfaces. They consist of tangible AR, collaborative AR and hybrid AR. Regarding the 'Tangible AR', it is difficult to determine the state of the computerized data that associated with the physical tools [12]. Besides, using a markerless tracking technique without the clarity of the textures, the system will fail to proceed [13]. 'Collaborative AR': it could cause internal noise if people would like to be more independent during the tour. Moreover, if the museum is crowded, this method will be not work successfully. 'Hybrid AR': these interfaces could be complex if the user in a situation that needed to deal with all of these functions together. Sometimes, the sophisticated design might be hard to be used [14] and the user will not be satisfied eventually.

The third category is 'Display techniques', which consisted of 'See-through HMD', 'Projection-Based displays', and 'Handheld devices'. See-through Head Mounted Displays (HMD): The VST-HMD that State, Keller [15] and their team created was having a very sophisticated design. The devices were in a need of feedback that obtained from users who wear it in order to identify the satisfactory level. Regarding the Head-mounted projection displays, the light in HMPD needs to go through many optics which can occur a reduction in the brightness of the image. Moreover, this paper assumes that it might not be convenient to the end user. Concerning the 'Projection-Based Displays

(HMD)', these devices do not support the privilege of mobility to guide on the walk. Regarding the 'Handheld devices**', t**he drawbacks of these devices are allocated in the AR interfaces which designed for these devices are having small screens with small keypads. Comparing to HMDs, the images that are displayed on the screen and generated by processors are not in high quality [14]. In addition, holding handheld devices and pointing the camera to targets with lifting arms up might considers a constraint for most of the people. Therefore, if this paper takes the account of human factors, these devices are fatigue and not helpful enough for long visits inside museums.

3 The 'Feedback' Factor

Feedback is considered one of the significant factors in the communication method. Besides, the message itself will be changes [1]. What usually differentiate the mass communication methods and the direct communication methods is feedback. Figure 3 depicting a flowchart of the developed communication model based on current AR guiding systems after taking the account of the feedback factor.

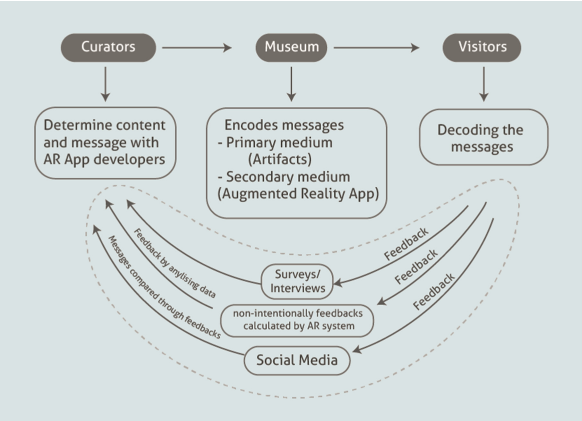

Fig. 3. The feedback channel in AR systems as a communication method

In this flowchart, the augmented reality became the second medium in the model after the artefacts were the first medium. Thus, the curators create the targeted content and the role of the AR developer/designer is to encode and transmit the message towards the channel of the museum which contains the exhibited artefacts and the AR guided system. Then the visitors' mission is to decode the messages that conveyed from the exhibited objects and AR system. Feedback channel comprises of three ways of getting feedbacks from visitors; The first way follows the research methods which could be surveying [16] interviews or recording their facial expressions, verbal and non-verbal reactions along the visit. The previous way is considered an intentional surveying and visitors are aware of the feedback process and they can contribute in it. The next following feedback process that introduced in communication process is a part of Ph.D.

research conducting at this moment. This method extracts feedback from visitors by the system statistics. In other words, if the visitor points his device's camera to run AR guided system in order to reveal the information, a numeric counter in the system will count the time that visitor consumes. The time calculated highlights the level of the visitor's engaging and how much the visitor was interested in this object in particular. The third method of receiving feedbacks from visitors is the world of 'Social Media'. This could be done by exploiting social media websites and attaching the AR system with social media websites [9].

4 Gamification

This section made to emphasise the concept of considering AR a vital medium in museums especially if AR in a combination with gamification techniques in one application. Gamification is defined as "the adoption of game technology and game design methods outside of the games industry" Helgason [17]. Gamification has been utilized and exploited in various domains including the museum sector [18].

The dynamics of gaming are built on the human desires; moreover, they are might be the reasons which influence the player's behaviour. These mechanics are synthesised by McCurdy [19] including: rewards, status, achievement, self-expression, competition and altruism. There are some studies combine AR with gamification for various purposes [20]. However, Rubino [16] built an AR mobile application that can engage visitors on-site. The combination of AR and gamification not only served the previous purposes but it could support attracting visitors in external world [21].

The current research is working on adding the games elements in order to educate visitors the history and the culture of ancient Egyptian. The game 'Horus' will take place in the context of ancient Egypt and it will be applied in the Egyptian museum in Cairo. The content of the game deployed is telling and educating the Egyptian story of deities Osiris, Seth and Isis. The image depicted in Fig. 4 represents Seth, the chaotic and violated god with enemies are trying to attach visitors and his dogs. The principles of defeating the evils after knowing the story will have a good influence on visitors.

Simply, the augmented reality game will be registered in a specific location in the museum. This registration on the floor is created in order to recognize the fixed tags in the wide hall of the Egyptian museum. The scenario of this game is to start with a narrative of the Egyptian superstitious story with a 2D graphics video. Followed by starting the actual game and the player will take the avatar of Horus which represents the hero who has good principles. The monsters of this game are the god SETH who is flying and some scary dogs running on the ground. The player is supposed to shot the evil monsters and get the highest scores. The player has the opportunity to post this results on social media website to obtain the sense of achievement. After playing this immersive and engaging game, this research expects the player might learn that story and get distinguished experience in the context of Egyptian culture.

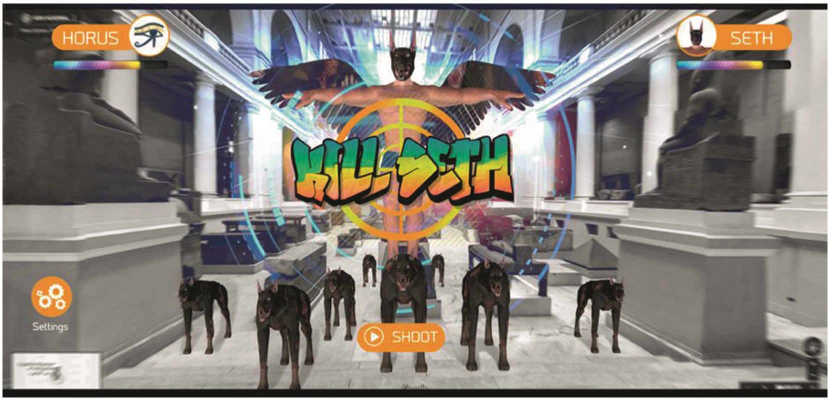

Fig. 4. The ‘Horus’ game mockup (Museum image source: Google maps)

5 Conclusions

This paper emphasises on the multi-shapes of ‘Noise’ that can occur in the equation of the communication method runs by AR guided systems in museums. Likewise, this research paper emphasises the importance of the feedback factor in the AR communication model and revealed new approaches to follow in order to enhance the existed AR guided systems. Moreover, this paper gives an example of using AR in a combination with gamification technique in the Egyptian museum in Cairo.

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Design, Development and Analysis

The RAGE Software Asset Model and Metadata Model

A. Georgiev[1], A. Grigorov[1,6], B. Bontchev[1], P. Boytchev[1], K. Stefanov[1(✉)], K. Bahreini[2], E. Nyamsuren[2], W. van der Vegt[2], W. Westera[2], R. Prada[3], Paul Hollins[4], and Pablo Moreno[5]

[1] Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria
{atanas, alexander.grigorov, bontchev, boytchev, stefanov}@fmi.uni-sofia.bg

[2] Open University of the Netherlands, Heerlen, The Netherlands
{kiavash.bahreini, enkhbold.nyamsuren, Wim.vanderVegt, Wim.Westera}@ou.nl

[3] University of Lisbon, Lisbon, Portugal
rui.prada@tecnico.ulisboa.pt

[4] The University of Bolton, Bolton, UK
pahl@bolton.ac.uk

[5] Universidad Complutense de Madrid, Madrid, Spain
pablom@fdi.ucm.es

[6] Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria
grigorov@math.bas.bg

Abstract. Software assets are key output of the RAGE project and they can be used by applied game developers to enhance the pedagogical and educational value of their games. These software assets cover a broad spectrum of functionalities – from player analytics including emotion detection to intelligent adaptation and social gamification. In order to facilitate integration and interoperability, all of these assets adhere to a common model, which describes their properties through a set of metadata. In this paper the RAGE asset model and asset metadata model is presented, capturing the detail of assets and their potential usage within three distinct dimensions – technological, gaming and pedagogical. The paper highlights key issues and challenges in constructing the RAGE asset and asset metadata model and details the process and design of a flexible metadata editor that facilitates both adaptation and improvement of the asset metadata model.

Keywords: Serious games · Software assets · Game assets · Asset model · Asset metadata model · Metadata editor · Gamification

1 Introduction

In accordance with the requirements of the European Horizon 2020 Research and Innovation Program, the RAGE project[1] aims to develop and provide open advanced technology modules (assets) for applied gaming and to make these assets available

[1] http://rageproject.eu/.

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through a repository that encourages further development, sharing reuse and repurposing of the assets. The assets address pedagogically oriented functions that support game-based learning, particularly in the capture and assessment of user data and the support of strategic interventions and social representations in the game. The purpose of these assets is to support game studios in developing high-quality, pedagogically authentic applied games.

RAGE game assets will be stored in the game asset repository, a central component of a RAGE Applied Gaming Ecosystem. In this context many of the existing approaches and methodologies used by game development companies cannot be directly applied as they typically focus on design and development of bespoke domain-specific games.

In this paper we try to provide answer to the following main research problem, identified in the RAGE project: How do we enrich and transform advanced gaming technologies into self-contained assets for applied gaming that facilitate essential pedagogical functions, that can be linked together into higher level aggregates and that can be easily integrated in existing game platforms?

2 The RAGE Asset Definition and Model

A RAGE Asset is defined as a self-contained solution that demonstrates economic value potential, based on advanced technologies related to computer games, and intended to be reused or repurposed across a variety of game platforms. The RAGE assets comply with the asset definition of the W3C ADMS Working Group [19], which refers to abstract entities that reflect some "intellectual content independent of their physical embodiments". In principle, not all assets include software, e.g. media assets, common in game development, may refer to graphical objects, audio files, videos and other such objects. This paper focuses specifically on the software assets. The RAGE assets contain advanced game technology components (software), enriched and transformed to support applied games development. They are supported by value adding services and attributes (artefacts), such as instructions, tutorials, examples and best practices, instructional design guidelines and methodologies, connectors to major game development platforms and content authoring tools/widgets for game content creation. These additional artefacts not only support but enhance assets usage. Figure 1 provides an exemplar of a RAGE asset and related artefacts.

In order to preserve the software asset's portability across different game engines and platforms, a component-based asset architecture has been described and validated elsewhere [1]. This architecture addresses both the internal workings of an asset and the level of interaction of assets with the outside world, including the mutual communications between assets. The RAGE architecture avoids any dependencies on external software frameworks and minimize any code that may hinder integration with game engines. Furthermore, it relies on a limited set of standard software patterns and well-established coding practices.

A centralized Asset Manager component is included as a coordinating agent, which is used for the registration of the assets and for the use of shared code that is commonly

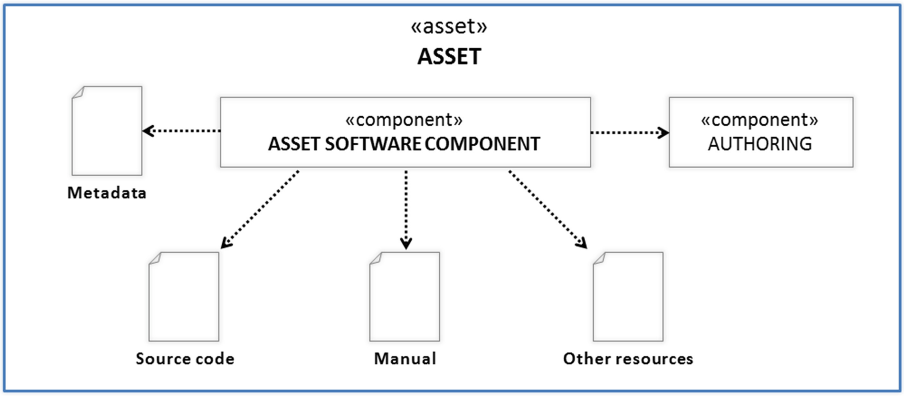

Fig. 1. Example of a RAGE Asset

used by multiple assets, such as the name and the type of the game engine, or user login/logout info for assets that would need a user model.

Proofs of concept in four principal code bases (C#, Java, C++ and TypeScript/JavaScript) have validated the RAGE architecture [1]. In addition, the easy integration of the HAT asset (difficulty adaptation routine) in three different game engines (Unity, MonoGame and Xamarin) has been successfully implemented [2], demonstrating the portability and flexibility of the RAGE asset architecture.

Using interoperability components or named assets in game development involves three different broad disciplines from computer science: software engineering (because the assets are implemented in games as software components), game development (as the assets are integral elements of different games) and Technology-Enhanced Learning (TEL) (as the assets should provide additional pedagogic "values" to the games).

In the following paragraphs we present the principal outcomes across these three related disciplines related to our research (section Related work), further we define the RAGE Asset Metadata model, and finally discuss our initial implementation findings in relation to the research question, highlighting key issues to be addressed.

3 Related Work

In the gaming domain the term *asset* is often applied to media files to be incorporated in a game. The Intel® XDK HTML5 Cross-platform Development Tool[2] offers an asset manager for game development in conjunction with several game platforms. Here assets are considered as audio-visual game objects, to be included in a project. Similarly, the Unity Asset Store[3], which is a prosumer-based community and market for game assets, is dominated by such media assets, these are imported and used in the Unity game engine. Historically game developers would apply the term *asset* for such

[2] https://software.intel.com/en-us/html5/tools.

[3] https://www.assetstore.unity3d.com.

media files rather as opposed to software artefacts, the Unity Asset Store is increasingly including software assets, e.g. code for physics, special effects, controller software, Graphical User Interface software, Artificial Intelligence, and maze generation.

However, this particular and quite specific definition of assets in game world is not useful for the RAGE project purpose. For a more detailed understanding of how to describe and classify assets, we start with the analysis of best practices from the Technology-Enhanced Learning domain (TEL) and the games for learning (applied gaming and serious gaming) domain.

By exploring a variety of game ontologies/taxonomies, we have an established position on classifying assets as game components. The best suited to the RAGE project are from two related propositions: SharpLudus Game Ontology [5] as well as the Game-Based Learning Systems (GBLS) Ontology initiative [6]. They both define the main structure and functions of applied games and their relationships with the TEL domain.

One of the directions in applied games research is linked with the mapping of game mechanics and learning activities [7]. By exploring the LM-GM model (Learning Mechanics – Game Mechanics), the study addresses the similarities between game mechanics and educational components at the implementation level. A simplified game model based on Bloom's theory is in a similar vein. Peeters [8] present an ontology related to applied games, consisting of 6 main areas: Task domain, Trainee, Didactics, Instructor, World, and System. A mapping between game activities, learning activities and learning resources was presented by Prensky [9].

Very close to these ideas is an approach based on the concept of educational game design patterns. In general, applied games design patterns should be based on the well-established knowledge of game design patterns [10], with the addition of a second foundation besides entertainment: pedagogy. A major conceptual tool for better applied game design is the definition of pedagogically informed game design patterns. Kiili [11] identified a number of patterns, proposing six categories addressing key educational aspects. The mapping of learning functions onto game design patterns was presented by Kiili [12].

Whilst these efforts have attempted to link game design with learning design, another approach is based on extending the IEEE Learning Object Metadata (LOM) standard with additional features reflecting the game functionalities and how they affect learning. The SG-LOM profile adds new fields to the LOM categories "Educational", "Annotation" and "Classification" [13]. Hendrix [14] proposed a metadata schema for describing applied games also as an extension of the IEEE LOM standard by supplementing the number of fields to IEEE LOM and having two different levels. In [15] applied games are regarded as active learning objects (LO) that exchange information with the host Learning Management System (LMS) for tracking and assessment purposes.

An asset in the Information Technology (IT) domain of is generally defined as a collection of related artefacts that provides a solution to a problem [16]. Some asset definitions are restricted to content and/or media rather than software. For instance, Niekerk [17] distinguishes three major groups of "digital assets": textual assets (digital assets), images (media assets), and multimedia assets (a combination of different content forms). The IMS content packaging information model [18] likewise uses the word asset to describe the term resources: “the resources described in the manifest are assets such as Web pages, media files, text files, assessment objects or other pieces of data in file form”.

IBM’s Reusable Asset Specification (RAS) [16] uses a high level definition of an asset as “a collection of related artefacts that provides a solution to a problem”, allowing it to package together as an asset almost anything: Models, Design documents, Patterns, Web services, Frameworks, Components, Requirements documents, Test plans, Test scripts, Deployment descriptors, Model templates, UML profiles, Domain specific languages, etc. The W3C specification of the Asset Description Metadata Schema [19] defines an asset as an abstract entity that reflects some intellectual content. An asset differs from an asset distribution, which is typically a downloadable computer file (but in principle it could also be a paper based document or API response) that implements the intellectual content of an Asset.

A model-driven serious games development framework is defined by [20]. They present a platform-independent model incorporating nine core units, namely user interfaces, models of game content, game technology and game software, Model Driven Engineering (MDE) tools, components library (involves art assets, artificial intelligence, physics and e-learning sites), code templates, artefacts, technology platform, operating platform and software. The implementation of this model was presented in [21].

4 RAGE Asset Metadata Model

Metadata is an essential part of the information infrastructure and is critical for creating information services including description, classification, organization, store, search, creation, modification and aggregation of information [3]. Metadata models define the essential characteristics of information assets [4] describing their key components and functions. These models influence and support key services required for asset management including cataloguing, workflow to create and store the assets, how to use, reuse and repurpose assets, etc. Additionally when users or processes interact with the assets, this interaction takes place within the metadata model framework.

The RAGE asset metadata refer to machine-readable information such as keywords and semantic information that can be used by the repository’s search engine. Metadata also include information that is essential for running the asset software in an operational environment, e.g. on a game platform. The metadata includes version information and data about dependencies from other software assets. Consequently, the definition of the RAGE Asset metadata model is a key element in the RAGE project, which enables authentic implementation of the RAGE Ecosystem for the development and exchange of RAGE assets.

Before defining the metadata model, we performed an extensive needs assessment study [24], including asset developers, educators and game producer. In order to support identified set of services through the software repository and other related tools and, in parallel, to be close to the specified domain of reusable gaming components (RAGE software assets), the RAGE metadata model is focused on the following main aspects:

- **Technical** – how the RAGE asset might be used by game developers. We follow the RAGE asset model which describes assets as software components.
- **Contextual classification** – here we focus primarily on the pedagogical, educational and game characteristics, whilst leaving space for further characteristics.
- **Usage** – not restricted to how to install and configure the software, but also providing additional artefacts such as training materials, tutorials, educational goals, etc.
- **Intellectual Property Rights** – to enable various business models proposed by RAGE project to be implemented.

Whilst designing the model, we broadly adhered to general metadata design principles as specified in [3]:

- **Reusability** – reusing where possible existing metadata models, standards and available taxonomies and ontologies. We reuse parts of the RAS and ADMS metadata fields as well as parts of the LOM taxonomy.
- **Flexibility** – to easily facilitate extension of the metadata description of an asset with additional features and characteristics.
- **Simplicity** – we define most of the fields as not mandatory in order to easy the efforts of asset developers. We plan to develop tools for automatic extraction of the most important metadata field values.

The RAGE asset metadata model reuses and extends the specifications of RAS [16] and ADMS [19]. We have chosen the approach to use a core subset of RAS (see elements Asset, Solution, Usage, Artefacts, Requirements, Design, Implementation, Tests from Table 1) and extend it with elements from ADMS (like Classification, Context, Concepts), IEEE LOM (used inside Classification and Context) and metadata related to the applied games domain. We could not use LOM (or even SG-LOM) directly, as it does not provide features for describing compound software objects. The most comprehensive and close to our needs RAS model is too general and complex, has slow adoption and is difficult for users [13, 15, 16]. It is also not consistent with current Software Engineering (SE) practices, as it supports the "waterflow" model for software development. For this reason we simplify significantly elements reused from RAS, and changed some details. The ADMS does not provide support for external artefacts and, similar to LOM, is lacking support for important SE features.

Several taxonomies are used as different Conceptual schemes inside the Context for describing educational elements such as Learning Goals, Knowledge transfer, Skills, Educational Disciplines, Teaching Phase, Learning Purpose, Educational Context, etc.

Although the internal representation of the RAGE metadata in the asset repository is in RDF, we have chosen to use XML as a manifest file format (a special file that contains information about the files packaged in a RAGE asset package) and an XML schema for the model for the following reasons:

- If the manifest file in the asset package is in RDF, it is difficult to validate it – as demonstrated in [22].
- The URIs of the asset and artefacts are automatically generated after the asset is ingested in the repository so we cannot use them in the manifest beforehand.

Table 1. Description of RAGE metadata schema elements

Asset	A self-contained solution that demonstrates economic value potential, based on advanced technologies related to computer games, and intended to be reused or repurposed in a variety of game platforms and scenarios.
Classification	Includes a set of descriptors for pedagogical classification of the asset (learning goal, learning functions, educational patterns used, etc.) as a learning object, as well as a description of the educational context(s) for which the asset is relevant
Context	Defines a conceptual frame, which helps explain the meaning of elements in the asset (game context where asset can be used, educational context, and links between game and learning mechanics in the game).
Concept scheme	A vocabulary, thesaurus or taxonomy used for organizing concepts.
Concept	Represents a particular concept within a vocabulary, thesaurus or taxonomy.
Solution	Describes the artefacts of the asset.
Usage	Contains information for installing, customizing, and using the asset.
Related assets	Describes the asset's relationship to other assets.
Artefact	Any physical element of an asset corresponding to a file on a file system. Artefacts can include also version and license information.
Requirements	Contains artefacts that specify the asset requirements such as models, use-cases, or diagrams.
Design	Contains artefacts that specify the asset design such as diagrams, models, interface specifications, etc.
Implementation	Has a collection of artefacts that identify the binary and other files that provide the implementation.
Tests	Contains artefacts (models, diagrams, artefacts, and so on) that are intended to describe the testing of the asset such as testing procedures, concerns and test units.
License	Contains conditions or restrictions that apply to the use of an asset or artefact, like is it in the public domain, can it be used for non-commercial purposes, etc.
Agent	Describes a person or organization that is a contributor (creator, publisher, and owner) of an asset or artefact.

Thus, we have chosen to use an XML schema for validation of the manifest files and to follow the approach used by the Europeana[4] project for representing RDF in XML. We have used some of the XSD schema files used by Europeana[5] and modified them according to the specifics of the RAGE project. This approach provides for automatic validation of manifest files and easy transformation from XML to RDF and vice versa.

[4] http://www.europeana.eu/portal/.

[5] https://github.com/europeana/corelib/tree/master/corelib-edm-definitions/src/main/resources/eu.

The RAGE Metadata Model defines the format of asset metadata as an XML schema, which is implemented in all tools that require the processing of these metadata, e.g. a package metadata editor, the asset repository, asset installation widgets, etc.

The XML schema represented by a UML class diagram in Fig. 2 can be interpreted while taking into account the following issues [23]:

- A UML class represents a complex XML element. For example, Asset is a complex XML element that has XML attributes and/or child elements.
- Within a UML class definition, the prefix «attr» denotes that the corresponding field is an XML attribute (and not a child element).
- Within a UML class definition, a field without «attr» prefix denotes a child element nested inside the element represented by the UML class definition. The field represents either a new definition of a simple element or a reference to an element (either simple or complex) defined in a referenced schema (e.g., dcterms).
- Composition connection denotes a parent-child relationship between two complex elements defined in the RAGE Metadata Schema (RMS).

Table 1 provides a textual description of the XML elements of the RAGE metadata schema.

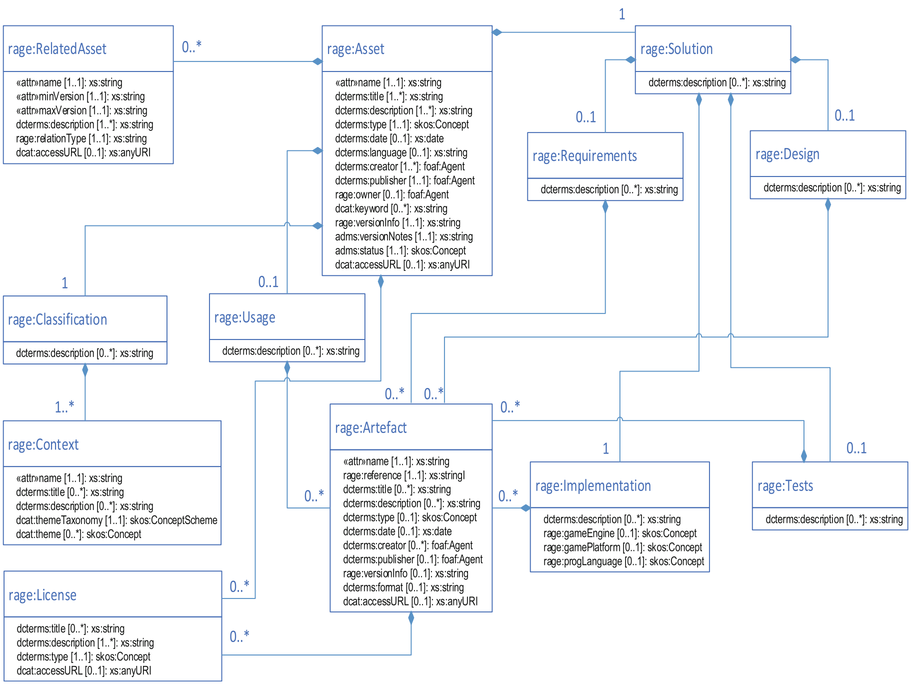

Fig. 2. The RAGE metadata schema

5 The RAGE Metadata Editor

An important aspect of the metadata usability is the development of a metadata editor. This is a tool that facilitates the modification of asset metadata. The design of the RAGE metadata editor follows principles similar to these of the RAGE asset metadata model design in that:

- **Simplicity** – the editor hides the internal complexity of the metadata representation;
- **Flexibility** – the interface is generated on-the-fly, based on the metadata schema;
- **Usability** – various features for increasing the user comfort while editing metadata.

The visual simplicity is a principle that focuses on the user experience with the metadata editor. The metadata schema uses 7 different metadata structures that capture the spectrum of various data types and relations of asset descriptions. For example, there are data which are stored as attributes, as simple data entities or as sequences of data. There are data which are conditional, or which have values from some predefined vocabulary. The editor hides this complexity and the user is not exposed to the internal structure of the metadata.

Figure 3 represents a small fragment from a sample asset's metadata. It demonstrates how four of the different internal types are visualized consistently. For example, the *Name* of an asset, marked by (1), is internally stored as an XML tag attribute; the *Title* (2) is a simple string datum, the *Creator* (3) is an optional field, which is currently set to *Organization* and the elements *Name*, *Mbox* and *Homepage* (4) of the creator form a sequence of data, describing the creator's organization.

Each metadata entry could be defined with a set of additional properties, like cardinality, current language, etc. They are also presented in the user interface. The small list boxes to the right of some metadata fields, like *Description* (5), allow the user to set the language of the content. The *Description* has cardinality 1+, which means that

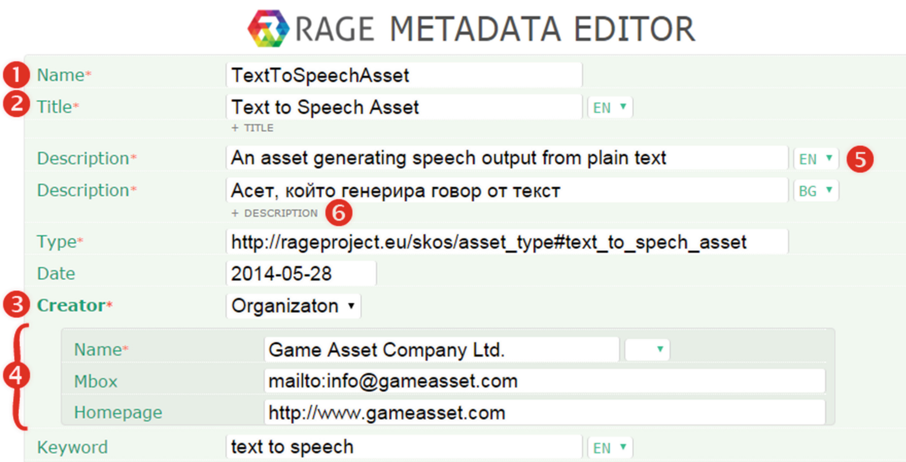

Fig. 3. Sample asset metadata visualized by the editor

it is compulsory (marked by red asterisks) and it may have several instances (marked by the small +DESCRIPTION (6) buttons below the metadata box).

The principle of flexibility means that the editor is not bound to a fixed metadata structure. Instead, it reads the metadata description, extracts the schema file and then recursively processes schemas until it reconstructs the full structure of the metadata. Currently, except for the main asset metadata schema (stored in DefaultProfile.xsd), the editor also processes ADMS (Europeana's Asset Description Metadata Schema), DCAT (Data Catalog Vocabulary), DCTerms (Dublin Core Terms), FOAF (Friend-of-a-friend Schema) and RDF (Resource Description Framework).

Once the editor is familiar with the metadata structure, it builds the corresponding interface. Then it populates it with the actual metadata of the asset. This may recursively request the editor to generate new sections of the interface, if there are many instances of metadata with 0+ or 1+ cardinality. Because the actual structure could easily become too complex, the editor arranges the user interface elements in collapsible nested blocks.

The main advantages of a dynamic metadata editor are: (1) changes in the structure of RAGE asset metadata do not require corresponding changes in the RAGE metadata editor; this allows the RAGE project the flexibility to adapt and improve the metadata model with minimal impact on other project software; and (2) the editor builds the interface by examining the schemas referenced by the metadata. As a result, it is possible to feed the editor with another metadata and other schemas. In this way the asset metadata editor can be used as a metadata editor of other RAGE entities, such as asset packages and artefacts.

When the interface is completely collapsed, it fits into a single screen and displays the most basic metadata of an asset like its name, description, keywords, versions, etc.

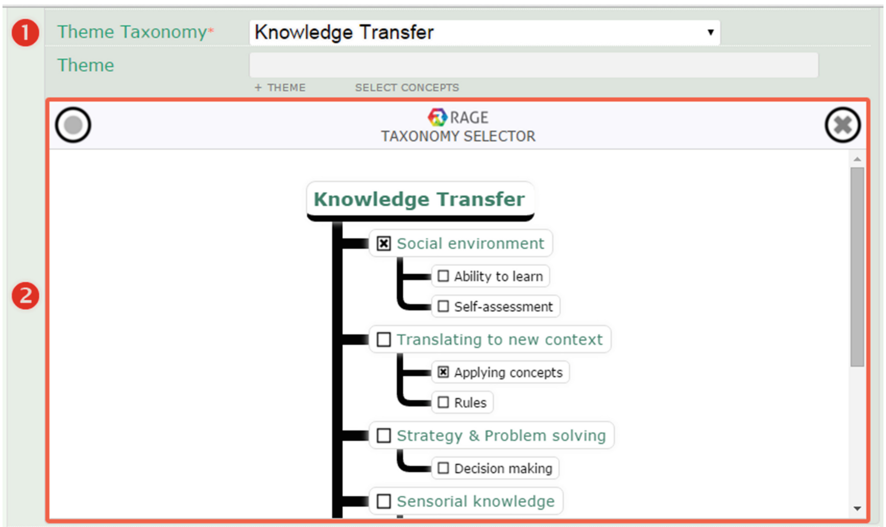

Fig. 4. The RAGE Taxonomy Selector used within the RAGE Metadata Editor

The classification of assets is implemented as references to taxonomies' concepts. To provide a convenient interface to concept selection the Metadata Editor embeds the RAGE Taxonomy Selector. This selector provides an interactive approach to select items from RAGE taxonomies that can be used to classify assets. Figure 4 shows the Taxonomy Selector embedded in the Metadata Editor. The currently selected taxonomy is *Knowledge Transfer* (1) and the selector is (2).

After a user completes the editing of asset metadata, the editor generates an XML file. Prefixes are used in order to make XML tags shorter and easier to comprehend. Tags are aligned horizontally and vertically to provide clues for the hierarchy of metadata sections. Such styling easies the manual metadata manipulation during the initial phases of the software development.

6 Conclusion

In this paper we discussed a new approach for providing reusability, repurposing and interoperability of game software components called assets. The RAGE asset model is introduced, and the problem of how to describe applied game software assets in a machine-readable way to be used by game developers to add pedagogical and educational value to their games is discussed.

The paper presents in detail two key outputs for the RAGE project – the RAGE metadata model and the RAGE metadata editor. Both are created using simple design principles providing flexibility and reusability. The RAGE metadata model extends a core subset of RAS with elements from ADMS, IEEE LOM and applied games metadata. Its metadata schema provides support for the metadata of game artefacts, software engineering features and learning objects, this makes it very promising and useful for any applications dealing with applied gaming assets. The proposed interface of the metadata editor is driven by the RAGE metadata schema, but any structural changes in the RAGE asset metadata will not incur further changes in the metadata editor. Moreover, its interface changes automatically when feeding the editor with other metadata schemas. This makes it useful for editing other metadata such as these of asset packages or artefacts.

Both the RAGE metadata model and RAGE metadata editor provide a basis for classification, search and retrieval of gaming assets, by using references to taxonomies' concepts through a Taxonomy Selector. The generated XML file represents structurally the asset metadata and facilitates both software interoperability in game development and usage of assets' educational values for technology-enhanced learning applications.

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Framing Activity-Based Narrative in Serious Games Play-Grounds Through Objective and Motive

Tim Marsh[1(✉)] and Bonnie Nardi[2]

[1] Griffith Film School, Queensland College of Art, Griffith University, Brisbane, Australia
t.marsh@griffith.edu.au

[2] Donald Bren School of Information and Computer Sciences, University of California Irvine, Irvine, USA
nardi@ics.uci.edu

Abstract. Building on previous work, we extend Leontiev's (1959/1981) original activity theory to bridge conceptual gaps and lay the foundations towards operationalizing a framework for activity-based narrative in serious games. In particular, in this paper we propose that the relationship between the concepts objective and motive and the degree to which they *coincide* or *merge* provides an approach: (i) to frame activity (ii) for design and crafting of narrative, scenarios, interaction and gameplay in serious games (iii) for the assessment of task-based as well as experience-based purposes in serious games and (iv) framework and tool to support iterative serious games development cycle from conveying an idea through narrative, implementation, playtesting and assessment. In addition, we propose a link and connection for activity to the environment through "play-grounds".

Keywords: Narrative · Scenario · Story · Experience · Activity theory · Objective and motive · Play-grounds · Design · Evaluation · Analysis

1 Introduction

A flexible, powerful and rich way to represent and describe human actions and behavior is through narrative. Just about everything we do in the world that surrounds us, whether for work, leisure, play or for creativity, and whether performed in a strictly ordered, repetitive or more flexible sequence of behaviours or actions, can be described as (and through) narrative. What gives sense to what humans do in the world is intention or motive.

Narrative media such as film, literature and theatre (non-improvisational) generate different narrative forms that allow them to transmit narrative and story in efficient and well-crafted ways characteristic to the media. So what is possible in a novel is realisable in different ways, or perhaps not at all, in film or theatre and vice versa [2]. Likewise games, simulations, virtual reality and serious games provide a narrative medium that presents characteristics that are different to narrative forms in literature, film and theatre. A key difference being, in games, simulations, virtual reality and serious games, just like in the real world, human actions, behavior, interaction and choice have an effect on

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narrative. So rather than playing out or unfolding in a strictly linear narrative manner as in film, literature and theatre, with interactive media, players and participants can have influence on the dynamic non-linear narrative. As Laurel et al. (1994) described it over two decades ago, “one is not done unto, but doing” and utilizing narrative to describe “doing” in games and interactive media is obviously not a new idea and has a long research history, including [2, 4–6] and in serious games [7].

Fig. 1. Serious games continuum: showing from left to right, games for purpose (with traditional game characteristics) to experimental & experiential environments for purpose (with minimal game characteristics), as follows: Waker [12] with game characteristics with purpose to learn about aspects of displacement and velocity; 2020 Classroom [13] to learn about physiological and biological process of human organs; Body Music [14] play with aspects of music to learn about dynamics and mixing; The Reef Game [15] swimming through the ocean to experience the beauty and wonder of the Great Barrier Reef (first scene) and destruction from human activities (third scene)

By incorporating “doing”, through action, interaction and behavior, and the reason for “doing” through intention and motive, activity theory has been identified as a potentially powerful tool and framework for design, planning, development and crafting of narrative, scenario and story for games, simulations, virtual reality and serious games. While in previous work [8, 9] we have made some headway utilizing activity theory-based narrative and scenario in serious games, the focus of this earlier work was on task-based and goal-directed actions and gameplay. However, by considering the serious games continuum as illustrated in Fig. 1 [10] (that identifies examples of serious games and how they are located across the continuum according to the degree to which they have traditional game-based characteristics and described as “from games for purpose to experiential environments for purpose”) we can see that task-based interactions and gameplay are by and large appropriate to serious games with traditional game-based characteristics, such as tasks, goals, conflict and challenge, identified predominantly as being on the left-hand side of the continuum. While work is beginning to appear that applies activity theory to serious games, it is also restricted to task-based actions/activities and as discussed later has other associated limitations [11]. An increasing and emerging variety of experiential and experimental serious games are beginning to appear that have little, if any, traditional game characteristics (e.g. task, goal, conflict or challenge), but where for example, exploration, navigation, relaxation, emotion, feelings, moods and experience might be the central purpose. Such games fall predominantly on the right-hand side of the serious games continuum and are identified under the heading "experiential environments for purpose". Other notable examples from [10] include Fullerton and Viola's The Night Journey where participants navigate or explore "an individual's journey towards enlightenment".

So for activity theory to be an appropriate framework for design, development and crafting of narrative in serious games that fall on the right-hand side of the serious game continuum, it needs to be extended to encapsulate experience-based actions and activities.

In this paper we focus on Leontiev's (1981) activity theory and build on previous work [8, 9, 16] and propose a framework that on the one hand is sufficiently flexible to support narrative and scenarios at any level of complexity, while on the other hand provides a standard template with which to frame narrative for all serious games genres "from games for purpose to experiential environments for purpose". To this aim, we extend Leontiev's (1981) activity theory to incorporate user experience and this provides a mechanism to reason about the success of activities in serious games through the relationship and degree to which objective outcome coincides or merges with motive. This is also a key driver for design and crafting of narrative and scenario in serious games. In addition, we propose a link and connection for activity to the environment through "play-grounds" following Huizinga (1955) [17].

2 Play-Grounds and Spheres of Engaged Narrative Activity

Whatever the platform, VR, desktop, tablet, smartphone, console, etc., we start by identifying and locating the place and space where we engage in narrative. When we undertake/perform actions with tools and technology we are said to be engaged in activities and the term engagement is used widely to refer to the level and focus of attention that we commit to activities. Engagement in interaction and gameplay with technology is used synonymously with, or to infer, quality of user experience [18–20]. In games, virtual reality and serious games, many terms and concepts have been proposed to describe a state of engagement in activities such as, immersion, presence, agency, flow and magic circle.

Csikszentmihalyi's (1975, 1990) concept of flow has been a popular approach to describe engagement in activities with strong and intense focus of attention. For example, activities such as mountain climbing, chess playing, performing surgery, athletics, etc., and in game research it has been widely adopted to describe engagement in game play [21, 22].

However, in common with these activities is challenge, and the concept of flow is defined as the optimum balance between challenge and skill [21, 22], and identifies serious games that are predominately on the left-hand side of the serious games continuum and so excludes being engaged in activities that don't require challenge identified on the right-hand side of the continuum. So how can we deal with engagement in activities, interactions and gameplay within virtual, simulation or serious games that have little or no challenge, and as identified in our earlier discussions belong to the right-hand side of the serious games continuum? For example, emerging experimental and experiential interactions, gameplay and serious games that are not challenging and hence not captured by the concept of flow.

Another popular term to describe player engagement in gameplay in digital games is "magic circle". "Magic circle" originally appears in the English translation of the Dutch philosopher Johan Huizinga's (1955) book "Homo Ludens", literally meaning Man the Player [17]. In the original Dutch version of the book "Homo Ludens" (Huizinga 1938), the term "magic circle" is described as "toovercirkel". "Magic circle" was first introduced to games studies by Salen and Zimmerman (2005) [23] to describe an invisible boundary that forms when players engage in and adhere to game rules and culture. The magic circle separates the game world from the outside world and within it players experience a temporary game world during gameplay. While many games scholars and academics identify with Huizinga's (1955) seminal work [17], they generally restrict its application to play and games-related activities and focus exclusively on the poetic term "magic circle" [22]. However, while attractive a term as it is, academic dialogue continues to resonate around the misinterpretations and misuse of "magic circle" extracted from a long list of other examples that Huizinga (1955) identified under the broad heading "play-grounds" [e.g. 24, 25].

"Play-grounds" are environments, spaces or places in which people engage (interact, play) in rituals in "temporary spheres of activity" according to, and are guided and constrained by rules and constraints. Huizinga identifies "play-grounds" and associated rules as follows:

> *"The arena, the card-table, the magic circle, the temple, the stage, the screen, the tennis court, the court of justice, etc., are all in form and function play-grounds, i.e. forbidden spots, isolated, hedged round, hallowed, within which special rules obtain. All are temporary worlds within the ordinary world, dedicated to the performance of an act apart." [16: p.11]*

As seen from Huizinga's examples, "play-grounds" refers to places for religious worship or to practice law, to movie and theatre worlds, and to table or field games, etc. Here "play" refers to taking a role and acting and adhering to rules and rituals, as well as to, "play" according to formal game rules and to non-formal "play". While we acknowledge and welcome the value of this wider perspective and framing of "play-grounds", we identify however, its main weakness to be that of being devoid of any framework and corresponding concepts appropriate to identify, analyze and reason about the idea of "play-grounds" in this wider context, let alone to the virtual and games world nor appropriate for the purposes presented in this paper. So how can we deal with engagement in activities, interactions and gameplay within "play-grounds" that is either with or without challenge, and is irrespective of platform that takes place in virtual and/or game worlds? In addition, how can we represent, describe, model, frame, create and analyze interactions and gameplay narratives? Building on our work captured in "spheres of engagement" [16, 26], that extends Leontiev's (1981) activity theory, we propose an approach, framework and concepts to extend to players/participants' activities across games for purpose to experiential games for purpose performed in serious games "play-grounds".

3 Activity-Based Narrative in Serious Games

As illustrated in Fig. 2, there are currently two main versions of activity theory, each with their roots in the work of Lev Semenovich Vygotsky: A. N. Leontiev's (1981; 1978) original hierarchical framework of activity [1, 27] and Engeström's (1987, 1990) expanded triangle incorporating collective activity [28, 29].

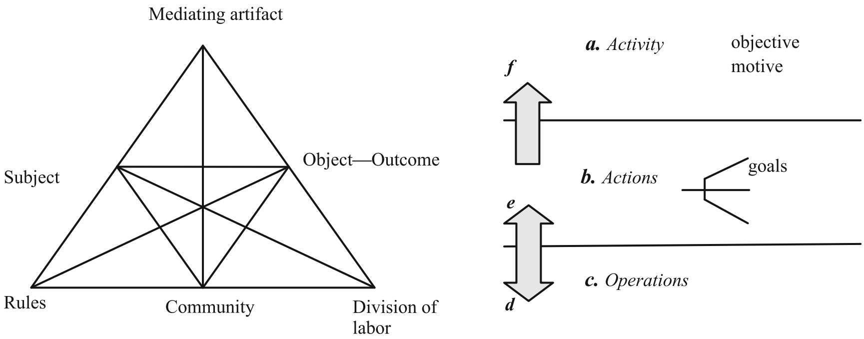

Fig. 2. Engeström's (1987, 1990) expanded triangle (left) and A. N. Leontiev's (1981) original hierarchical framework of activity (right)

Even though Leontiev's (1981) and Engestrom's (1987, 1990) activity theory are different, and have different views of the same concepts (e.g. see [30] for informed discussion on "object"), questionable practice persists in the mixing of these two main versions of activity theory together. For example, while previous work has applied activity theory to serious games, practice continues to mix Engestrom's activity system with Leontiev's hierarchical framework and furthermore, without explanation adds the concept of "motive" from Leontiev's activity theory to the activity system of Engeström [11].

3.1 Framing Narrative of Activity Through Object and Motive

Extending Leontiev's (1981) activity theory, an activity-based scenario/narrative approach and framework was proposed [8], to plan, model, describe, develop and evaluate narrative of interaction and gameplay. In reference to Fig. 2, central to this is the hierarchical framework of activity composed of: (a) activity, (b) actions and (c) operations and characterized respectively by objective, goals and conditions. The hierarchical structure is dynamic with shifts between activity, actions and operations orchestrated according to activity theoretical concepts and determined by rules, mechanics, situations and circumstances (of interaction and gameplay). Its power comes from its lens-like ability to focus on any level of abstraction from high-level descriptions of activities to zoom in to any level of narrative detail/complexity. So providing a flexible and dynamic framework that supports design, development and analysis of interaction and gameplay. In reference to Fig. 2, activity is directed towards an objective (as denoted by "a"). The objective is a process characterizing the activity as a whole. The objective is closely related to motive, and the motive is the intention that stimulates and drives the participant or player. In activity theory, the objective's outcome and motive have to be considered in the analysis of "activity proper" [1]. There are two ways to reason about the relationship between objective outcome and motive, as illustrated in Fig. 3.

The first and widely published [8] way using Leontiev's (1981) original activity theory is the degree to which the outcome from objective *"coincides"* with motive. When the outcome from objective coincides with motive, it is fulfilled or complete and the activity ends, and as Leontiev (1981) states, this identifies "activity proper" and is appropriate to task-based actions/activites on the left-hand side of the serious games continuum (Fig. 1). For example, with task-based activities in serious games, Marsh (2010) proposed *"objective outcome coincides with motive as a measure [assessment] of learning"*.

The second and alternative way that we propose to assess the relationship between objective outcome and motive is through the degree to which objective outcome *"merges"* with motive, that we argue also identifies "activity proper" [16, 26]. This reading and interpretation of the relationship between objective outcome and motive has to our knowledge received very little if any attention, nor has it been previously used in the assessment and design of activity. Merges implies two important aspects, firstly, the actions, behaviour or processes undertaken are heading in the right direction and secondly, merges doesn't necessarily suggest an end point but suggests that as long as actions are contributing to the merging, then motive is being fulfilled or satisfied. So for example, if a motive is for stimulation, experience, learning, training or practice (art, music) and the outcome from carrying out/performing processes (actions, behavior) provides just that (stimulation, experience, learning, training, practice), then the objective outcome merges towards motive. If this condition is maintained then players and participants could hypothetically continue to be engaged in interaction, play and practice indefinitely (or at least until some other need arises, from disruption or fatigue, etc.).

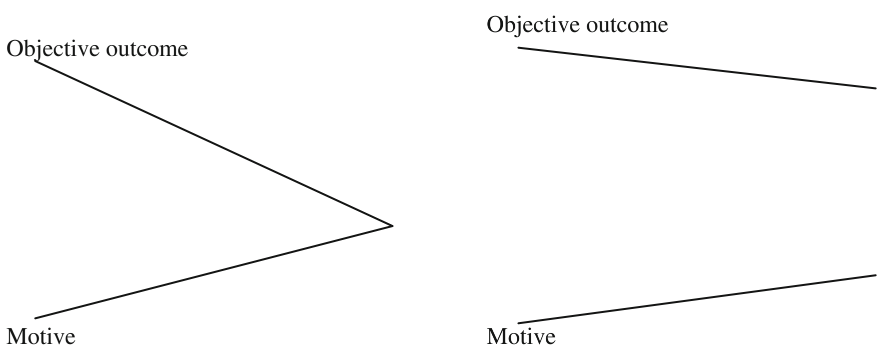

Fig. 3. Objective outcome *coincides* and *merges* with motive

This has far reaching implications for using activity theory for design and crafting of narrative for serious games and encapsulates activities on the right-hand side of the continuum (e.g. swimming in the ocean and experiencing the wonder of corals and marine life [15]).

Actions are performed by a combination of operations. Operations are performed with little conscious thought or effort in the use of physical interactive and virtual in-game artifacts triggered by conditions of actions ("c"). Players' shifts in focus between action and operation levels provide an indication of learning and reflection. For example, the early phases of using an artifact will have been performed with deliberate and conscious attention. At this point they are actions. When they become well practiced and experienced, actions become routine. That is, they do not need to be planned and at such a point are performed with little conscious thought or effort.

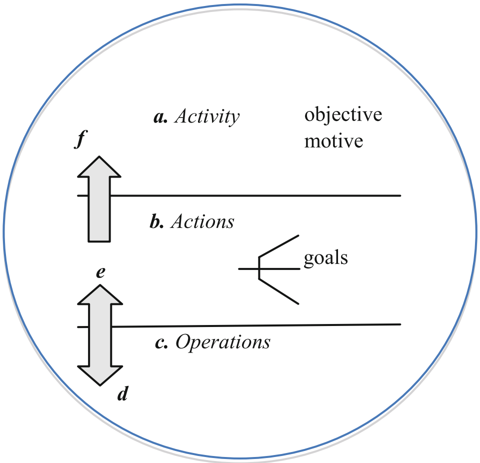

Fig. 4. Sphere of engagement: participant/player engagement in pursuing objective driven by, or towards motive - identifies and encapsulates processes/narrative and operations of activity

In this way, actions become operations as represented by the downward pointing vertical arrow ("d"). This provides a way to reason about the mastery of (in-game, interface, virtual, real) artifacts/tools. Conversely, operations become actions when something goes wrong, impedes interaction, or is associated with user-player learning represented by the upward pointing lower vertical arrow ("e"). This provides a way to reason about "focus shifts", "breakdown", learning and opportunities for design [31, 32]. Finally, "f" represents the situation when an action/process becomes so stimulating that it transforms into activity and represents the creation of new activities.

In earlier work on activity theory [16] the idea of spheres of engagement was developed as a way to represent engagement in activities (Fig. 4). A key purpose for devising the spheres of engagement was to get away from the idea that activity is a container for actions, interactions and gameplay but instead engagement in activity is formed through the relationship between objective and motive and this is represented by a sphere.

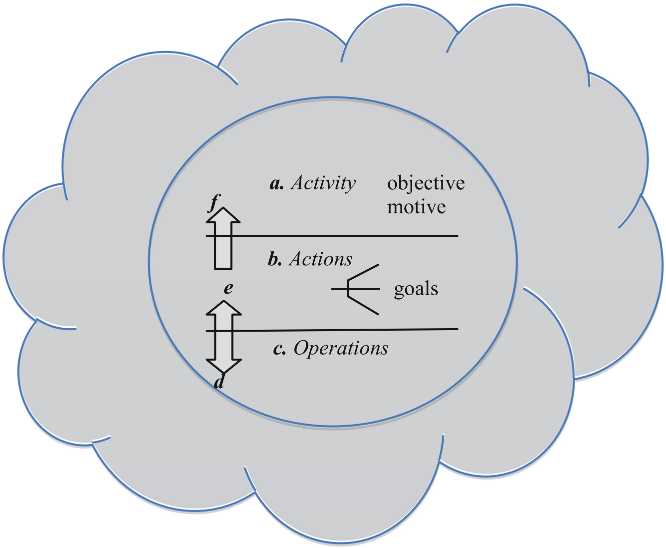

Fig. 5. Activity in Play-ground: showing activity and sphere of engagement performed in a play-ground environment

However, activity is not performed in a vacuum and so we need a way to deal with, and represent the environment in which activity is performed. Following previous discussions we identified Huizinga's (1955) idea of "play-grounds" provided a way to describe and represent the environment where activity is performed. Such that, "play-grounds" could be either the same as activity and sphere of engagement (Fig. 4) or the activity and sphere of engagement is performed in a "play-ground" (Fig. 5). In this way, play-grounds then becomes our arena or container for activity and link or connection to the environment and the social and therefore, we can begin to start reasoning about and consider the effect or impact it has on activity.

4 Discussion and Conclusion

In this article we have explored the original writing of A. N. Leontev (1981) and proposed extensions to bridge conceptual gaps to operationalize an activity-based narrative approach for serious games, building on previous work [8, 9, 16, 26]. This provides a framework to envision, reason about, and design for both task-based and user experience-based activities and narrative for all serious games genres "from games for purpose to experiential environments for purpose". Considering activity through the relationship between *objective* and *motive* provides a means to frame activity. The degree to which they *coincide* and *merge* provides powerful ways to reason about people engaged in activity as captured in the term sphere of engagement. The framework's narrative lens-like ability provides a way to describe/represent to any level of abstraction from high-level descriptions of activities to zoom in to any level of detail/complexity. Finally, borrowing from Huizinga (1955), herein we propose the idea of "play-grounds" to reason about, consider and link to environments where activities are performed.

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A Concurrent Think Aloud Study of Engagement and Usability in a Serious Game

Geoffrey Hookham[1(✉)], Bridgette Bewick[2], Frances Kay-Lambkin[3], and Keith Nesbitt[1]

[1] University of Newcastle, Newcastle, Australia
{geoffrey.hookham,keith.nesbitt}@newcastle.edu.au
[2] University of Leeds, Leeds, UK
B.M.Bewick@leeds.ac.uk
[3] University of New South Wales, Sydney, Australia
f.kaylambkin@unsw.edu.au

Abstract. This research presents a think-aloud study examining issues of engagement and usability in relation to a serious game and a more traditional online program. Results from twenty concurrent think aloud sessions involving a serious game called Shadow and its more traditional counterpart called SHADE are reported. Both programs are designed to help counsel young adults with depression and alcohol or other drug issues. An analysis of the think aloud results reveal issues related to both usability and engagement with users' concerns cycling between content and operation of the interface. The main themes emerging from the study provide an alternative lens designers.

Keywords: Engagement · Serious games · Think aloud · Usability · Design

1 Introduction

The study of games as learning or training tools has been ongoing for many years; using the term serious games to describe these tools since 1970 [1]. A motivation to developing serious games is the idea that they are in some way engaging, perhaps more so than other approaches, and this higher level of engagement can help improve the intended outcomes [2, 3].

This paper will begin with a brief discussion of the concept of engagement. The paper will go on to describe a study into issues related to usability and engagement, in a project designed to compare a traditional online psychological treatment program, called SHADE [4], with a serious game called Shadow [5]. These programs are designed to assist in the treatment of young adults with depression and alcohol or other drug issues. Previous work related to these programs have been reported elsewhere [4–7]. This paper provides a brief introduction these programs to provide context for our study. The intention of the paper is to report on a study examining usability and engagement issues with both SHADE and Shadow using concurrent think-aloud. The outcomes are relevant for designers of serious games who wish to have an alternative lens on usability and engagement.

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2 Concepts of Engagement

In simple terms, engagement refers to a person's involvement in a specific activity. Stemming from examinations on pupil engagement in school-work [8], one succinct description of engagement suggests it is "a complex meta-construct with behavioural, affective and cognitive components that vary both situationally and dispositionally" [9]. The concept of engagement in interface design has further been related to the notions of immersion, presence, flow and absorption [10].

The concepts of presence and immersion are often used interchangeably in the literature. However, a key distinction lies within how actively game content is experienced [11]. Immersion is a process through which one becomes deeply involved in the material, gameplay or story. Presence can then be seen as playing a part in inducing immersion. Both presence and immersion might be experienced in other, less interactive media, such as books, music and film. By contrast engagement implies a more active participation with the material [11], The active engagement with material, whether solving puzzles, understanding concepts or overcoming challenges [11] links directly to the design of user interactions within video games.

The immersive and engaging capabilities of video games can lead the player to experience what is described as the 'Flow' state [12]. It is generally agreed that the concept of Flow, or the optimal experience, is an identifiable and key element in the concepts of engagement and immersion tied to the balance of game challenge and player skill [13]. From Flow, the GameFlow [14] model of player enjoyment in games was developed, which can aid the design and evaluation of games.

3 SHADE and Shadow

SHADE is a web-based intervention program for helping to treat binge drinking and depressed mood [4]. SHADE consists of information and interactive components, including case vignettes and in-session exercises. It provides tips for reducing alcohol consumption and improving mood. The module used in this study focuses cognitive behaviour therapy (CBT) and motivational interviewing techniques to encourage behavioural and cognitive change related to a person's mood, and misuse of alcohol/other drugs. While the SHADE program has demonstrated efficacy in reducing depression and alcohol use over time [4], treatment completion rates are 36 %, with average attendance at 5-6 out of the full 10 sessions. Sessions 5-6 within the SHADE program correspond to a move from behavioural tasks to more complex cognitive strategies, which seem to be difficult to relay in the more traditional interface style used with SHADE.

Shadow is a prototype serious game, developed to try to improve completion of the SHADE program and to encourage program users to understand the cognitive tasks associated with SHADE treatment. Shadow is being developed and evaluated as an alternative training approach [5].

Shadow presents users with short scenarios and response paths. These paths are selected based on the player's ability to successfully identify and sort unhelpful, automatic thoughts into categories, or thought patterns. These strategies are characteristic of the cognitive tasks associated with typical CBT programs, and the SHADE computer program in particular.

4 Method

Five males and five females, primarily students, 18–30 were recruited for the study using poster and word of mouth. No history of depression or substance abuse were required for participation, however participants were screened for suicide risk with provision of crisis information if required. Participants were required to have normal or corrected to normal vision. All participants were informed about the study intention and methods to be used in the experiment. Participants completed two phases of the experiment, an evaluation of Shadow and an evaluation of SHADE. These evaluations were carried out in two separate sessions at least a week apart. The order of evaluation was randomised with five experiencing Shadow, the game, followed by SHADE, the online program. The other five experienced SHADE first followed by Shadow.

The evaluation process included a range of measures including Startle reflex modulation [15] and think-aloud [16] over a 10 min period. Three questionnaires were completed at the end of each session. Two of these were standard interface usability assessments, the System Usability Scale [17, 18] and an adapted Perceived Usefulness survey based on the Perceived Usefulness and Ease of Use survey [19]. The third was a survey typically used to profile behaviour measuring different aspects of user engagement [10]. Results of the startle reflex and survey responses are discussed elsewhere [6, 7].

Think-aloud records data in the form of verbal reports from participants during specific conditions; completed during a task or immediately after [16, 20]. Participants were asked to verbalise their thoughts during the 10 min sessions and were introduced to the think-aloud activity during a practice session prior to recording. This approach of concurrent think-aloud is in keeping with recommendations for improving validity of verbal protocol analysis [16]. Video recordings of the 10 min sessions were later transcribed by the research team for further analysis. Transcriptions of the 20 think-aloud sessions (10 for SHADE and 10 for Shadow) were analysed using an approach described as framework analysis [8, 9]. Following these guidelines, two specific coding frameworks were generated from the data, and used to analyse participant utterances and the where in the program these occurred. The transcription data were segmented into individual utterances involving an iterative process of revision of the coding framework and consultation between research members.

5 Results

Across all 20 transcripts, a total of 15601 utterances were identified. Dual coding frameworks were used to allow comparison of interaction forms differentiated between passive elements (reading) and participatory elements (problem solving and decision making). The first framework consisted of 10 codes based on location in the game or program. For example, Introduction, Instructions, Dialogue, Mindful Mode, Activity Sheets, and

Content/Main areas. The location framework allowed grouping of utterances within areas defined by dominant interaction forms. The second framework used 41 codes based on participant utterances. This framework included participant utterances or audible interaction events (clicks) related to their activities within the program, or the operation or components of the programs themselves.

The codes from the utterance framework were summarized into eight relevant themes (see Table 1) related to the game or program content or were helpful in understanding participant reactions or thought processes. From these eight themes, four meta-themes were derived from the perspective of participants' experiences (see Table 1). Next we discuss results for each meta-theme in relation to usability and engagement in both SHADE and Shadow.

Table 1. Emergent themes and meta themes from think aloud study

Meta themes	Component themes
1. I'm trying to do this.	1.1 Frustration/Confusion with the game/program. 1.2 Reflections of own action or experience. 1.3 Development of understanding.
2. I'm interested in doing this.	2.1 Connection with the game/program. 2.2 Response to game/program event.
3. I want to progress.	3.1 Interacting with the game/program. 3.2 Comments on presentation of game/program.
4. I'm able (or not) to do this.	4.1 Progression through the game/program.

6 Discussion

Think aloud revealed key differences between Shadow and SHADE. Shadow provided agency over the progression of the game compared to SHADE's linear progression. Puzzle solving elements unique to Shadow presented more 'eureka' moments of delighted understanding. Participants' eureka moments followed a similar pattern; expressions of frustration, followed by interaction, problem solving and finally the expression of delight (Table 1: 2.2) or eureka. Participants nonetheless indicated signs of engagement with the more passive presentation of SHADE's content, though comments regarding the wordiness of its content were frequent.

The commonality between participants' usage of SHADE and Shadow was the cyclic nature of the meta-themes. Participants would attempt to use the programs, and in so doing become interested and invested in their activity. This interest lead to a desire to progress. The participant's ability to use the program, or from their perspective if the program allowed them to progress, then became the crux of this cycle. If participants encountered difficulties with the program operation, whether through usability issues or a lack of contextual understanding, they would break out of a focus on content and instead focus on the workings of the program. Once the program operation was understood, the focus shifted back to engagement with content. This cycle occurred in every session, and all participants finished in the content cycle having shifted to program operation at least once.

7 Conclusion

The intention for this study was to understand any difference in engagement between serious games, like Shadow, and more traditional interfaces in programs like SHADE. We also hoped to determine if fundamental usability differences between Shadow and SHADE might impact engagement moreover than game-like features unique to Shadow. The meta themes representative of this cycle, present potentially useful lenses to understand the interplay of usability and engagement in serious games.

Each program presented minor issues with usability, including display errors, complex navigation and progression walls. These issues were found to trigger shifts in focus, but not necessarily break engagement as participants were engaged with working out the program rather than with content. The purpose of serious games is often focussed on improving learning, training or therapeutic outcomes. Barriers to progression or usability issues, while beneficial to reduce, may be deliberately leveraged to step participants out from intense focus on content and allow contextualisation of the serious game purpose.

The think-aloud method provided immediate, actionable feedback on user-centred aspects of a game design. This revealed which components drew player's attention, where they got stuck and how they overcame challenges.

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Rhythmic Entrainment in Games

Brigid Mary Costello(✉)

School of the Arts and Media, UNSW, Sydney, Australia
bm.costello@unsw.edu.au

Abstract. This exploratory paper focuses on the rhythm of game interactions and the rhythmic experience of the player. The player's experience of a rhythm involves patterns of attention that are formed through processes of entrainment and habituation. The player's body both opens to a rhythm and is influenced by it. There are voluntary and involuntary, conscious and unconscious aspects to these processes and this paper explores the characteristics of these rhythmic dynamics within game experience. In discussing the range and complexity of the processes of rhythmic entrainment, the paper also suggests that this perspective might be useful for the design and analysis of serious games.

Keywords: Rhythm · Entrainment · Games · Serious games · Player experience

1 Introduction

In computer games, player actions and their corresponding game reactions form rhythms - patterns of space, time and energy. Player experience of these rhythms can often be unconscious, for example, when play is going well and the player feels in sync with the game. At other times the rhythms of gameplay will be more consciously felt, for example when a move requires precise timing or a complex sequence of key presses. Rhythms pattern the moment-by-moment actions of gameplay but also play out across game levels, within game sessions and in the intersection between gameplay and a player's everyday life. This exploratory paper focuses on rhythms within computer gameplay and in particular on the ways that these rhythms can be perceived as controlling or controllable and also as voluntary or involuntary. The discussion draws on theories from game studies and also those from music, dance and performance studies – disciplines that already have a strong theoretical focus on rhythm and rhythmic experience. The hope is that rhythmic experience will provide a useful perspective for both analyzing and designing games and, in particular, serious games.

Attention is an integral part of the experience of a rhythm within computer games and, as James Ash describes, attention can be either thrust upon the perceiver or voluntary [1]. We can have our thoughts interrupted by a loud sudden birdcall or we can choose to listen to a bird singing. A second pair of opposites describes the way that our attention can be drawn to things we wish to avoid and also drawn to things we are attracted to. We can smell rotting garbage and cross the street. We can also smell a sweet flower and move closer to the bush. These two pairs, captive/voluntary and aversive/attractive, operate across a continuum of attention that can be "conscious and focused" or

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"unconscious and environmental" [1]. We can be unconsciously aware of the drip of a tap as we prepare dinner or consciously focused on each drop when its rhythms interfere with our desire to fall asleep.

Experiencing any rhythm requires both perceptual attunement and a synchronization of attention, a process described by the term entrainment. A rhythm must be attended to in order to be perceived, and in this attending we need to synchronize "some aspect of our biological activity with regularly recurring events in the environment" [2]. This biological activity may involve listening or seeing but might also involve physical movement. The tapping of a foot or clapping along to music, for example, can help someone perceive a rhythm. Experiencing a rhythm, then, involves an opening of our perception as we attend to it and a focusing of our attention as we synchronize with it. The body is intimately involved in the experience of a rhythm and this involvement can be simultaneously voluntary and involuntary. We can choose to listen to the dripping tap but, having opened our perception to it, the rhythm of its drips can then take control of our attention so that we can no longer shut it out. Our attention bends with the rhythm of the tap like a blade of grass bends to the rhythm of the wind. Those writing about rhythm frequently use metaphors to describe these entrainment processes and in these metaphors we see a similar interplay between voluntary and involuntary, controllable and controlling. Rhythm is described as something that can possess and contaminate but also as something that can entrance and enhance. Rhythm can enslave us or we can have the expressive control of a performer playing a score. This paper discusses the two entrainment processes of opening to and being bent by a rhythm within computer gameplay. Separating out these two intertwined processes will allow us to ask, who is doing the opening and who is providing the rhythm that is being opened to? To ask, who is being bent and who is bending them? In asking these questions the aim is to begin to describe the range and complexity of the processes of rhythmic entrainment within games and in so doing to begin to discuss how they might operate within serious games.

Because computer game experience emerges from a dynamic rhythmic interplay between game player and game form, the "who" of the questions above could be either the player or the game. A computer game not only has its own dynamic vitality, it also gains vitality from the resonant traces of the 'voice' of the game designers and from reflected vitality projected by game players. It is, therefore, "a form of being that is irreducible to either biological bodies or inert passive matter" [1]. The vitality of rhythmic experience is, thus, a capacity that is shared by both game player and game form. And this vitality is crucial for a play experience because it allows the player to feel the responsive presence of a plaything or playmate. Without this vital presence there is nothing to play with: the responsive bounce of a ball is replaced with the dull thud of a puncture [3]. This paper, therefore, starts with an acceptance that the dynamics of the rhythmic relations between game form and game player are crucial for the creation of a play experience. Because of its importance to play, a focus on rhythm, it is suggested, will provide a useful perspective for both the design and analysis of serious gameplay experiences.

2 Opening to a Rhythm

> …a beat lands on your joints, it docks on the junction between your joints and articulates itself onto your joints, it seizes a muscle, it gives you this tension, it seizes you up, and suddenly you find your leg lifting despite your head…Anywhere you have a sense of tension, that's the beginning, that's the signs of a bodily intelligence switching itself on. And that's what rhythm is doing. [4]

Writing on the rhythmic psychedelics of dance music Eshun describes the process of synchronizing one's attention to a rhythm as a type of possession over which the "head" has no control. In this characterization, a rhythm captivates the body, if not explicitly against his or her will then with no sense of will involved. This is a perspective often reflected in descriptions of the addictive quality of gameplay, in which there can be sense of wonder at the unconscious ease with which game rhythms can invade and disrupt the rhythms of everyday life. We can see such addictive compulsion expressed in this statement by a player of *EverQuest* (Daybreak Game Company, 1999): "I have headaches from the countless hours I spend staring at the screen. I hate this game, but I can't stop playing" [5]. This metaphor also describes of a type of experience that can occur in first person gameplay when the mesh between the rhythms of player action and avatar movement combines with the rhythmic demands of gameplay to create a sense that, as this player describes, can feel as if one has been possessed:

> …I don't even think about what I am doing and just watch my character move and feel my fingers twitch and am consciously totally detached from what I am doing. Like I am sitting outside of myself going "how is he doing that"? For me, that is a kind of divine … [6]

This possession metaphor implies an ethereal mesmerizing external force that takes over the will of the body forcing it to attend to its rhythm. Similarly, a serious game like *Unsavory* (NERDLab, University of Miami, 2015) forces the player to match fast rhythms when it asks them to quickly and accurately complete a sequence of taco orders. This game intentionally takes control over the rhythms of the player wanting the player to "push …[his or her] body to the limit" [7] so that the player can experience some of the pressures faced by many restaurant workers in the US.

Another perspective with a similar sense of involuntary possession characterizes rhythmic entrainment as a viral spread that contaminates or infects the body [8]. This viral metaphor implies a relationship to the contaminator that is if not hostile then at least hints at the potential for the body to be corrupted in an unconscious internal way by a multiple (and multiplying) rhythmic force that is alien in composition and scale. In this metaphor we can perhaps see a description of the type of viral contamination that occurs in a networked game like *Words With Friends* (Zynga, 2009), where the rhythm of phone alerts can infect every moment of the day; telling players a move has been made, reminding them to play or suggesting a new opponent. As Portanova points out, this metaphor also carries with it the suggestion that a rhythm is something that can, like a virus, be blocked or fed and be spread through contagion. These processes can be used to describe the way *Words With Friends* and its rhythms can spread throughout friendship networks, a contagious process that is either fed through the game's connection with Facebook or potentially blocked by privacy settings or personal choice. We see these types of viral rhythms used for more serious purposes in game-like applications that aim to improve player health by breaking old habits and/or forming new ones. In these health applications the contaminating rhythms of game reminders and the game's viral spread through friendship networks can be used to motivate changes in behavior.

These metaphors of possession or contamination seem to share a perspective that the process of opening to a rhythm is both involuntary and unconscious. But is this necessarily the case? The first person player description above with its talk of "a kind of divine", describes an experience of being possessed that, although involuntary, is not necessarily one of being haunted or bedeviled by a rhythm. It could be more accurately described as an entrancement that leads to rapture or ecstasy and this implies a possession that is moving towards the conscious and focused end of the attention spectrum. It also describes an attention that at times resonates between voluntary and involuntary, between something that is thrust upon the body and also intentionally surrendered to. This rhythmic resonance between voluntary and involuntary is one we also see operating in the type of health applications described above. The player voluntarily makes a choice to try to change a behavior but needs the involuntary rhythms to help them effect a change in habit.

So are there other ways of opening to a rhythm that could be described as conscious and voluntary? One perspective that does this emerges from McNeill's description of the "muscular bonding" process of entraining to a military drill. As he moved in sync with row upon row of other men, he relates how being

> …conscious of keeping in step so as to make the next move correctly and in time somehow felt good…a strange sense of personal enlargement…becoming bigger than life, thanks to participation in a collective ritual [9]

We see a similar sense of personal enlargement in massively multiplayer gaming environments where participants describe the pleasure they get from sharing a common goal as a "megafized feeling" [10]. It can also be found in first person player experiences when gameplay results in a prosthetic sense of expanded bodily capabilities [11] and the player sympathetically feels the lurch and leap of character movements. These rhythmic dynamics might play out in serious games that use player input to help solve real-world problems, for example, *Play to Cure: Genes in Space* (UK Cancer Council, 2013), the sense of a collective goal helping maintain player engagement. In the taco building section of the game *Unsavory* a sympathetic sense of prosthetic connection with the character might also occur, further helping the game to portray the pressures of restaurant work.

A slightly different perspective of this sense of personal enlargement is provided by Sklar, an anthropologist who uses kinesthetic empathy or "…the capacity to participate with another's movement or another's sensory experience of movement" as a method for analyzing and understanding movement practices [12]. She describes how copying the moves of dancers brought an understanding of their rhythmic performance that could not have emerged from observation. This insight is echoed by Lefebvre and Régulier who point out that "…in order to grasp a rhythm one must have been grasped by it, have given or abandoned oneself 'inwardly' to the time that it rhythmed" [13]. In games players develop knowledge as they perform the rhythms of the characters they control. For example, Gee describes how by getting "the Full Spectrum Warrior soldiers moving from cover to cover in good synch with their world" the player develops specific problem solving abilities and knowledge [11]. In the serious game *Darfur is Dying* (mtvU, 2006) the age and gender of each character impacts the rhythm and speed of their movement across the desert. The player experience of these rhythms as they try to avoid being captured by the militia provides an embodied awareness of this aspect of life in Darfur: one that has much more affective impact than the textual description provided elsewhere in the game. In this perspective of opening to a rhythm, then, enlargement comes from knowledge that arises through a conscious softening into, yielding or abandonment to the rhythms of another.

So far, in our examples of the rhythmic entrainment of game experience, we have viewed the rhythmed other as being represented by the game and the entrained body by the player. It is also possible to consider the reverse of this. That is, to consider the playing body as the rhythmed other that the game is opening to. For example, a multi-player game could be described as contaminated by the players' when a pattern of social rhythms destroys gameplay. The practice of "lag cheating" where network lag times are used to override the game rhythms [14] could be described as a form of possession of the game by an external rhythm. A game could be described as yielding or softening to the player when it gathers knowledge from the rhythms of players in order to adjust difficulty. And a massively multiplayer online game could be described as being enlarged by the variety that the dynamic rhythms of players bring. This perspective is an interesting one to consider in relation to serious games, which tend to be tightly focused on their serious purpose and often do not have the complexity of structure to allow for this much play in their gaming rhythms. It could be worth exploring further what kinds of serious purposes might benefit from allowing space for these dynamics to emerge.

One final interesting perspective to consider is the possibility of the game or player not opening to the rhythms of the other. That is, to consider situations where the entrainment process might be being blocked by something. In an online discussion about game length one player pointed out that some games are just not suited to the shorter time-spans that those who work can devote to them while another admitted that he based his playing around games that did suit his work-life rhythms: "Seems like I end up just replaying multiplayer games these days, so I can get some satisfaction from a 'couple hours'" [15]. A similar rhythmic mismatch can occur in *Words with Friends* when a player who only has time to make a move once a day tries to play someone who has the time to play quickly and prefers to do so. In these examples we see a mismatch between the everyday rhythms of the player and the rhythmic demands of gameplay, a mismatch that can then block the entrainment process. Rhythmic mismatches can also occur between player actions and game responses. Hamilton describes this type of mismatch when he voices his frustration with the combat controls in *The Witcher 2* (CD Projekt, 2011) describing how "the animations play out in conflict with my button inputs, and the whole thing winds up feeling like playing a guitar duet over Skype" [16]. The frustration that he is expressing is not about his ability to manipulate the controls in order to achieve a game outcome. It is about a perceived lack of synchrony between the physical rhythms of movement he is opening to within the game and the visual rhythms that these movements are triggering. This is a mismatch that blocks his potential captivation by this rhythm of the game. For games focused on a serious purpose such blockages will at best diminish their affective power and at worst negate their serious intent.

The process of opening to a rhythm within game experience is, then, one that can have the unconscious, involuntary quality of mindless possession or of viral contamination. It can also be a process involving a more conscious entrancement and an oscillation between voluntary and involuntary attention that potentially leads to ecstasy. Entrainment can produce a conscious and voluntary sense of personal enlargement when it extends capabilities, expands the perimeters of the self or leads to the transmission of rhythmic knowledge. As we have seen, these processes of entrainment, unless they are blocked, work to create a rhythmic synchrony between the player and the game form. In serious game design these rhythmic dynamics can work to provide affective impact, communicate embodied knowledge and motivate player engagement.

3 Bending to a Rhythm

> An enemy is approaching, and you must jump at just the right moment to land atop and dispatch him. A leap to a moving platform must be timed just so. Enemy missiles must be ducked at exactly the right time. Success at Super Mario Bros. Depends on hard-won interface mastery and a sense of the rhythm of the game… [17]

In this description of “hard-won” mastery we see a reflection of the hours of repetitive training that players go through in order to be able to perform the exacting rhythms of computer gameplay. This bending of the body to the rhythm of the game involves often lengthy and repetitive cycles of punishment and reward. As game theorists have pointed out, not only is this experience within gameplay often laborious [5] but it also trains the body for the rhythms of modern computer-based labor, which similarly involve spending hours focused on screens performing repetitive tasks [14]. Like the socio-political theorist, Lefebvre, many see this repetitive labor as a compulsive, involuntary process. Lefebvre’s use of the animal training term *dressage* to describe this process carries with it the sense that rhythms are imposed upon the body being trained and that these are habits being inculcated not knowledge being taught [18]. In this perspective the relationship of being bent to a rhythm is one of master to slave. Serious games like *Unsavory,* with its repetitive taco building sequence, and *Papers Please* (Lucas Pope, 2013), with its cycles of passport processing, make use of these laborious rhythms to help achieve their serious aims.

Games use rhythm to not only train the player in new habits they also draw on habits of rhythmic experience developed through other games or through other rhythmic aspects of player’s lives, such as dance, music or gesture. Watch an Australian child pick up a new computer game and you will see how easily their body accommodates to habituated rhythmic patterns of action from previous gameplay. Kirkpatrick suggests that this ease also depends on how well the game synchronizes with our everyday bodily practices. He compares the open performative bodily practices of the Wii to the focused hand movements of the mouse or classic game controller, arguing that the reason the Wii proved so popular with a female audience was because it tapped into gendered habits of movement [19]. The rhythmic habits of the gaming body are, thus, formed within everyday life as well as while a game is being played and can then be both performed and developed in subsequent games.

Most game designers will readily accept that they use strategies that are designed to train the playing body and draw on its existing rhythmic habits. However, they would not necessarily agree that this makes them a trainer who tames the captive gaming body. There is a distinct skittishness within interaction design theory of notions that a game design can control the experience of the player. An oft-cited phrase when discussing strategies for design, for example, is to make a distinction between designing an experience and designing "for" an experience [20]. The concept that one can design an experience is rejected because it is seen as "manipulative and culturally sterilizing" [21] but also, more importantly, because practitioners know that the variable nature of gaming bodies and contexts makes achieving such pure control precarious and often improbable.

An alternative perspective on the process of bending to a rhythm that reflects this less controlling approach is to see gameplay as a dance that is performed by the player and choreographed by the game designer through the game form [19]. This metaphor not only gives the player more potential for agency within the bending process it also positions the game designer as a guide rather than a slave driver. Kirkpatrick sees none of this potential, arguing that the game is a "script" that is merely followed. But this mistrust of manipulation is, Schieffelin argues, a western cultural convention that limits our thinking. By only ever depicting the audience as one that "opens itself to being led … and is drawn in and beguiled", such conventions close off other possible relations [22] and tune out their dynamic complexity. To focus on the manipulative, the involuntary, on captive attention is similarly limiting in terms of how we analyze game experience, the types of games we design and especially the relationships we envisage between game designers, game and player.

Viewing the player as a performer who potentially has agency, reframes the process of becoming habituated to a rhythm as a discipline, as a voluntary practice similar to one that musicians and dancers go through in order to have expressive control over their instrument. Through repetitive practice performers develop muscle memory and a knowledge of rhythmic categories that enables them to both perceive expressivity and play expressively [23]. We have already discussed how embodying a rhythm can communicate knowledge. Rhythm can also play a role within the processes of making sense: Comprehension emerging from the "continuity and connection" provided by patterns of attention and memory within rhythmic experience [2]. Rhythm can thus be described as a "way of thinking" [24]. It is a way of thinking that can be transmitted, become habituated and be performed. The repetitive practice of musicians gives them the skills and knowledge to play expressively, so that the score guides their performance but does not dictate it. In this perspective the habituation process has some play. There is a to and fro motion that allows for potential transformation on both sides. Knowledge is produced and the master/slave relationship is transformed into that of teacher/pupil or even the more expressive one of choreographer/performer.

This last relationship of choreographer/performer is one that could be used more frequently by serious game designers. Given their often educational aims it is very common for serious games to fall into the rhythms of a teacher/pupil relationship (think for example of an education game like *Game Over Gopher* (New Mexico State

University, 2012). While this relationship is often entirely appropriate, creating space for expressive performative play can be a useful way of building understanding and creating knowledge. Sandbox games like *Minecraft* (Mojang, 2009) successfully use this type of rhythmic dynamic to the extent that the roles of choreographer and performer are constantly exchanged between player and game over the course of the gameplay. *Minecraft* is, of course, an exceptional case. Designing the conditions for a successful choreographer/ performer rhythmic dynamic is an extremely difficult task and one that goes beyond the budgets and production time-scales of most serious games developers.

An interesting illustration of this difficulty and the precariousness and mutability of the process of bending to a rhythm can be found in choreographer Yvonne Rainer's description of her dance work *Trio A* (1965-). Rainer allowed the dance to be learnt by others from a video recording of the dance until one day she saw a version of it that was "unrecognizable":

> When I hear rumors of people learning Trio A from the video, I know that they have achieved only a faint approximation of the dance with little understanding of its subtleties. [25].

The dance was then recorded using detailed labanotation but again she found that dancers who had learnt from this score needed "not just fine-tuning but gross adjustments" [24]. Accepting the impossibility of transmitting the rhythmic practice of the dance through either video or notation she instead trained and named five dancers as "transmitters" of the dance. As one of these puts it:

> …learning and doing this dance can give some understanding of it in a way that nothing you read or see about it can. Its history is embodied in its doing. [26]

This example illustrates the complexity of trying to bend someone to a rhythm. In gaming culture we see an example of this in the way it is often necessary for other gamers to act as transmitters of game knowledge through websites and video walk-throughs or guides. Similarly, many serious games are designed to be played within a guided classroom setting but the guidance here is often more focused on educational knowledge than embodied knowledge. The *Trio A* experience emphasizes the importance that embodiment and lived practice has for both the body being bent and for that doing or transmitting the bending. It also exposes the level of detail required to accurately perceive and transmit rhythmic practice. Using transmitters in a similar way could help serious games more accurately convey embodied knowledge but also help their players achieve the level of rhythmic skill required for expressive rhythmic performance. This could be one solution to the lack of expressive dynamics that can result from the low-budget, tight development time-scales of serious game design.

A further perspective that is suggested by allowing for agency within the process of being bent to a rhythm is that of possible rebellion against a rhythm. Rebellion against nature is, for Souriau, one of the key pleasures of movement; one that he describes as the pleasure of meeting a challenge:

> Let nature but invite me to do something and I will refuse. Let it seem to forbid me and I will go ahead, from a spirit of contradiction or even rebellion. Thence the pleasure of climbing a slope, of pushing aside an obstacle, of clearing a ditch, of walking against a strong wind. [27]

Challenge is, of course, an integral part of much computer gameplay but not necessarily the type of challenge carried out in the spirit described above. Most meeting of challenges in games is about accepting an invitation, about working out what the game seemingly wants you to do. Gameplay that involves a falling out of step with or a railing against the rhythms of the game is often described as cheating but can result in interesting creative and subversive outcomes. Equally, a game that rebels against the rhythms that the player would like to bend it to can be interestingly creative and subversive. Think, for example, of *Loneliness* (Magnuson, 2010) whose 'characters' will not engage with the player, *Vesper5* (Brough, 2012) where the player can only make one move per day or *The Path* (Tale of Tales, 2009) where the player has to break rules in order to play. Here again there is an opportunity for serious game designers to provide more room for expressive play in their designs.

A master slave relation is, then, but one way of characterizing the process of being bent to a rhythm. Within this characterization it is possible that the game could be a slave to the player's rhythms as much as the player could be enslaved to those of the game. The relations between the body being bent and the rhythm that it is bending to can also be viewed as one similar to that between a teacher and pupil or take on the more expressive character of that between performer and choreographer. This perspective implies a transmission process that is more precarious and mutable and allows for some agency on both sides of the relationship. It also implies that there might be a structure of choreography that could then be transmitted by others acting as guides. Finally, allowing agency into both sides of the relationship opens up the possibility of a rebellion against the rhythms of habit. This brief discussion has revealed a broad palette of rhythmic dynamics that are available to designers of serious games and suggested some ways that these dynamics might open up opportunities for expressivity in the rhythms of these games.

4 Conclusion

This is just the beginning of an exploration into rhythmic experience within games. To explore rhythm in game experience is not to say that games are music or dance. It is rather to acknowledge that, in common with music and dance, games are forms that involve performed rhythms and that provide a rhythmic experience. This paper has explored but some of the possible ways of thinking about the macro-level processes of rhythmic entrainment. Perhaps not surprisingly the movement of rhythm has allowed us to see some fluidity within the available positions of the player and game form. The discussion has frequently relied on metaphors as a way to talk and think about rhythmic processes. These metaphors have emphasized that rhythmic practice is performed across a continuum of voluntary and involuntary attention; that it can be a form of possession or contamination but also entrancement and enlargement; that it can involve manipulation and compulsion but also be a way of thinking or learning. Rhythmic experience relies on the repetition of past habits but lives in the spontaneous difference of the moment of performance. Rhythm both has vitality and produces vitality. And that production of vitality is key for the creation of interesting game experiences.

Our short exploration here has highlighted some of the types of knowledge and practices that can be evoked through rhythmic performance. It has suggested that a focus on the rhythms of game interactions could be a useful perspective for serious game design and analysis. In particular, the discussion has opened up some fruitful avenues for further experimentation within serious game design by suggesting multiple ways that designers could characterize the rhythmic dynamics between player and game.

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Crowdsourcing, Communities and Social Identities: Using Citizen Science to Combat Online Toxicity

Matthew D. Lee(✉)

Serious Games SIG, International Game Developers Association, Philadelphia, USA
serious@igda.org

Abstract. Today, over 1.5 billion people worldwide play digital games, a number projected to rise to 4.5 billion by 2020 due to the proliferation of mobile devices. With modern games being connected experiences where people from around the world coming together to compete, cooperate, and otherwise participate in virtual worlds, the social systems within games and the behaviors they facilitate have become topics of great interest, especially with the recent focus on player toxicity. Previously, successful commercial games simply had to engage players through compelling narratives, meaningful challenges, and a sense of achievement. However, with the rise of multiplayer elements and online games, the relationships players have with game communities and developer-constructed identities become far more central to enjoyment and retention. This paper suggests that online toxicity results from threats to the agency of these constructs, and that Games with a Purpose may play a role in managing toxicity-causing role paradoxes.

Keywords: Community management · Crowdsourcing · Online toxicity · Serious games · Games with a Purpose · Social Identity Theory · Psychology · Self-Determination Theory

1 Introduction

The notion of the magic circle, that play occurs in a conceptual space with rules distinct from those of the outside world [1], has long been accepted as one of the fundamental principles of game design [2]. As such, games – and digital games, especially – are often thought of temporary worlds detached from reality, each with a unique set of rules and systems that facilitate interaction and engagement. Indeed, single-player digital games created for the game console or the personal computer were designed to immerse players in multi-hour play sessions through compelling narratives, complex mechanics that were difficult to truly master, and rich graphical or aural experiences.

In contrast, the vast majority of titles enjoyed by the 1.5 billion individuals who consume digital games today [3] are not played in the living room, on consoles or computers, but on smartphones and tablets, either in what Levi Buchanan of Chillingo, a leading publisher of mobile games, describes as "stolen moments of time" [4], or, in the case of exer-games like *Zombies, Run!*, as an integrated part of another activity [5]. In these games, there is a noted absence of traditional single-player narrative-driven

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structures, which emphasized long-form immersion in an isolated world, with the emphasis falling on bite-sized narratives with "sticky ends." This change was made to accommodate changing playstyles and play environments, given that play sessions on the PC/console tended to be approximately 2 h, while 5-10 min – at irregular intervals, in sessions prone to interruption – is more characteristic of many mobile games [4]. As a consequence of this, leading mobile titles such as *Clash of Clans* or *Candy Crush Saga* cannot rely on traditional strategies for engagement. Instead, they feature high levels of social network integration to create a sense of community, leveraging intrinsic motivations such as relatedness to drive higher frequencies of play [6, 7].

This trend towards greater integration – and leveraging – of social systems is also present in games being developed for traditional gaming platforms such as console and PC, with larger developers increasingly turning their attention to the potential of online games with episodic play sessions and Free-to-Play (F2P) payment structures. Notably, these changes have resulted in higher numbers of players, with *League of Legends,* Riot Games' highly successful Multiplayer Online Battle Arena (MOBA) –the most popular game in the world with 67 million active players a month [8] – eclipsing the 5.5 million of Blizzard Entertainment's highly popular *World of Warcraft,* the leading subscription-based Massively Multiplayer Online Roleplaying Game (MMORPG) in the world [9].

The consequences of this shift in design methodology is not without issue, however. In these larger communities, players are often made to feel anonymous, and as a result become either less attached to a game (as is often the case with mobile), creating a culture of "disposable entertainment" [5] or fiercely, in some cases, competitive and territorial, seeking to make a name for themselves, a state that gives rise to much of the peer aggression and toxicity observed online today [10], thanks to the online disinhibition effect [11], a phenomenon which can be summed up pithily by the common saying that "anonymity brings out the worst (and best) in humans."

And as modern games become increasingly networked experiences, both becoming communities of their own as well as being integrated into existing social experiences, with people from around the world coming together to participate in these virtual worlds, the magic circle separating play and reality breaks down. The boundary, as Castronova puts it, becomes porous, as "people are crossing it all the time in both directions, carrying their behavioral assumptions and attitudes with them" [12]. As a result, with complete immersion into a virtual world giving way to increased interaction between the real and the synthetic worlds, online cultures begin to arise in the communities surrounding and supporting such worlds, as predicted by theorist Johan Huizinga [1], who saw play as a necessary condition for the generation of culture.

This has significant potential impacts not only for commercial games, but for serious games, given changing expectations of player audiences as a result of the shift towards a more socially integrated model of design. As such, it is vital that designers, developers, academics, educators, and others involved in this space are aware of not only how game design interacts with a game's clinical/educational/scientific purpose in creating stand-alone games, but also how design decisions can impact community behavior and long-term engagement in socially-focused network games.

2 Coopetition and Toxicity – The Case of MOBAs

Nowhere are the consequences of this shift more apparent than in Multiplayer Online Battle Arenas (MOBAs), which have earned a reputation for toxicity and hostile communities beyond that of any of the digital games currently on the market today. In this subgenre of real-time strategy games (RTS), players control a single character adept in one of several roles (damage dealer, tank, healer, etc.) in one of two teams. Aided by computer-controlled allies that spawn intermittently, they – and their team – are tasked with the objective of destroying the opposing team's main structure. As with other games in the RTS genre, players do not have access to the full range of talents or abilities of their champion at the beginning of a match. Instead, players unlock these abilities over time by gaining experience and gold – each of which is accrued individually as the result of completing objectives or defeating enemy characters. Individuals are thus incentivized to maximize their own experience gain, and so often find themselves in competition with the rest of their team for this limited resource, while simultaneously trying to cooperate with teammates against the opposing team, resulting in a state called coopetition [13].

This state, coupled with a lack of relevant information – for instance, a lack of information on how skilled a particular player is at any given role, or on any given map – is one where tension is inherent, as the logic of cooperation and the logic of competition [13] cannot come into play simultaneously in any one individual. To avoid role paradox, players must resolve these conflicting sets of interaction logics, using what information is available to them regarding their own capabilities, their teammates' capabilities, the needs of the team, and the strategy of the opponent. The ability to resolve these conflicts in a way that does not provoke frustration, is of course, contingent on having enough information to do so. This may be information about the game or game type one is playing (gained through experience, and roughly reflected by a player's overall rank), information about an individual champion's capabilities and synergies with others on the field, and subjective information regarding their teammates' personalities and level of ability, usually obtained through observation of in-game performance, player communications, and past experience (if any) with these individuals. When limited data leads to inappropriate, often suboptimal conclusions, team performance suffers, with the interaction logic of competition often resulting in increased aggression [14].

This aggression tends to be expressed in anti-social, or "toxic" behaviors [10] such as cyberbullying, which consists of offensive language and verbal abuse, griefing, sabotaging games by quitting or actively aiding the enemy team, or by simply ceasing communication entirely. These behaviors have resulted in the standardization of anti-toxicity measures such as restricted or opt-in chat, penalties for quitting without the agreement of the team, and systems for reporting unacceptable behavior [15].

It should be noted that, due to the tension and need to constantly evaluate personal and team skill, MOBAs tend to be extremely challenging, with the most successful players, those who are able to balance competitive and cooperative motives [16], experiencing a high level of satisfaction from their mastery of such interactions. Due to this level of challenge, however, one would also expect a higher degree of motive frustration, resulting in more online toxicity relative to other genres [8]. Indeed, this is the case, with MOBAs being notorious for the perceived toxicity of their player communities, particularly among beginners, where the information gap is greatest, and in high-level play, where competition is fiercest [17].

To combat this perceived – and actual – toxicity, Riot Games has attempted a number of approaches, including establishing the now-defunct Player Tribunal to give players a sense of control in establishing community norms [10], providing feedback to offenders on what exactly they had been punished for and rewarding reform, and providing meaningful penalties for those continue to offend [17]. The results so far have been striking, with a 40 % drop in verbal toxicity among ranked games and a 92 % reform rate among offenders, most of which were not habitually toxic, but were simply average players put into highly stressful situations.

Of course, none of that addresses the underlying dynamics of how the factors that drive increased toxicity in *League of Legends* are entangled with its co-opetitive mechanics, but given that the game – the first to be coined a MOBA – has been well established for over seven years at the point of this writing, any fundamental changes to the basic structure of the game would not only be impractical, but would be quite likely detrimental to the existing player community.

The more recent title *Heroes of the Storm (HotS)*, the so-called "hero brawler" by Blizzard Entertainment, on the other hand, does not suffer from these constraints. As such, beyond utilizing the feedback and penalty systems pioneered in *League of Legends,* the game has been designed from the ground up to eliminate the role conflicts that drive toxicity in many MOBAs. In this title, play is highly team-focused and team-driven, with the drivers of intra-team competition largely eliminated. Experience, accrued individually in other MOBAs, is shared across all members of a team in *HotS*, meaning that what benefits one player benefits the entire team – and that conversely, no single player can become an over-levelled, unstoppable force.

However, while addressing this role conflict through design choices may well help, how successful this title will be in reducing toxicity remains to be seen, given other consequences of the migration away from immersive design, some of which can be seen in the shifting power dynamics between developers and player communities.

3 Player Communities and Developers: Unequal Partners

Despite attempts to curb the growth of 'toxic' cultures in online communities, developers have been less than entirely successful at this for a number of reasons. The most significant of these is that game design by its very nature seeks to engage and retain players through a combination of psychological factors, and that as design standards have shifted, so have the factors in play. In immersive design, designers traditionally leveraged autonomy (meaningful choice) and competence (the power fantasy), two of the three aspects of intrinsic motivation, according to Self-Determination Theory [6, 7] to drive satisfaction and retention, but with the shift towards more episodic, networked games, relatedness, the third aspect, has taken an increasingly prominent role.

As such, players are courted for their connections to their peers, with incentives offered for recruiting new members of a community. Corporate messaging often calls players valuable partners in making a game a success. Developers now participate in discussions with communities about desired features and upcoming changes. And community managers have become a fixture in many companies, mediating communications between developer and player, indicative of the increasing importance – and level of responsibility – accorded to players.

This empowerment and recognition of the community, unfortunately, gives rise to conflict when community elements perceive themselves to have been disenfranchised or disrespected in the developer-community partnership, with their contributions – largely in creating guides and mentoring others in the community – dismissed as unimportant.

Traditionally, a developer's responsibility has not simply been to create a game, but to demonstrate to potential players how a game should be played. Indeed, under the older model of immersive design, developers were able to set aside time for in-game tutorials and well-crafted questlines to introduce players to new mechanics and abilities as they played, bringing them to a certain level of competence before letting them loose upon the world at large. However, the rise of episodic play styles – and the resultant restrictions on time – mean such things are no longer possible, as players tend to be less tolerant of what are seen to be arbitrary restrictions or play that isn't truly play. Even if they were not, however, even the best tutorial cannot prepare a player for the chaotic experience of a live match in a multiplayer game, given that tutorials generally focus on teaching one aspect or mechanic of a game at a time, while live matches require an awareness of every aspect at once.

As a result, many newcomers to gaming communities often have little to no idea what they are doing, with fellow players forced to rely on community-written guides, the advice of peers, and community mentors who help them past the initial, often steep, stage of the learning curve. Indeed, in some of the more competitive games, such as *League of Legends,* the attrition rate in the first month can be up to 80 % for those who do not have a friend in the community to help them. Those who make it through and eventually become accepted by others as a competent player feel a sense of individual accomplishment – which naturally leads to increased frustration when a game is patched and what they have learned or taught becomes invalidated [7].

This frustration can be greatly exacerbated when developers, who ultimately have control over a game, and the player community, who invest a great amount of time, effort, and energy into learning and playing the games, have differing perceptions of whether an ability, item, or mechanic is working as intended. When something the community sees as problematic is left alone, without any acknowledgement of the community's concerns or any comment from developers, it is very easy for players to come to the conclusion that they are being ignored, when the reality may be that the issue was simply not noticed due to the complexity of these ever-evolving games. Worse, if developers see an issue with a popular mechanic or item, and actively move to fix it in a way that drastically changes how the game is played, players will often become angry, wondering how the developers could not have foreseen the effects of their design, why the so-called issue wasn't caught in testing, and most of all, why something that had long been accepted as a cornerstone of the world is only *now* being changed – rendering their carefully built knowledge, and their investment of time and effort, meaningless.

In truth, these changes occur because of the player base using an item or ability quite differently from how a developer intended, with an item having very different effects on game balance than predicted, since given the scale of social games, testing every use case for an item is difficult at best, but not having access to the same data, players do not see this. As such, interventions can feel arbitrary and capricious, with players complaining that developers don't even understand the game they've created, and either don't value players, or value them only for the money they spend. Indeed, some may come to think that while they have been courted as and spoken of as partners in making a game a success, encouraged to invest time, money and effort into building up a given game and community, they are very clearly not *equal* partners, with their opinions and thoughts only counting when the developers decide they do.

At times, when the change affects an item promoted as a limited-time collectible or only obtainable with a premium currency, as is often the case under F2P monetization schemes, the reaction from the player base can be even worse.

The most dramatic of these reactions, and those that catch the most media attention, are, of course, death threats [18], but these are not the most damaging to the health of a game, or its surrounding community. Worse are accusations of fraud, malign intent, or even incompetence, which tend to be fly in the wake of these interventions, with some going as far as to say that developers don't care about the game at all, or its players. And whatever is said officially, developer actions spin a different narrative: that of intentionally releasing an expensive, unbalanced item, only to pull a bait and switch at the expense of credulous members of the community. Even those who may not agree with these accusations tend to feel some annoyance, given many of them put their faith and passion into enriching the game, no, the world, the developers created. For their services to the community, though apparently offered freely, were based upon the implicit understanding that the developers would do a good job of testing their product and maintaining a high standard of quality.

Indeed, as those who defend the developers and those who ascribe more pecuniary motives to them come into conflict, tensions mount and tempers flare as community members react to perceived threats from without and within [19].

This tension is only made worse if other situations occur in which the community's role as a valued partner is perceived to be diminished. Re-recruitment campaigns, a common method of drawing lapsed players back to a community by offering them valuable incentives, are often a source of outrage, with loyal players feeling cheated that those who left the community are effectively being rewarded for doing so, while those who stayed get nothing. Another common source of upset is content exclusively available through some unusual means, with *Destiny's* Red Bull promotion, where one had to buy a can of the energy drink to unlock a quest in-game being one example, with the community at large feeling miffed that this does not target them. Yet a third may come from developer communications where player concerns appear to be dismissed, perhaps in a botched interview or misinterpreted blog post.

Any of these behaviors, coupled with the language of partnership and feelings of betrayal, can easily lead to toxic behavior quickly emerging on official forums, in game chat, or on popular blogs or streams, setting the tone for newcomers. Slowly, with the realization that no player, and not even the community at large in some cases, can change the realities imposed by the developer, the community fractures, with each emerging faction coming to see the other as problematic, turning the creativity and relentless problem solving capabilities gamers are famous for on each other.

Just as observed in the case of MOBAs, it is not habitually malicious individuals, so-called trolls, who are responsible for the majority of toxic behavior in these online communities, given that even in a competitive, high-pressure environment like *League of Legends*, only 1 % are consistently toxic, with the actions of these few accounting for perhaps 5 % of the toxicity observed [10, 17]. Instead, the vast majority of such behavior comes from normally well-behaved members of a community who lash out for one reason or another, mostly due to changes that diminish their perceived worth as valued members of – and contributors to – that community.

And while a number of methods to reduce toxicity have been tried here as well, they fail to address the underlying factors driving the aggression and hostility, with the power imbalance being the most significant. From a marketing perspective, it makes a degree of sense to refer to players as valued partners in a game's or franchise's – success, to give them a sense of belonging and importance.

From a psychological standpoint, however, constructing these in-groups – these social identities – is not without drawbacks. Certainly it may have advantages, as giving individuals a sense of shared purpose and identity encourages them to contribute to the cause their identity is centered on, whether through buying games or DLC, spreading the word about a new title or development to recruit new members, helping create guides and mentorship programs, or other such. However, constructing these identities for marketing purposes has marked disadvantages as well, given that if the expectations and assumptions of value built into them come under threat, the result can be incredibly toxic, arising from frustration beyond that arising from impaired motive satisfaction [19].

As such, peer aggressive and online toxicity cannot fully be dealt with on an individual level, through harsh enforcement of behavioral standards, draconian punishments, or other such techniques. It must be dealt with on the level of the community itself, given that otherwise, the norms and expectations of the community itself may work at cross-purposes to developer control.

It should be observed that aggression is a natural response to perceived threats, and with threats to one's worth and self-concept – higher level needs, according to Maslow – provoking visceral – and quite genuine – responses. The fact that the identity under threat was constructed for some other purpose makes little difference, as the feelings of frustration, powerlessness and disrespect evoked are the same regardless.

Given that player identities are built around the idea of contribution, perhaps the way to address toxicity lies not in regulation, but in the provision of an alternate pathway for contributing to the greater good – and not to pecuniary interests.

4 Citizen Science, Communities, and Commercial Games

The techniques of Human-based computation games, or Games with a Purpose (GWAPs), a category of serious games which use interactive entertainment to harness human time and energy for citizen science projects, may provide part of the answer [20, 21]. Compared to most other serious games, which have historically not been not multiplayer, community driven experiences, GWAPs like *Foldit* or *Eyewire* rely on the involvement of large communities to accomplish their goals, and like many commercial games, actively seek to draw and retain players with engaging content and competitive play.

This is a rather stark divergence from how serious games as a whole are described, given that the tendency in the field is to emphasize how different they are from entertainment-focused games, both to set themselves apart from ongoing controversies in the industry at large (something as relevant today due to Gamergate, as it was when Serious Game Initiative launched in 2002, due to the allegations that video games caused violence) and due to how serious games are usually funded.

While commercial games rely on retail performance to justify their creation, serious games are often client-funded or grant-funded. In this model, developers are hired simply to create a game, often to the specifications of an academic or clinical partner, with their task ending upon the completion of the game [20]. Unfortunately, this also means that unless there are specific considerations made for services beyond the terms of the original grant, such games are rarely maintained or updated. Further, as grants do not usually cover things such as publicity or distribution expenses, many serious games are effectively lost among the other content on the internet. Unfortunately, releasing a game is only the first step in disseminating it, and without broader outreach, the vast majority of serious games are never discovered or played, much as up to 90 % of papers published in academic journals are never read or cited [22].

Indeed, without the economic pressures of the market driving developers to fuse educational content with gameplay in a "fun" manner, as was the case with popular edutainment games like Oregon Trail [20], many serious games – especially those meant to be distributed freely on the internet – have developed a reputation for being unengaging and often poorly executed, with gameplay and clinical/educational goals at cross purposes [23].

The exceptions – games like *Journey*, *This War of Mine*, and *Never Alone* –regarded as some of the most successful and critically acclaimed games today, serious or commercial, embrace the commercial model, eschewing the label of serious game and keeping distribution and outreach in mind from the very beginning. Like successful commercial titles, these games feature online communities full of passionate individuals, though these have far less in the way of toxicity compared to larger studios. The reasons for this are varied, with the nature of the audience playing some role, though the facts that these games are generally standalone immersive experiences and that the studios behind them are smaller, so developers can build a closer relationship with their communities, without a mediator, are rather greater contributors.

The only serious games which do not eschew the label and still have major communities are GWAPs, where people, as a side effect of playing a game, perform a small task of a massive computation [21], with the best known example being *Foldit.* In this game, over 200,000 players compete to manipulate proteins into more efficient structures [24], players have been shown to match or outperform algorithmically computed solutions [25], achieving feats such as deciphering the structure of a retroviral protease in a simian analogue of the AIDS virus – something scientists had been unable to do for over a decade [26], and redesigning a synthetic enzyme to increase its activity by more than 18 times [27].

The twin challenges of GWAPs, long-term engagement and drawing larger user bases, mirror those of commercial network games, hinting that the integration of citizen science and crowdsourcing techniques into existing commercial games, such as through *EVE Online's* Project Discovery [28], may be of benefit to both, giving scientists access to large, engaged communities – and giving these communities a chance to contribute to a larger case.

EVE Online is a science-fiction themed sandbox MMORPG focused on freedom, consequence, and autonomy, where players, immortal starship pilots known as capsuleers, may do as they wish [29]. Some explore unknown space. Some mine. Some conduct diplomacy. Some establish corporations and seek to make a profit. And some gather alliances and wage wars on a galactic scale, with the Battle of B-R5RB featuring 7548 players from a dizzying array of alliances clashing over 21 h in the single largest player versus player engagement in the history of any game to date [30].

Aside from the scale of the game, however, *EVE* is also well known for its innovative approach to player governance and community management, with CCP Games being one of the only developers to empower a community to set and enforce their own standards of behavior in-game, reducing the overall level of toxicity, as well as allowing them to electing a group of individuals to represent their interests. This group, the Council of Stellar Management, is one of the primary routes by which players can make requests for changes and improvements to the mechanics, presentation, and content of *EVE Online* [31], with each representative having the privilege and authority to lodge six requests with developer CCP Games per year on behalf of the player base, requests that CCP Games, by contract, must acknowledge, respond to in detail, and often – when possible – implement.

Perhaps it is no surprise that *EVE* was also the first MMORPG to incorporate citizen science techniques with the launch of Project Discovery, a joint partnership between CCP Games, citizen science platform Massively Multiplayer Online Science (MMOS), and the Sweden-based Human Protein Atlas (HPA) [28]. Referred to in-game as a "classified research program" to analyze biological samples of the Drifters, a mysterious faction in the galaxy in which *EVE* takes place, and thus unlock their technology, the real-world purpose of the project is to put the players of *EVE Online* players to work mapping protein expression in human cells.

Thus far, the project appears to be a success, with players surpassing the most optimistic expectations from all parties involved, processing the entirety of the first data set provided – 8 million cell elements – in a single month [32]. These results are promising enough from a citizen science perspective that MMOS and CCP Games are seeking to expand Project Discovery into other data sets from cancer, neuroscience, or cosmic background radiation research, by the end of 2016 [28, 32].

5 Discussion

The early success of Project Discovery highlights a promising avenue for integrating GWAP techniques into existing commercial games, a course that would benefit scientists seeking larger communities from which to crowdsource human computation, with *EVE Online* itself serving as an example of how developers can partner with their communities in ways that are not adversely affected by the inherent inequities in the player-developer relationship.

Today, those who enter the player communities of large online games are encouraged to invest and contribute to the community, both in material and immaterial ways. In doing so, these individuals buy into the constructed identity of the player being a valued partner in making the game a success, which is by no means a negative thing, as this sense of belonging and contribution to a greater whole satisfies the relatedness motive and drives players towards deep and continued engagement.

However, it should be noted that in general, players are likely to interpret the well-being of a game and its community through the quality of their individual play experience and communications with developers, while developers tend to be focused on larger scale issues such as game balance, economy, and releasing new content. When these priorities come into conflict, and the interests of various community groups are overruled or seemingly ignored, some degree of discontent begins to form. With each insult to the constructed identity, tensions mount, until at last, the community begins to fracture, with some – those who are getting their needs met – continuing to believe in the partnership, and some – often those who invested significant amounts of time and money into the community but feel disenfranchised, becoming disillusioned.

At that point, tensions can easily boil over into hostilities due to what would be otherwise be minor provocations, with developers left with the equally unfavorable alternatives of strictly enforcing community standards (giving the appearance of stifling dissent), or simply ignoring the hostilities, giving the appearance of dismissiveness, with no effective tools left to both combat online toxicity and build engagement.

What is needed is a larger focus on preventing a community from becoming toxic in the first place, whether by resolving the role ambiguity that exists between players and developers, improving the channels of communication between them, or providing players a means to participate or contribute to the value of a virtual world that cannot simply be invalidated or rendered meaningless by prescriptive or emergent issues, a stable pole around which an identity can be constructed.

Perhaps the intelligent integration of citizen science elements and GWAP techniques into existing and future commercial games could be one method by which the last might be accomplished, leading to a future where every online game can double as a large-scale virtual laboratories, a possibility that the National Institutes of Health first envisioned after *World of Warcraft's* Corrupted Blood Incident [33].

In the early 2000s, the designers of serious games pushed to differentiate themselves from commercial games to distance themselves from the controversy around video games and violence – and from the perception that games were simply toys or entertainment. Indeed, from the very inception of the Serious Games Initiative, those who created serious games have always concerned themselves with making games that were not just entertaining, but meaningful.

Perhaps it is only appropriate then that the ongoing controversy around online games and toxic communities provides an opportunity for designers of serious games to add meaning to entertainment, and in doing so, help in solving a major problem in the industry today. Beyond that, however, integrating citizen science into commercial games – particularly titles like *EVE Online* or *League of Legends* – has the potential to do more than simply reduce toxicity and peer aggression in online communities, or provide players with a way to feel good about themselves by contributing to human understanding. For this integration would ensure that every online game would be more than just entertainment, that every online game was, in part, a serious game.

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Poster Papers

Cross-Domain Interactive Composition in Music

Szu-Ming Chung(✉), Chun-Tsai Wu, and Tzu-Yun Maggie Chen

Ling Tung University, Taichung, Taiwan
{szuming,ktctht53,liebemaggie}@teamail.ltu.edu.tw

Abstract. This cross-domain interactive composition in music is based on the comprehension of a human's mental ability of representing (schemata), associating, and cross domain mapping. While combining with the perception of improvisation, it is structured for creating interactive composition and animation. First, we select certain music pieces to represent musical motives (melodic or rhythmic patterns) associated with images as referents and the knowledge base. Secondly, through interacting with these associated auditory (music)-visual (images) motives on the game interface, the player improvises and creates an animation, the results of which will be a display of sounding images on screen as a complete animated music. Based on Piaget's cognitive development and Kratus' progressive mode of improvisation, it is designed for concrete operational children and will be tested in a public elementary schools.

Keywords: Schemata · Associating · Cross-domain mapping · Cognitive development · Progressive mode of improvisation

1 Introduction

Spearman [1] claimed that creativity involves process, a process of seeing or creating relationships, both conscious and subconscious processes operating. Therefore, one or more precepts or ideas are given, a person may perceive them in various relations, such as near, far, the cause of, the result of, a part of, etc. We adopt this creative process and apply it in this research to offer experience for years 7 or 8, concrete operational children. According to Piaget's cognitive development, around the age of 7 years, children start to develop the ability to coordinate many aspects of perception (*conservation*) [2]. Six masterpieces of music are selected by criteria as pseudo-pentatonic motives in an Arch form (Ma Shui-Long's *Rain*), loosely connected motifs in a quasi ABA form (Emmanuel Chabrier's *Idylle* from *10 Pièces Pittoresques*), thematic development in a sectional piece (Claude Debussy's *Pagodes* from *Estampes*), imitative melodic and rhythmic patterns to pictures/images (Erik Satie's *Le Water Chute* from *Sports et divertissements*), Fandango dance motifs in a thru-composed piece (Enrique Granados' temperamental *Goyesca No. 3 El Fandango de Candil*), and the lively motives to describe trout swimming in a river from Franz Schubert's first movement of *Das Forellen Quintett, D.667, Op114*. These 6 music are animated and programmed in mobile applications. In testing, the testers or music teachers would give a short introductory background of the music, its composer, and its meanings to the first graders. Each of these 6 music

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animations was played beforehand, all functional buttons and links in gameplay will be demonstrated, and then provided game-based applications for them to play in a separate classroom. During gameplay, children would perceive different animated musical motives, and arrange or re-arrange them in different orders. In results, they would view various sequential animation with associated music motives. The testing of 6 application games has been executed for a course of 6 consecutive weeks in a public school in Taichung, Taiwan.

2 Theory

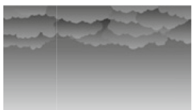
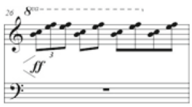
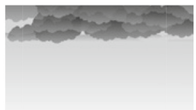
Music technology shares many features with other fields, such as games, science, and physical activities. The creation of music and listening skills require the support of the development of representation and cognitive adaptation in learning [3]. Representation is formed psychologically as a simplified and diminished version of external images (color photos or videos). Nevertheless, through operating useful messages, we can produce images, solve problems, predict, instruct, memorize, execute, and manipulate. In the views of psychology and music, such representations are manipulated in music creation and listening skills [4]. It is defined as artistic imagery by Neuhaus [5]. Gordon [6] adopted *auditation* to represent inner hearing, or other similar terms. Neurologists found that hearing and musical images initiate the same area as images in brains. So to speak, musical images are not completely auditory. This concept can also be referred to music theory, emotions, images, and kinesthetic motions. Cross-domain mapping is not an unusual process in cognition, which empowers us to operate unfamiliar or abstract aspects with a concrete and familiar manner. It plays two important roles in music learning and comprehension: it offers the function of connecting musical aspects with other domains, including languages, and the function of distinguishing the musical aspects from daily life. These functions establish relationships between aspects, theorize musical aspects, and associates them with other domains, such as the physical space, gesture, or movement to create a rich imagined world [7]. Davidson and Scripp's Matrix of Cognitive Skills in Music [8] shows how cognitive process is classified and mapped to a given task in making music. Six categories of cognitive music skills are labeled to trace ways of knowing in production, perception, and reflection on music. Using appropriate experimental methods, any aspect of this model is amenable to testing and validation. The researchers adopt and apply the aspect of production which encompasses composing and interpretive performance to construct this testing.

3 Applications Design

According to first three stages of progressive mode of improvisation, exploration, process-oriented improvisation, and product-oriented improvisation, by Kratus [9][1], the researchers choose 6 musical masterpieces and create music animations these 6.

Interface Design. The researchers intend to create usable game interface which facilitates the process of interacting and responding in computer gameplay. Considering the age range of users, the graphical design is preferable. Each game has (1) a motive list; (2) a button/link list; (3) color pallets (rainbow colors representing 7 pitches in C Major; (4) image pallets; (5) start/play/stop/quit signs; and (6) display area.

Table 1. Animated music motives

Starting Measures	Animated Images	Starting Measures	Animated Images
			
			
			
			
			

[1] Kratus described a progressive mode of improvisation in the following 7 stages: (1) Stage 1: exploration (exploring sounds and combinations in a loose context); (2) Stage 2: process-oriented improvisation (creating more similar patterns in process); (3) Stage 3: product-oriented improvisation (improvising by consciously using key centered music and rhythms); (4) Stage 4: fluid improvisation (manipulating instruments in automatic and relaxing manners and attitudes); (5) Stage 5: structural improvisation (knowing the entire structure of improvisation and developing a structural strategy); (6) Stage 6: Stylistic improvisation (improvising in a certain style to integrate melodic, harmonic, and rhythmic characters and improve the familiarity); (7) Stage 7: Personal improvisation (creating a new style of improvisation).

Sample Module. In integration of music and images, the researchers select music pieces which are intended to describe specific characters, events, objects, and scenes. The authors create expressive animations based on certain musical ideas (motives or motifs) and often seen images in Taiwan, and then the users can improvise a new music piece by arranging a sequence through interacting with these motives. One of the selected music pieces is "*Rain*" by a Taiwanese composer Shui-Long Ma in 1976 (A Sketch of the Raining Harbor for Piano). It is recorded on Finale music notation software and exported as an audio file (mp3). To enhance the music to be expressive as human playing, Finale allows the recorded music to be configured by setting "Human Playback Controls" which apply defined styles, instrument techniques, dynamics, volume, MIDI data, and so on. The musical motives of this piece are animated as movieClips in Flash (Table 1), which represent improvisation referents for Musical Sequence. After the entire animation is programmed, it does not always play on time with music. Since the music has been configured to human playback style, the animation has to be refined subtlety to match the music (Table 2).

Table 2. Configuring gameplay interface

Screen Scale 16:9			
Choosing Images	Choosing Pitches	Display Area	stop/play/restart/next/ exit signs
"Rain" image list	Color Pallet	• Buttons/Links are listed on the right-hand top corner; • If choosing play, it will play the single animation with musical motive; • If choosing treble clef sign, the game will continue to the play page.	

4 Conclusion

The goal of this module is to provide a situated circumstance for experiencing, improvising and creating interactive composition in music. Through considering a human's mental strengths of cross-domain mapping and perception in music, we can create interactive composition game-based applications for children to interact kinesthetically and appreciate their creations. We select a certain set of music pieces to present various musical ideas as referents and the knowledge base in the perception of improvisation. The players are esteemed as artists in the process of learning and interacting in game-based learning. Interactive composition is created and completed at the same time. It displays an innovation in teaching strategy for creativity; the subjects are motivated to create in interactive activities. They can explore many different ways of producing different results. In implementation of these applications, the authors will collect data by participant observations, video recording, and subject's personal input data on tablets. Since the musical referents are controlled by the music motives associated with animations; the players' actions by manipulating these integrated auditory and visual motives, which are concrete and can be traced throughout the entire process. The testing has been undertaken for a 6 week period in a city center public school, which can be expected to contribute empirical data for creativity in interactive composition in music.

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Choose Your Own Uni Adventure: An Orientation and Transition Game

Briony Wainman(✉)

Griffith Film School, Griffith University, Brisbane, Australia
brionywainman@hotmail.co.uk

Abstract. University orientation and transition strategies enjoy limited success, in part due to poor attendance, but largely due to the inability of these programs to communicate expectations in a meaningful way. The solution offered here is an educational game, not as an alternative to orientation, but as a complementary, self-directed orientation and transition experience. *Choose your own Uni Adventure* teaches the language and practices of university and allow players to draw inferences about university values and expectations in a way that will engender engagement and motivation. The aim of the project is to create a proof of concept for the game, the design of which is described here.

Keywords: Transition · Orientation · University · Serious games

1 Introduction

Student attrition costs Australian universities an average of $36million per institution per year [1] in addition to the personal and financial cost to the student. It has been said that "it is much cheaper to retain a student than recruit a new one" [2] and the key to retaining students, particularly in the early stages, is to better prepare them for the transition into university [3]. In order to better communicate university expectations, the solution offered here is an educational game, *Choose your own (Uni) Adventure*, as an orientation and transition activity.

2 Background

There are a number of university transition games on the market such as *The Sims 3: University Life* expansion pack for Sims. Whilst this is a fun university simulation with some good key messages, the emphasis is on entertainment and learning is superficial.

Campus Quest and its online-study counterpart *E-Study Quest* are online games that seek to prepare students for university study. Part of the Curtin AHEAD program, developed by Curtin University and 2 Educational Games, the game offers sound advice and tips to commencing students, however, reviews were not encouraging [4]. The player experience feels didactic and does not engender engagement. It does not demonstrate the skills required or the consequences of not completing the quests.

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Choose your own Uni Adventure, on the other hand, will not only ensure the learning objectives are achieved through rigorous pedagogical quality control, but will also provide the kind of entertainment and challenge that students seek in a video game.

3 The Game

The game allows players to learn the language, procedures, values and expectations of university in a format that will engender engagement and motivation. They will also draw inferences about university values and behaviours through playing the game; these higher order cognitive skills are readily achieved through simulation games [5]. It is designed to be offered before orientation, which has been identified as a key moment for intervention [6]. An important aspect of game play is that it will prompt students to make choices about how they conduct their studies and, importantly, they will play out the consequences of those decisions. They are able to change strategies so that they can experience multiple outcomes in a low-stakes environment.

Players navigate *Sandbox University* campus to complete a number of quests. The player can choose to play or skip these quests, but will experience heightened stress (indicated by a stress barometer) when they make decisions that are not conducive to successful study. Too much stress will prompt the player to change their strategy to a more successful one.

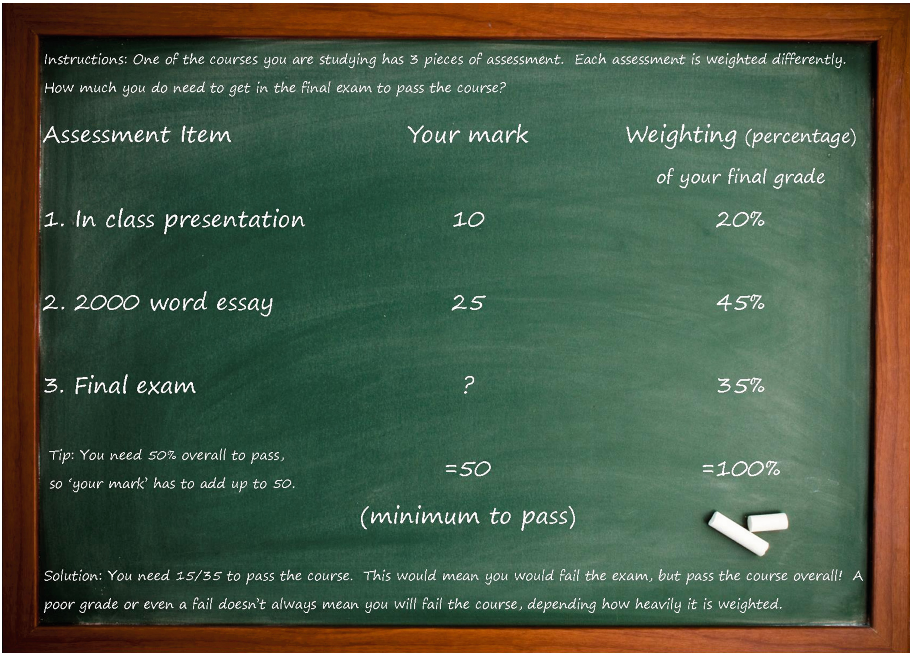

Fig. 1. Illustration of the blackboard puzzle "Learn how to Calculate your Grades"

The player uses point and click controls to control their avatar's movement through the 2D environments and context-sensitive actions to interact with objects. For example, to complete the 'Learn how to Calculate your Grades' quest, the player will need to find some chalk, then find the tutorial room and interact with the blackboard, which features a puzzle that explains how to calculate their grades (see Fig. 1). Calculating grades is an important skill for making decisions about where to invest time and energy.

Another example of a quest is 'Create a Study Schedule' (see Fig. 2). Students often cannot conceive how their time will be spent at university and tend to over-commit. In this puzzle activity, the player will be given coloured tiles that represent different time commitments – lectures and tutorials, independent study, paid employment, eating and sleeping, social, family and sporting – and will need to organise them into a weekly schedule. Too much work will cause the stress indicator to rise, forcing them to adjust the schedule until it is balanced. As a consequence, the student learns the *skill* of creating an effective study schedule whilst also learning the *value* of creating a study schedule for emotional wellbeing. This is far more compelling as a learning activity than merely being told it is advisable to create a study schedule.

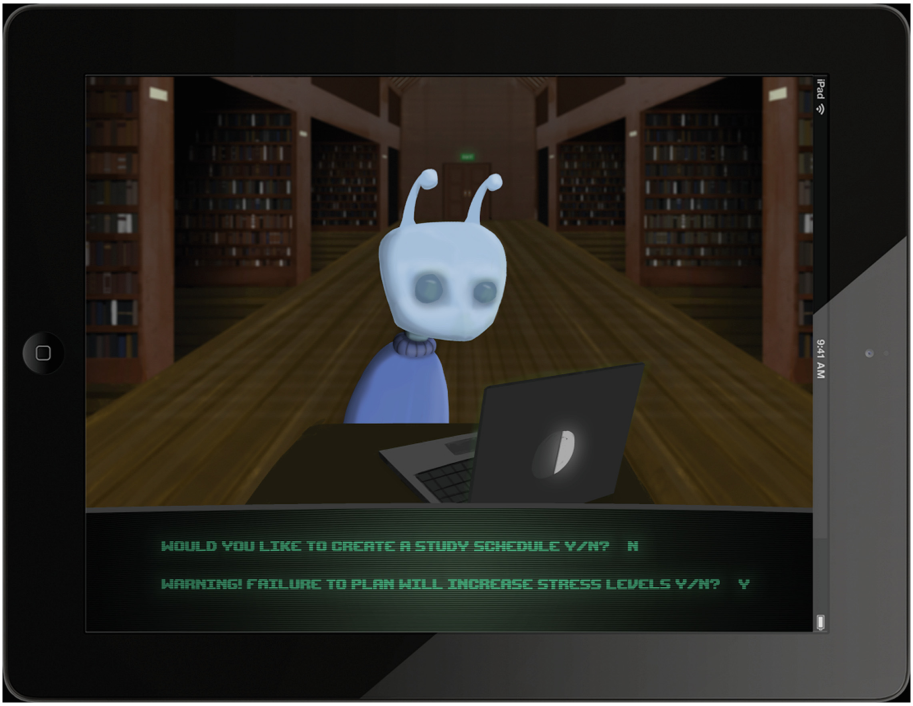

Fig. 2. Illustration of the "Create a Study Schedule" quest on the library computer

In each level, following completion of the quests, the player must go to the library computer and 'Start the Semester'. They select four 'subjects', each of which contains

3-4 puzzles that represent assessment items. They will then be offered the opportunity to plan out submission dates on a timeline at the top of the screen. Without this planning, game play will become insurmountably chaotic and result in rising stress levels. The puzzles will be timed and played concurrently, swiping between four different screens that each contain a puzzle. When they are alerted that one of the puzzles is due, they must submit it, even if it is incomplete, or risk losing marks for lateness and falling behind on the other puzzles. It is proposed that this will demonstrate the 'juggling' required in managing competing assessment deadlines and the importance of planning.

At the end of each level, the player will be able to view their 'transcript' that illustrates the subjects they have completed, the 'grades' they achieved, a mechanism for showing them how to calculate their GPA, and the subjects yet to be completed to achieve graduation.

4 Approach

The design draws on a methodology developed by Prieto de Lope, Medina-Medina, Paderewski and Gutiérrez-Vela [7]. Development of the proof of concept is separated into three pre-production and six iterative production phases. The first phase of pre-production involves identifying the knowledge, skills, attitudes, and behaviours to be targeted and then generating scenarios that will allow learners to acquire and use them. As proposed by Marfisi-Schottman, Schaier, George, Tarpin-Bernard, and Prévôt [8], there will be a pre-evaluation of these learning objectives as a pedagogical quality control.

The second phase of pre-production will consider the game characteristics, including gender, avatar control, platform, future users, narrative level, area of application and interactivity. The third pre-production phase involves design of the story and main characters – some of whom will provide the player with quests or pieces of in-formation.

The preliminary stages of production will map out the chapters and scenes for the game story, using flowcharts to illustrate the different outcomes caused by different choices or actions. At this stage the characters and environments will be sketched and backstories created. The design of the dialogue and play challenges will then be mapped out using the interactive design software, Twine. Educational objectives will be tied to the action and dialogue choices. At this stage educational objectives will be tested with a simple pretest-posttest strategy and using self-assessment questionnaires. Feedback from the testing will be incorporated into the design. A vertical slice prototype will be produced in addition to two animated play sequences. A Twine interactive user experience map will be further developed to give an overall 'play experience'.

The final stage of production will be the evaluation of the content. This will be achieved through beta-testing and a questionnaire, such as used by Whitton [9]. It is anticipated that students will report better understanding of university expectations following the game play.

5 Conclusion

This is an innovative solution to the orientation, transition and retention problem that draws on a substantial body of research and makes a significant contribution to this field of knowledge. It will also inform research and development of games for similar purposes. The use of a strong theoretical framework, sound pedagogical principles and rigorous testing will ensure that the game provides students with a sophisticated understanding of what is required to study at university and allow them to plan their studies accordingly, leading to reduced attrition.

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Classification of Isometric Playing Fields and Arenas in Geomorphic Tabletop War Games

Andrew Chiou(✉)

School of Engineering and Technology, Central Queensland University, Rockhampton, QLD, Australia
a.chiou@cqu.edu.au

Abstract. This paper presents the work-in-progress results to classify tabletop war games into different categories according to stylised layout of battlefields.

Keywords: Tabletop war games · Playing field · Classification

1 Introduction

This paper presents a pilot work-in-progress project to undertake the classification of the different types of playing field layout found in tabletop war games. The intention is to provide a point of reference and a consistently unique key using the classification presented in this paper to help identify the myriad of different tabletop war games commercially available. This paper presents the initial results of a comprehensive survey.

2 Background

In addition to its entertainment value, tabletop war games have been used as a training tool for the reenactment of historical battles and simulation of *what-if* and alternate scenarios. The scaled-down battlefield allows decisions to be played and replayed until optimal results are found. From this outcome, lessons from the decision making process are learnt and analysed. The ultimate purpose is for these optimal decision making process to be up-scaled to its real life counterpart. Through this role playing, benefits can be expected. This includes, cost savings, time lines can be accelerated, multiply scenarios can be played simultaneously and results can be analysed (Linehan 2009: Simões and Ferreira 2011). However, serious games such as these need to be accurately and precisely replicated, even at the scaled down version. Therefore, the modelling techniques employed need to be capable of transforming critical battlefield parameters into more stylised format resulting in a playable format. A typical tabletop war game consists of three key elements that need to be implemented successfully for the game mechanics to be reasonably playable. The three critical elements are: *the rules, the playing pieces and the playing field*. The rules govern the conditions on how games are won or lost depending on the regulated moves made by the players. The playing pieces

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represent resources, for example, such as soldiers, transportation, ration and different types of ordnance. The playing field represents the zone of conflict where the playing pieces are distributed, located and played. Of the three, the playing field determines the scale and complexity of the physical reenactment and the model of the problem space. While playing pieces can sometimes be attributed to the complexity of the game, the playing field ultimately determines how the playing pieces coexist in the overall framework of the game.

3 Terminology

Playing field. This is the physical playing area available for the complete game to be laid out. This can include the physical table top, the ground or any physical surface. **Arena.** The arena is the defined area of contention that exists within the playing field. It is the playing surface that reflect the conflict zone where playing pieces are manoeuvred and played across. The maximum size of the arena is always smaller than the playing field. The arena is most commonly composited of hexes termed as an hex or *terrain*. The hex shape provides the modularity required for a continuous layout. It also allow for elements of the playing pieces to move in 6 directions. While an octagon shaped terrain would have allowed 8 directions as per compass vectors, an octagon does not allow modularity between similarly sized oct-shapes to be continuously laid out without gaps or breaks. **Playing pieces.** These are the tokens in different shapes and sizes used to represent the resources available to the players. The playing pieces exist on the arena's surface. **Boundary.** The boundary defines the space and available space that the arena can exist within the playing field.

4 Findings and Classification

To classify the most prevalent types of arenas on playing fields available in different tabletop war games, a total of 234 different commercially available war games were studied. This include only wargames depicting historical wars and battles. A comprehensive list of these type of games can be found on Board Game Geek (Browse Board Games | BoardGameGeek 2016). The following types occurred the most frequently:

Type 1: Bounded playing field, dynamic arena

The dynamic arena is constructed from a draw pile of hexes before game play commences or during game play. However, the hexes can only exist within a bounded playing field. If the dynamic arena is constructed during game play, Type 1 allows the build-up of *fog-of-war* scenarios. Type 1 allows an arena to represent different historical scenarios as in Fig. 1.

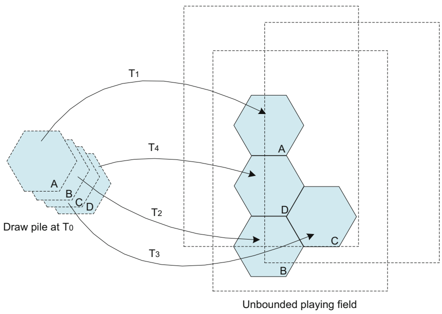

Fig. 1. Type 1: Bounded playing field

Type 2: Unbounded playing field, dynamic arena

Similarly to Type 1: The arena is constructed from a draw pile. However, it can exist in an unbounded playing field as in Fig. 2.

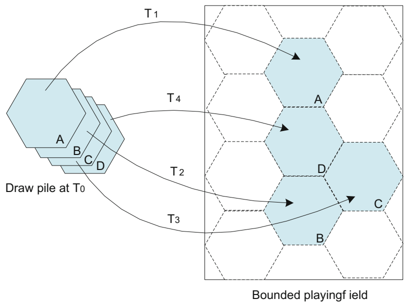

Fig. 2. Type 2: Unbounded playing field

Type 3: Bounded playing field, bounded arena

The scenario is predefined and normally models only can problem space. The hex terrains are fixed and often represent better known historical scenarios as in Fig. 3.

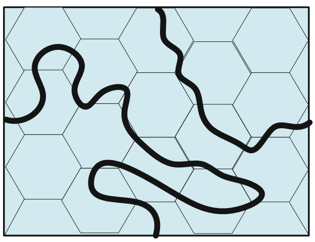

Fig. 3. Type 3: Bounded playing field, bounded arena

Type 4: Modular bounded playing field, bounded arena
This is similar to Type 3. However, the bounded arena is composed of several similarly sized arenas. Each arena is modular, allowing it to be arranged in different layouts. Each bounded arena has strategically positioned features at the edges of the arenas that allow continuous construction to form a much larger arena. In the following figure, please note that each four edges have a similar joint as in Fig. 4.

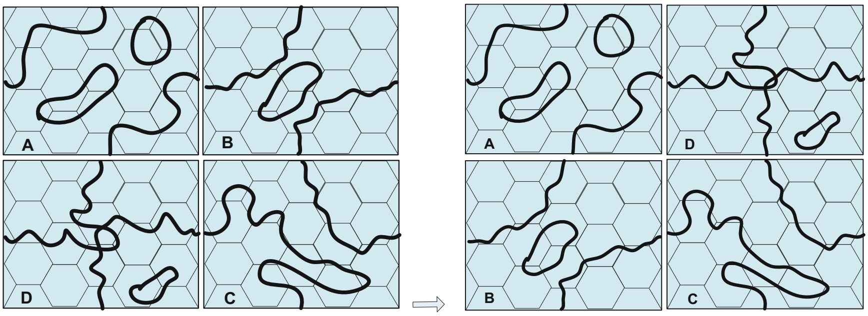

Fig. 4. Type 4: Modular bounded playing field, bounded arena

Type 5: Modular bounded playing field, unbounded arena
This is a variation of Type 4 with the arenas rotatable to provide further modularity as in Fig. 5.

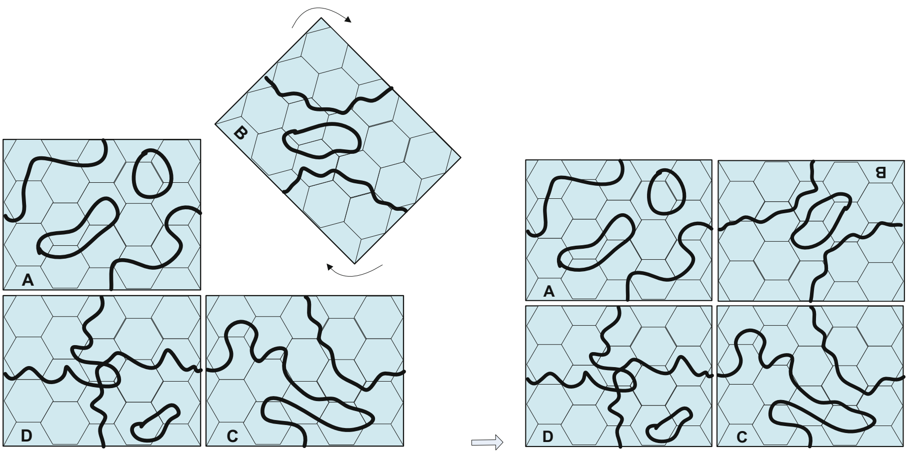

Fig. 5. Type 5: Modular bounded playing field, unbounded arena

5 Further Work

Further work will include the cross referencing of each of the types identified here with commercially available tabletop war games. In addition, actual historical conflicts will be referenced to the games it has been depicted in.

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Virtual Reality MRI Experience for Children

Jan Kruse[1(✉)], Gregory Bennett[1], Stephen Reay[2], and Andrew Denton[1]

[1] VR Research Group, Auckland University of Technology, Auckland, New Zealand
jan.kruse@aut.ac.nz
[2] DHW Lab, Auckland University of Technology, Auckland, New Zealand

1 Introduction

Magnetic Resonance Imaging (MRI) procedures can be intimidating experiences, in particular for young children. Leaving the impact of the sterile, clinical interior aside, the constant loud noise, claustrophobic experience of being moved into a tube, and the necessity to avoid any head and body movement for prolonged periods of time in order to produce images of diagnostic quality are often overwhelming. Children under 7 years of age are generally sedated during the procedure and the success rate of getting sufficient image quality in children between the age of 4 – 13 years is very low [1].

To counteract the necessity of sedation and in an attempt to improve diagnostic quality of MRI images, several approaches have been proposed. First, there are videos and other educational material available to children and their families to prepare them for procedures and operations [2]. Another promising preparation, applied in context of surgery, which frequently requires the use of MRI as a diagnostic tool for pre-operational investigations, is intervention through the use of therapeutic play [3]. These measures have shown only limited success, and have greatly improved through use of mock MRI scanners to educate children about the process, appearance and sound of the machine and the screening room [4]. The mock scanner unit looks like an actual machine and the table can be actuated, while there is no radiation unit or any diagnostic equipment involved in the educational process. They provide a simulated experience, and have improved diagnostic quality of images to around 90 % even without sedation of children under 7 years of age. While this is a noteworthy achievement, significant downsides of these mock scanners are the cost, spatial requirements and immobility of the setup.

This project aims to respond to these issues and also account for some of the positives of other initiatives such as therapeutic play. By taking the simulation into virtual reality, an immersive experience can be created. Further, it is possible to turn purely educational factors into a playful experience through gamification of the virtual MRI demonstration. Finally, the system is mobile and can be used off-site or in the patient's preparation rooms, rather than a dedicated space, with the possibility to use a phone-based VR headset, which makes it practically available to patients a long time before the actual procedure, so that the timeframe can be adjusted depending on the children's age and other requirements.

In the long term, this research is looking to establish whether a virtual reality MRI experience can match the success rates of mock MRI setups.

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2 Methodology

This interdisciplinary research utilizes Design Science Research (DSR) at its core, an iterative software development framework often used in Human-Computer Interaction (HCI) research [5]. Further, we draw from different User Experience (UX) evaluation methods such as Concept Testing [6] and Usability Benchmarking [7].

We are also looking to conduct an in depth evaluation in collaboration with social scientists and behavioural psychologists from the Design for Health and Wellbeing (DHW) Lab, but at this stage, the prototype is still being extended as explained in the following section, so that participatory study with children is considered a long term goal. This long term evaluation will be conducted using a comparative study with young patients divided into two groups, one being prepared through the use of a mock MRI machine at Auckland Hospital and the second using the vrMRI prototype described in the following section.

3 vrMRI

The VR Research Group at Auckland University of Technology, in collaboration with the DHW Lab, a design research center which is situated inside Auckland City Hospital, to develop improved services and experiences with all hospital users, created a virtual MRI experience for children, which we call vrMRI.

The prototype consists of a VR headset, driven by a small PC, which is running the Unity 3D Game engine. A phone-based version using a VR headset with a mobile phone as the display and processing unit has also been tested.

vrMRI uses a full 3D model of a General Electric Optima MRI scanner, which is accurately dimensioned and textured in the game engine. The environment has been built in two different ways to account for the differences in computing performance of the PC and the mobile phone. For the PC, a fully three dimensional environment based on photogrammetry has been constructed, in order to provide a walk-through experience for the user. The phone-based variant uses a 6-sided cubic HDR panorama image, projected into simple geometry, which requires much less computing performance and therefore allows for sufficient frame rates on mobile devices.

Control is provided through the head tracking of the VR device, and an additional Xbox controller can be used with the PC-based version of the application. The use of a controller allows for a playful approach to the experience. The room can be explored and different features explained. But it is also possible to lay down on the motorized table, and get transported into the tube, all features that are switched with the press of a button, once the user is ready for that particular part of the overall experience.

The sound design is based on several approaches. First, we use recordings of an MRI screening room for the background noise, which is quite significant, even when the machine is not actively imaging. Second, we use actual machine recordings for the scanning process. These sounds can be varied in intensity, frequency and rhythm. Finally, a few custom sounds using software synthesizer and modified guitar sounds haven been created. The stackable sound system provides a way of intensifying the experience for the user, and originates in the fact that sound is one of the more intimidating parts of a MRI scan.

The combination of scalable sounds, navigation through the room and the features around being moved into the diagnostic tube, allow for a gamification of the overall experience. Designing an effective gamified experience for the vrMRI draws on guidelines from the gamification of education. Knewton identifies the need in progressing through a game for ‘success’ to be ‘visualised incrementally’ [8] Progression should incorporate positive feedback which promotes a ‘child’s status within the game’ and is also ‘an indication of progression through content’ [9]. Pedagogical content needs to integrated seamlessly into the ‘storytelling and narrative components’. Cascading Information Theory is also a useful framework for the delivery of educational content within a gamified context– to ‘unlock information continuously’ during the game experience [8]. A variety of media should also be employed across visual and audio modes [10].

Children can start with an easy task, such as exploration of the room. Educational aspects can be touched on by the use of a demonstration sequence of what is inside the scanning unit (the tubular part of the scanner) and why the patient has to go into the tube, rather than stand next to it. The user can earn experience points, which are counted towards a high-score. Further, the simple mechanics of being moved into the tube can be experienced to gain even more points. Finally, different stages of sound level, intensity, visual impact of being moved through the tube itself, and the necessity to remain as calm and still as possible are all rewarded in the game.

4 Conclusions

The vrMRI prototype is a gamified virtual reality MRI experience for children, which provides a cost effective and mobile alternative to physical mock up solutions.

We are also investigating possible avenues using 360-degree video for the background to make the room setup more realistic. Additionally, the use of avatars to guide the gaming experience and support the educational aspects of the machine demonstration is being considered. We hope to add a deeper level of immersion through multiple iterations of the existing prototype, once a pilot study has confirmed the requirements for future improvements.

While its diagnostic success rate is yet to be established in further research, the immersive capacity of virtual reality applications is very promising on one side [11] and the necessity to find a smarter, more cost-effective solution than mock scanners on the other side, seems to be unchallenged. This lets us to believe that vrMRI will be a successful tool alongside the existing measures that are taken to improve diagnostic quality of MRI scans while reducing the impact on its users.

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A Conflict Resolution Intelligent System for Informed Strategy Expert (CRISIS-Expert)

Maneerat Rumsamrong and Andrew Chiou(✉)

School of Engineering and Technology, Central Queensland University, Rockhampton, QLD, Australia
{m.rumsamrong,a.chiou}@cqu.edu.au

Abstract. Resource management in conflict resolution poses a great challenge to resolve in almost all types of decision making processes. Much of the expertise contributing to providing optimal advice is in human intelligence. This paper presents a proposal to explore the design, technical aspects and outcome of an intelligent decision support systems (IDSS) shell proposed specifically for providing expert advice over a range of strategy recommendation and actions. To demonstrate the viability of the proposed IDSS, a prototype expert advisory system will be developed based on scaled-down models.

Keywords: Serious game · Gamification · Tabletop wargame · Intelligent decision support system · Expert system · Computational intelligence

1 Introduction

Resource management and decision-making are important processes in life-threatening situations, such as military training, demand discrete and precise input in order to yield accurate results that offer cost-effective and optimal solutions (Wilson et al. 2016; Perla and McGrady 2011). These situations can be scaled down in gamified environment involving strategic qualitative parameters such as human intuition, prior experiences and informed knowledge that will contribute to refinement of results. It is complex to model these parameters in relation to existing real world challenges. Overall, the complexity of real world problems requires the assistance of computational intelligence in decision-making processes. The computerised intelligent approach will be measured against human decision making processes to innovate effective computational intelligence methods. This in turn will be used to develop an IDSS shell for users in decision-making. Linking to the current study, performance and results of different core inference engines will be compared to those of human decisions in actual conflicts or problems so as to identify the inference engines that offer optimal actions. The identified interference engines will be encapsulated into a decision support system. Thereafter, performance between simulated human players who use the decision support system and those who do not use the system will be compared.

In relation to the present study, computational intelligence is used in the context of gamification, an area of study where real world challenges and open-ended problems are modelled into a game-type environment, termed as "serious games". Serious games

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are gamified versions of accurate models of their larger and more complex counterparts, which are a small-scaled competitive arena where players act the role of resource managers (Wilson et al. 2016; Aldea et al. 2014; Cheong et al. 2011). The layout of an arena represents a problem space, and is composed of various assets to represent real life resources, environment, tangible assets and intangible assets. For example, in military wargames, the arena consists of the defined battle (the area of contention) and the resources would be the army's tangible assets such as soldier, trucks and tank.

Serious games can be applied to different arena representing different real world problem space, allowing large problem sets to be modelled into a more manageable framework that allows testing, application of different solutions and repetition of experimental data. In particular, serious games have been an important tool for military research. Indeed, the United States have been used wargames to train America military (Dunnigan 2003). Overall, the proposed project has been illustrated in the framework (Fig. 1) for transformation of real world problem to serious game, which focuses on the use of computational techniques in to investigate the effectiveness of innovative models and the subsequent construction of the most optimal models to develop the CRISIS-Expert.

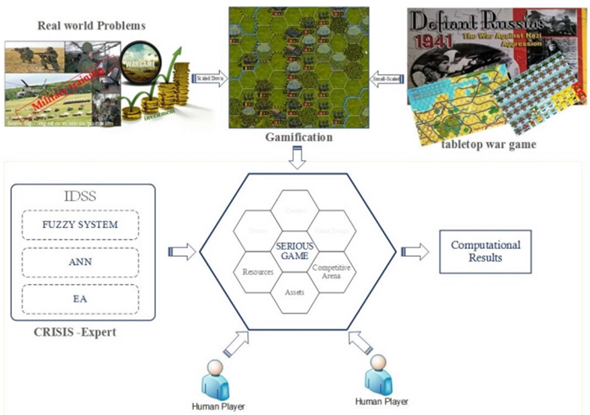

Fig. 1. CRISIS-Expert framework.

Specifically, the study will use three types of intelligent model techniques, namely, fuzzy systems, artificial neural network and evolutionary computation. Further, this proposed study will use gamification (e.g., war gaming) to test the intelligent modelling techniques and construct the CRISIS-Expert that produces the most accurate results. It is expected that these results can derive more modular and systematic methods that could be reproduced and applied to solve a similar problem in real-life situations. The simulated human players will act the role of resource managers to resolve conflicts in wargame arena, with and/or without recommendations from CRISIS-Expert.

2 War Games

In particular, game mechanics have been employed in critical problem solving from ancient to modern times. While games are more popularly known for its entertainment value, in the context of serious games, it serves a more critical role in the areas of simulated problem solving.

Game mechanics in simulated processes of scaled down models of its larger problem space counterparts provide the following benefits (Feron and Hoffman 2012; Perla and McGrady 2011),

(1) Cost effective solution.
(2) Physical and real resources are not expanded.
(3) Not readily available problem space can be simulated and created. This can include unpredictable weather, season and hostile environment.
(4) Game mechanics is capable of providing iteration and repetition of the problem solving procedures until optimal results occur.
(5) The process of the game mechanics simulation can be accelerated to allow several iterations to occur until optimal results occur before the real deadline. Hence, providing a forecast or prediction.
(6) The process of the game mechanics simulation can be de-accelerated to allow closer inspection of each time frame to study its inference processes. This allows human decision maker to explore how each turning point before a critical decision was inferred.
(7) Multiple scenarios can be processed concurrently.
(8) Explanatory capabilities can be implemented to allow automatic self-discourse to allow clarification of the inference process.
(9) Decision making involving committing valuable resources and human lives to critical or dangerous real life situation can be minimised or avoided.

With the afore mentioned advantages in the previous section, the most complex problem space that uses serious games mechanics to generate optimal solutions or decision process are in military conflict resolution (Feron and Hoffman 2012; Cheong et al. 2011; Lai and He 2011; Sanchez and Smith 2007). This presents the most comprehensive problem space to carry out the proposed experiments. Due to resource consideration, this will be scaled down further to tabletop war games. Even though stylised and streamline, the tabletop war game is a suitable platform that has been employed in the study of battle field contention as it provides the most comprehensive model. In addition to providing entertainment and educational value (Simões and Ferreira 2011), tabletop war games have proven its usefulness and accuracy in critical simulation of actual conflict resolution. Perla and McGrady (2011) and (Linehan et al. 2009) emphasised the need for board-game-like tools that has been compared as manually managed open systems to allow participants and decision makers (i.e. players) to see or change how elements and components of the games models work. This is further translated into effects and events, culminating into thinking and decision making processes that can be repeated and applied to different scenarios. Perla and McGrady further reiterate that board-game-like tools is most suited to be adapted to computerised version of similar problem space.

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Exhibits

La Petite Mort

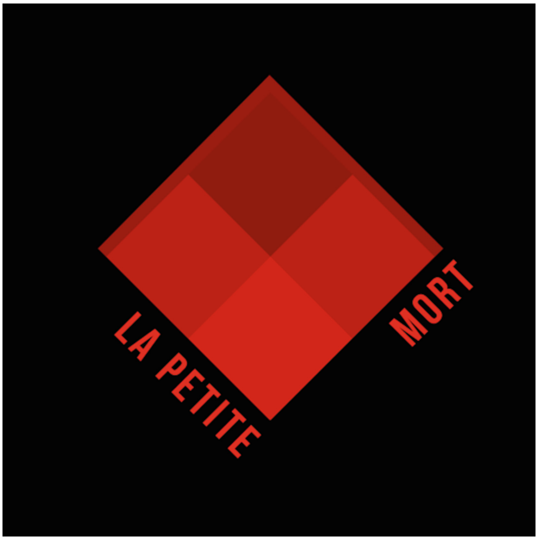
Andrea Hasselager and Patrick Jarnfelt(✉)

The Lovable Hat Cult, Copenhagen, Denmark
andrea.hasselager@gmail.com, patrick@jarnfelt.dk

Abstract. La Petite Mort is an experimental non-explicit digital erotic experience designed for touch. It focuses on female pleasure, and encourages the player to go slow and take their time. As much as giving a more nuanced picture of female pleasure and stimulation, La Petite Mort is also a statement of a different way of interacting with, and using the tablet. La Petite Mort has a simplistic style and musical design that moves you through highly pixelated, but weirdly sensual landscapes, ending in a cacophony of musical climaxes.

1 Outline

The purpose of La Petite Mort is to encourage people towards more sensuality and to empower female sexuality. To emphasize this, we've build into the work that you can't pleasure/advance in the game, if you move too fast, and this is accompanied by a negative musical feedback.



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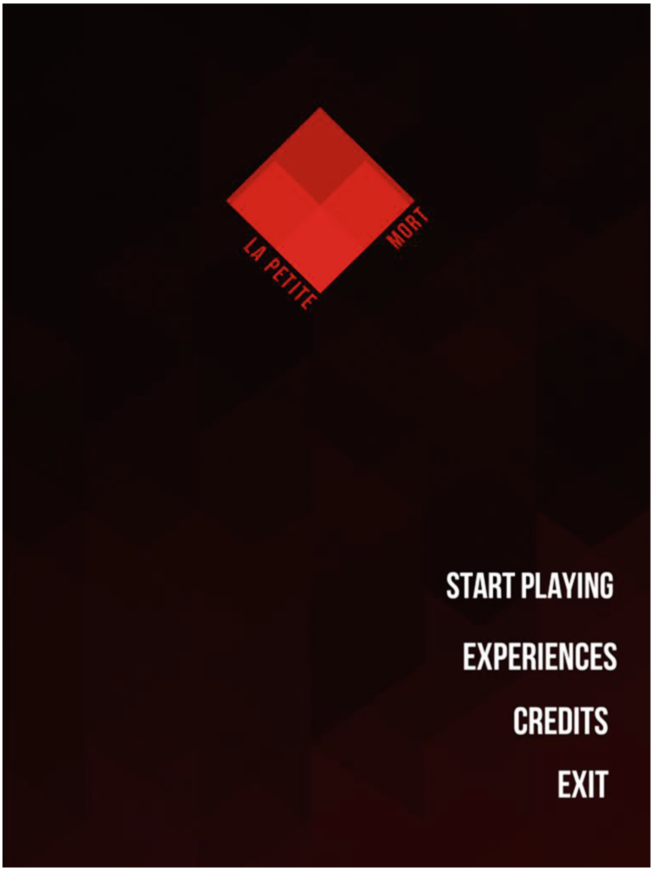
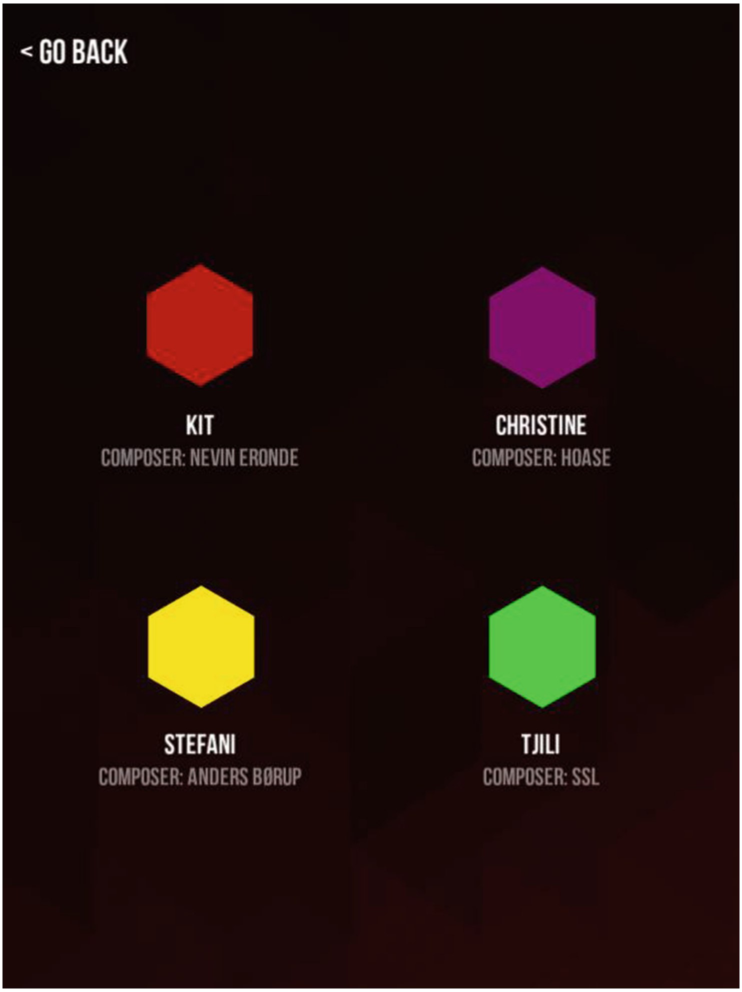
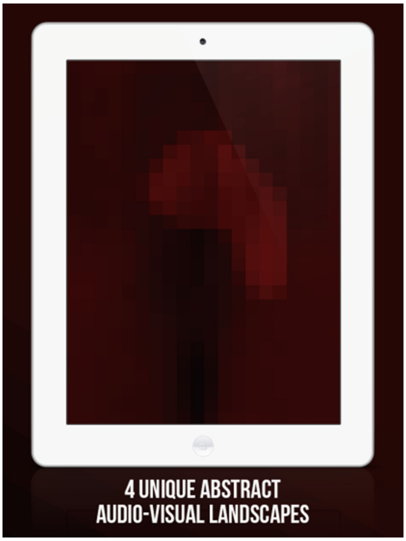


You start out by choosing one of the 4 levels, each one will respond differently to your touch. You then start moving your finger/fingers slowly over the tablet, and you will get a musical response, that will increase in intensity if you do it right. You will find out that there are certain spots where each vulva likes to be touched more. For each level we have a different music composer that has made his or her interpretation of how a build-up and musical climax may sound.



We used ‘cellular autonoma’ to technically build up how the cells react to each other. One cell can send a ‘pleasure signal’ to the one besides it, if it get’s touched in the right way, and that’s how you, as a player, can create an area of intensified pleasure.



You can get different endings, depending on how you touch, just like in real life. The art piece will give you feedback on how you did. You can therefore try again, touching in a different way, to get a different ending.

Transmission

Daniel Galbraith[1(✉)] and Sean Fitzpatrick[2(✉)]

[1] Braith, Brisbane, Australia
dgalbraith2@gmail.com
[2] Queensland College of Art, Brisbane, Australia
jonathonsean@gmail.com

Abstract. *Transmission* is a statement on the fragility of communication systems, and an exploration of human interpretation when traditional communication fails. These topics are examined through the context of the Vietnam War - specifically, the capture of Saigon by the National Liberation Front of South Vietnam and the People's Army of Vietnam. *Transmission* captures the panic, tension and stress of the period by placing participants within a period-authentic area and tasking them with deciphering incoming transmissions. With no context to the situation, those involved must interpret their role in the events they uncover. The tension of the event therefore lies not in the event itself, but in the unknown circumstances that arise out of participation. In the context of this project, the term "transmission" is used to describe "the act or process by which something is spread or passed from one person or thing to another" [1]. Under this definition, the "transmissions" found in our piece refer to the process of conveying information, both organically and digitally.

1 Description

Transmission is intended to be experienced with no prior knowledge of the project, and will last as long as the participant wishes. It is estimated that participants will complete all interactions between 5 and 15 min after starting.

Participants enter a private area and sit at a desk fitted with a CRT monitor which displays a telephone switchboard with movable electrical cables and dials. Participants will use this interface to manipulate the virtual switchboard, in an attempt to establish connections between unreliable signals. We understand that the monitor is not period-accurate - however, it is a solution to replicating mostly-obsolete and incompatible pieces of technology (Fig. 1).

After being seated the participant will wear a pair of high-quality headphones, and once comfortable the game will begin. With no context to their role other than their surroundings, involved parties will attempt to decipher broken and static-filled transmissions by manipulating the onscreen switchboard. While this virtual switchboard is not of a specific model or make, it bears superficial resemblance to communications switchboards of the period. The interface itself comprises three large dials located in the centre of the console. These dials are intentionally obtrusive – they are the main vehicle for the participant's input. This allows for immediate readability, as well as the suggestion of interaction. Above these dials are a row of ¼ inch plugs; they are receptacles for

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Fig. 1. Aesthetic reference - note the rounded edges of the terminal and the industrial metal of the switchboard [2]

a single audio jack which is initially coiled on a hook to the left. This cable can be removed and plugged into the sockets, which allows the player to receive a different transmission. To further emulate e the superficial elements of an old switchboard the system bears markings, scratches and a barely-visible serial number on the console's bottom. We believe that this lends authenticity to the intended aesthetic of the piece, and that the tactile, skeuomorphic elements of the scene provide a natural, intuitive user interface (Fig. 2).

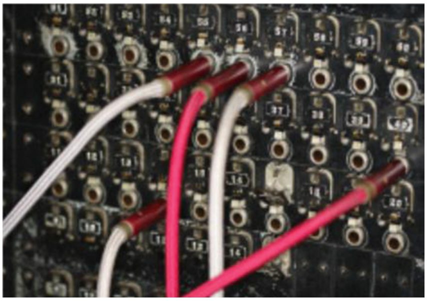

Fig. 2. ¼ inch audio jacks – the non-descriptive markings and worn metal paneling of the console provides an excellent reference for the user interface.[3]

From a technical point-of-view, manipulations of the audio jacks change what audio sample is being played, and manipulations of the dials change a fader which plays static over the audio sample; each sample has a different point at which static can no longer be heard. By finely tuning the dials, participants uncover parts of the developing narrative. In preliminary tests we have found this process to be surprisingly intuitive; manipulation of the dials is forgiving, and so requires little understanding of audio systems. Once the dials have been aligned correctly the participant will be able to clearly hear the audio transmissions. These transmissions all revolve around the capture and American evacuation of Saigon on April 30th, 1975; messages range from famous military broadcasts such as “The temperature in Saigon is 105 degrees and rising.”, as well as music of the time including the evacuation signal - Bing Crosby’s version of Irving Berlin’s “I’m Dreaming of a White Christmas”. The intended conclusion of this experience is that the participant, who had no prior experience of the subject matter, slowly goes through a process of understanding. We believe this replicated process of understanding to be similar to how many of us interpret the world - through communication with others, context, and a developed sense of understanding. This project breaks two columns of this process in an attempt to question the third - if we have no context to a situation and methods of communication are unreliable, is our understanding of the event equally unreliable? Furthermore, this project will contribute to the study of modern history, ideally producing a system by which we may understand the confusion and tension of the period. By placing participants within a specific role, individuals may experience the stress of the event from the perspective of a communicative occupation. By undertaking that role, it is our intention that these participants will under-go a subtle realisation of the fragile and ambiguous nature of modern communication systems; experiencing reports of both past and future events in a more subjective manner (Fig. 3).

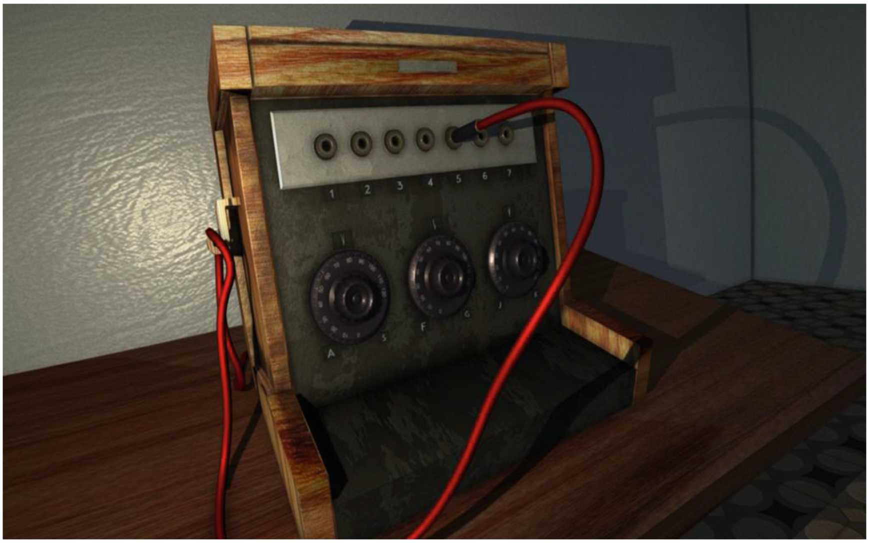

Fig. 3. ‘Transmission’s user interface. Interaction is carried out via keyboard.

Upon exiting the simulated space, participants will be asked to write down their interpretation of the event on a slip of paper; these slips will be gathered and placed within a box that will be examined after the event’s proceedings. This ensures that we can observe the different reactions to the project in a practical and concise manner, as well as review our assumptions of the project. To conclude, *Transmission* is a period examination of our most unreliable feature - the ability to communicate with others. It is our intention that the participant, and the observer, will feel a sense of unease as they come understand the statement of this piece. It is with great enthusiasm that we present this project to you, and we hope this document has been informative (Fig. 4).

Fig. 4. An evocative reference for the event - this well-known image captures the emotions and tension of our project [4]

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Blown Away (Sydney 365, 2014)

Brigid Mary Costello(✉)

School of the Arts and Media, UNSW, Sydney, Australia
bm.costello@unsw.edu.au

Abstract. Working with 365 days of pollution data from Sydney, Australia, Blown Away traces the intersection between wind and pollution expressed as rhythms of light and dark within a 3-dimensional grid of cubes. Each day's pollution particle count is represented by a cluster of cubes that fall from a point drawn from the daily wind direction. This process gradually destroys the grid structure and transforms a pristine white plane into a jagged dark landscape.

Keywords: Unreal Engine · Data visualisation · Pollution · Art with purpose

1 Description

Blown Away (Sydney, 365) is a data visualisation that aims to raise awareness about the impact of pollution. The work visualizes one year's worth of pollution data from Sydney (Bankstown), Australia. It was created using the real-time 3D gaming software Unreal Engine 4 by Epic Games. Each burst of falling black cubes represents one day's fine particulate matter count (PM2.5). These fine particles are dangerous for human health and cause a visible haze in the air when levels are high. In *Blown Away* the direction the cubes appear from and the velocity they move at is based on the wind data for the same day. The top of the screen is North, bottom South, right East and left West. The viewers perspective is from above as if they were suspended in the air looking down on the Earth (or the city of Sydney). When the pollution cubes hit the grid surface below they cause the spot on the grid that they hit to drop lower as if eaten away and to darken in colour (greyscale). Each time a spot is hit it drops lower and darkens further (Fig. 1). Once a spot is black it remains black but will continue to be eaten away if it is hit again. It takes 36 min for the year to play out. The video will then loop back to the beginning and start at January 1, 2014 again.

The visualization reveals the yearly rhythms of winds in Sydney (Summer months are mostly Easterly winds, big winds appear in Spring and Autumn etc.). There are also seasonal rhythms in the pollution count, for example, high counts caused by household fires used for heating in winter, or by summer bushfires. Other pollution count rhythms might be caused by industrial activity or traffic jams. The dark hole that appears in the centre of the visualization reveals that over the course of a year the winds do not blow away or evenly distribute the pollution rather they concentrate its effect on the city

Video documentation is available here: https://youtu.be/N3-DG3kUTvo.

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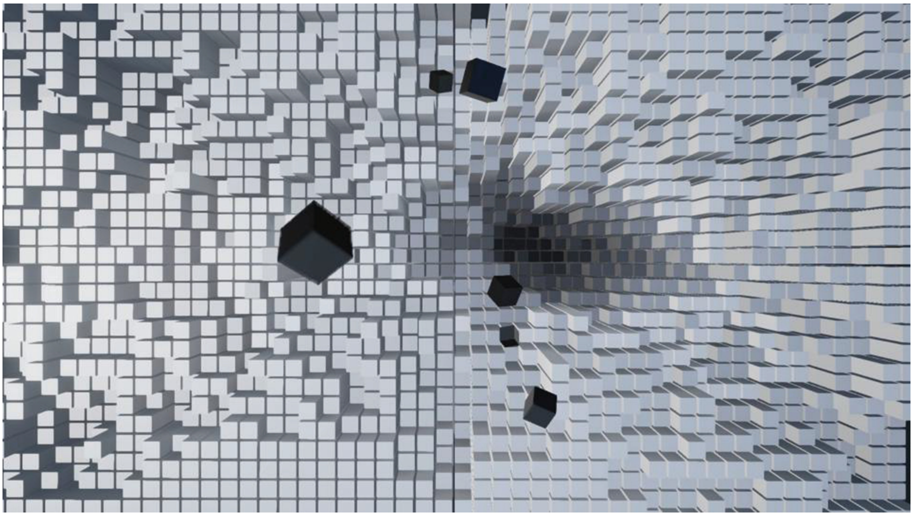

Fig. 1. Screen shot of Blown Away (Sydney 365, 2014)

below (Fig. 1). For the viewer, the animations can be mesmerising. Watching the slow tumble of each cube and observing its impact on the grid as it lands has a hypnotic beauty that contrasts with the grim meaning of the darkness they produce.

The animation uses the real-time physics simulation capabilities of Unreal Engine. Each cube has a velocity, start location and direction of thrust that is generated based on a particular day's wind data. The gaming engine then produces the animation in real-time, simulating the physics of each falling cube. There is a small amount of randomness coded into the animation of the cube in addition to the randomness within the gaming engine physics simulation. This is used to separate out the cubes generated for each day so that they do not all spawn in exactly the same spot and provides a small amount of rhythmic variation in their speed of fall and interaction with each other.

From an artistic perspective this work felt like it was produced in collaboration with the data and the game engine. I made the rules that translated the data into the movement of the cubes but it was the data and the game engine that were driving how the cube animations were sequenced together and producing the overall effect. If the work is played through the engine, each time it plays there are small variations in the patterns produced. This was an interesting shift in my practice, which has previously always involved audience interactivity. The role of the audience in these past works was to animate or bring the work to life. In Blown Away the data and game engine take on this role.

A major motivation in producing the work was to see what patterns and rhythms were revealed and as I created it I started to notice patterns appearing. For example, I noticed that in certain months some wind directions were more common than others. In creating the work I watched the year play out many, many times: something I doubt any audience member would ever do. It was this close relationship with the representation that revealed the patterns. This raises questions about where the serious purpose of this work most effectively plays out. There will be some value to the work as a representation of a particular data set and, if exhibited well, *Blown Away* will communicate something of its serious purpose to an audience. But does its value lie more in the process of creation and the knowledge that can be generated by working closely with the data and the form of its representation? With this in mind, in future work I plan to work with an environmental scientist and to document the creative process and any knowledge that emerges. The ‘game’ in this art with purpose perhaps lying in the serious play of creation.

Coming Through

Andi Spark(✉)

Griffith Film School, Griffith University, Brisbane, Australia
a.spark@griffith.edu.au

Abstract. Ever felt that the supermarket shelves were out to get you? Or that suddenly the silverware needs polishing at 2am? Or that every photograph is somehow sucking another gram of your energy? And you have a baby that is utterly adorable, but you do not deserve it; your life is inextricably changed, and so far, not for the better; and yours and ours and theirs and everyone we know's expectations of new motherhood are a big big lie? You're not the only one (despite what you might think right now) and your story adds to hundreds of other stories, creating a matrix of bearing witness to the lived experience of postnatal depression (in animated form).

1 Description

"Coming Through" is an interactive fragmented animated work about the perils of mothering and postnatal depression. The project relies heavily on visual symbol and metaphor, created with a deceptively simple line-drawn style mimicking a sketchbook or journal.

A humorous approach to the serious subject matter is the cornerstone of this work. In discussing comics and graphic novels, theorist Elisabeth El Rafaie states that "psycho-analytic approaches to humour propose that jokes can function as a welcome release from the constant need to repress our socially unacceptable desires" (El Rafaie 2012, 70). Likewise, I uphold that using humour in this context, particularly in discussing contentious subjects like feminism, gender disparity, disillusion and mental illness,

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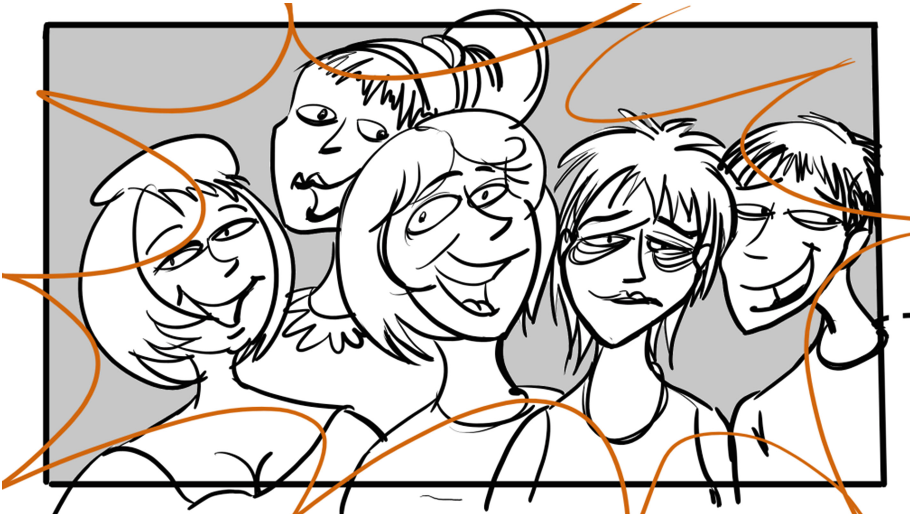
offers comic relief for the audience who may be identifying with similar socially unacceptable thoughts or feelings.



The animations vary in style of humour - sometimes eliciting a wry chortle, sometimes a surprised laugh, - and afford a contemplative window for considering serious issues.

Structured as a series of vignettes, it tracks one woman's experience through postnatal depression (PND) with each episode corresponding to a 'symptom' or experience/event of the illness. The series can potentially be viewed in a linear timeline, however the symptoms or events of PND can happen in any order—often not cumulative and often repeated, - with varying intensity over varying timeframes. Furthermore, many of these symptoms may not happen to some people at all (Buist et al. 2005). Therefore the project is designed so that the viewer may choose a vignette at random, choose according to their need or interest, or rearrange the order of the displayed scenes to form a sequence that may provide engagement, reflection or emotional connection related to their own memories or experiences.

Arty Swirly Colourful

Thomas Hanley(✉)

Queensland College of Art, Griffith University, Brisbane, Australia
thomas.hanley.envartist@gmail.com

Abstract. *Arty Swirly Colourful (ASC)* is an interactive relaxation experience. While most games focus on challenge, excitement, fear, or bombast, *ASC* seeks to provide the player with a calming, relaxing escape from everyday life. Players will freely roam a fantasy world, discovering various points of interest, and observing the beauty of nature's ever-changing presence. *ASC* is far from a traditional game; it does not feature a core conflict, obstacles, forced guidance or objectives. Players are free to explore at any pace, in any direction they want, over as many play sessions as they like. *ASC* can also be enjoyed passively allowing the player to engage as much or as little as they choose.

1 Description

ASC is best experienced in a quiet, private environment with good quality headphones and screen. However *ASC* can be equally well-enjoyed at home by anybody with a modern PC (Fig. 1).

Fig. 1. Visual Style – ASC uses a realistically rendered world to ensure the game is widely acceptable with little barrier to entry for those unfamiliar with games

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The game world of *ASC* is a realistically rendered and diverse natural landscape filled with a variety of interesting things for players to discover. Insects and creatures add life and charm to the game world while little houses and modern geodesic shelters provide subtle intrigue and a relatable human element (Fig. 2).

Fig. 2. POI Icon Statue – *ASC* uses these markers to highlight some of the more unique and interesting elements of the game.

The primary mechanic in *ASC* is the most simple and probably one of the most widely understood mechanics found in many games today. The player moves around the game world by using the mouse and WASD keys to turn, walk and run with the SHIFT key. Alternatively a gamepad can be used to control the game. As one of the core design goals of *ASC* is to let players explore and discover on their own, there is no explanatory tutorial. This mandated that the controls be very simple to understand, and they will be second nature to almost anyone that has played a game on a PC or games console before.

In order to highlight the various spectacles of the game world, *ASC* uses small icon statues with alternating lights known as *Points of Interest (POI).* The alternating lights convey various messages to the player. If the player has not visited a particular *POI* before, its marker will glow softly with a dark colour. When the player visits the *POI* for the first time the marker will flash into a bright colour and the relevant effects for the *POI* will activate. After the player has activated a *POI*, it will glow with a different colour when later encountered.

The world of *ASC* has a dynamic day and night cycle that adds a huge amount of variation in terms of lighting and the differing aspects of the day and night time skies. The day and night cycle also serves as a device to enable a variety of POI effects to be activated at different times. The weather also changes, and when combined with the day and night cycle adds even greater variation to the active POIs (Fig. 3).

Fig. 3. Dynamic Weather & Seasons – *ASC* uses these effects to add a large amount of variation across the entire game world.

To provide subtle guidance to the player a colourful Sprite will sometimes appear when the player has not visited a POI for some time. If the player notices and tries to approach the Sprite it will lead the player towards the nearest POI. Once the player has reached the POI, the Sprite will either disappear once it has left the player's line of sight or linger and attempt to lead the player to another nearby POI. Like all guiding elements within *ASC*, the player does not have to follow the Sprite if they do not wish to.

As the player visits more POIs, a Central Tower which is visible throughout the game world will progressively illuminate. Once the player has explored the entire environment and visited all POIs, the tower will unlock and the player will be able to enter it and ascend to the top. Once the player has reached the top of the tower they will find themselves on a viewing platform. From here players will be able to see the complete game environment. Reaching the top of the tower is the ultimate goal of *ASC* and serves as a reflective pinnacle. Players may have been expecting some sort of dramatic finale or cutscene as is common in most games; instead, the player will simply be faced with the ability to reflect on all the places they have explored. Once again this element is entirely optional as the player must remain free to seek relaxation in whatever way they like within the game's boundaries.

VR-Rides: Interactive VR Games for Health

Kiran Ijaz(✉), Yifan Wang, David Milne, and Rafael A. Calvo

School of Electrical and Information Engineering, University of Sydney, Sydney, NSW 2006, Australia
{Kiran.ijaz,Yifan.Wang,David.Milne, Rafael.Calvo}@sydney.edu.au

Abstract. VR Rides is a virtual reality game that aims to engage older adults in physical and cognitive exercise to reduce their risk of developing dementia. The experience combines a recumbent tricycle, real-world imagery (sourced from Google Streetview), an Oculus Rift headset and a Microsoft Kinect camera, such that the player can navigate real locations in a safe virtual environment. Using this platform, we further developed two game designs: Competitive (ghost/virtual player as opponent to guess visited cities) and affiliative (virtual tour to invoke and share memories). Our immediate goal involves deploying VR Rides into retirement homes, so that it can be evaluated in a realistic setting. The first primary measures of these experiments will focus on engagement and usability of older adults. However, we would also ideally measure the outcomes of using this platform on players' mobility and spatial skills in future.

Keywords: Virtual reality · Immersive VR games · Exergames · Health games

1 Introduction

Dementia is the most prevalent cause of disability in older adults. Globally, there are currently 46 million people living with dementia, and this figure is projected to rise to 130 million by 2050. The global economic burden is currently estimated at 818 billion USD, and projected to rise to over two trillion by 2030 [1].

Physical activity is widely recognized as key for reducing one's risk of dementia [2]. Unfortunately, age has a profound effect on mobility. This is particularly true for those suffering dementia, who often have great difficulty navigating and recognizing familiar locations [3]. Consequently, a simple walk around the neighborhood can be a frustrating and frightening experience. Many live an understandably sedentary life.

In this paper we present VR Rides, a combination of technologies that allows the user to safely cycle around almost any real-world location, without encountering traffic or worrying about getting lost. We hope that this computer game will engage older adults in physical and cognitive exercise, and consequently reduce their risk of developing dementia as possible outcome.

Older adults are far from the target audience for emerging technologies such as the Rift and the Kinect. However, we hope that in this case the technology will fade into the background to create a truly intuitive experience; one where there are no confusing

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buttons or fanciful environments. The user instead simply cycles around a location that they are already familiar with, just as they would in real life.

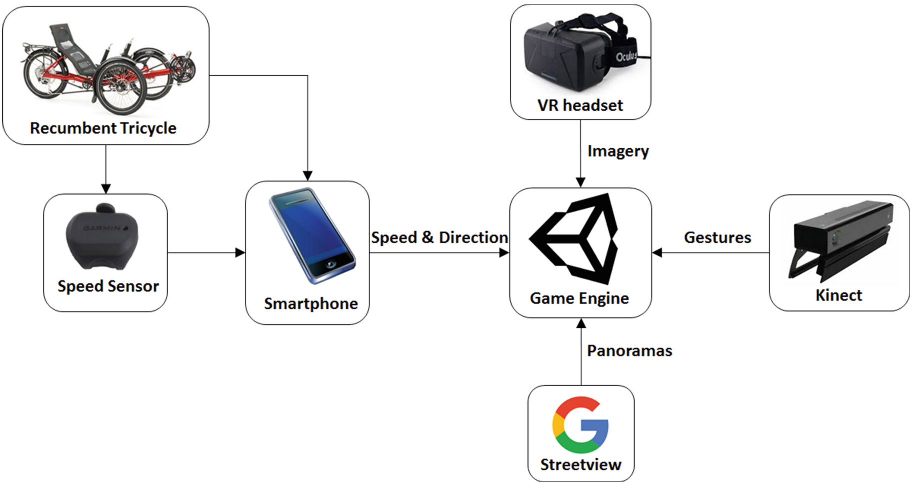

Fig. 1. VR rides architecture

VR Rides use a stationary recumbent tricycle as a game controller and to navigate the virtual environment (Fig. 1). A speed sensor and smart phone connected to the back wheel can track speed and direction of the cycle during the trip. The sensor's information is further passed to the Unity game engine that generates immersive virtual environment based on Google streetview imagery. The same game engine enables players to experience immersive VR environment with the help VR headset. Players can also interact with the game using natural hand gestures through a Kinect camera.

The key challenge of this project is to create a VR experience that older players will find appealing. It is common understanding that older adults are less likely to engage with technology simply for technologies sake, and may not be familiar with or respond well to traditional game mechanics. After establishing the VR platform with aforementioned technology, we developed two distinct game modes:

- *A competitive Guess Game*, in which players need to locate nearby landmarks in an unknown place to guess the city name. The activity is not a flat-out race (which would cause safety concerns for our older players), but is instead a strategic cycle ride that requires players to guess where the landmarks are located, and plan an efficient route between them.
- *An affiliative tour*, in which players take a virtual tour of famous cities by navigating around familiar historical locations. They can intuitively point out landmarks that have personal significance using the Kinect, and can describe the memories they evoke using a microphone. Tours and generated picture gallery are ideally shared with a friend, child or grandchild, but can also be saved and played back later.

McCallum and Boletsis [4] provide a recent review of dementia related games, and explain that while such games have a positive effect on cognitive-impaired patients, more research is required to measure whether the effects are persistent or can transfer to daily activities. The primary measures of these experiments focused on usability and engagement: e.g. whether players voluntarily register for future sessions with the bike. Participants' feedback suggest that VR Rides was well received and had successfully engaged older adults during the sessions.

2 Interaction

After initial familiarization with VR headset and trike, player can participate to play one of the two games. An immersive experience with VR Rides is demonstrated in Fig. 2. Both games start with an in-game tutorial that lets player understand the game components and mechanics. Once the player master the basic interaction, he is presented with first level of the game based on the game mode initially selected.

Fig. 2. An older adult riding the trike in immersive VR environment

Overall interaction is much the same across both modes. Both involve the participant using the Oculus Rift headset to freely look around a photo-realistic location, and then steering/pedaling the bicycle to navigate to between locations. In the competitive mode, players are asked to guess the cities they are navigating. In the affiliate mode, they have to follow a virtual tour of some of the world's famous cities, they can point out significant locations through gestures, take photographs and hear pre-recorded audio.

3 Conclusion and Future Work

VR Rides is an interactive virtual reality platform that motivates older adults to engage in physical and cognitive exercise. The two game designs use real-world imagery which provides flexibility of cycling in any real world location. Competitive guess game aims to challenge players to navigate familiar environments; in contrast, affiliative virtual tour allows players to share memories and locations that are of personal significance. Our primary aim is to encourage and engage elderly for physical and cognitive activity in an entertaining way. VR-Rides provide an intuitive setup where participant has to simply pedal to navigate in the virtual environment. In future, we would preferably measure use of these games for player's mobility and spatial skills.

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VR Immersive Slow Reef Experience

Tim Marsh(✉), Nathan Jenson, Whitney Constantine, and Elliot Miller

Griffith Film School, Queensland College of Art, Griffith University, Brisbane, Australia
t.marsh@griffith.edu.au, nathanjensen1234@gmail.com,
constantinewhitney@gmail.com, elliot@digitallyblessed.com

Concept Statement. In this ever-advancing world, technologies that are slow are considered inferior, of the past and redundant, passé or obsolete. But there is an increasing belief that faster technologies creating faster work, faster lifestyles and leisure pursuits is having a detrimental effect on, and eroding our values, traditions, cultures, practices and experiences. Counter movements that promote a slower pace of life are for example slow technology, slow food, slow families and slow fixes. Following this trend, our work explores some of the latest, fastest virtual reality technology as platform for slow serious gameplay, stories and experiences. This immersive VR experience is a continuation of our work on slow interactions, slow serious gameplay and slow interactive movies to create a sense of calm and peacefulness and so open opportunities for reflection and contemplation. Specifically, this work allows participants to explore, learn about and experience the beauty and wonder of corals, marine life and ecosystems in Australia's Great Barrier Reef and create awareness of human activity that is harmful, disruptive and is ultimately destroying the reef.

1 Slow Virtual Reality Experience

Using Oculus Rift, the VR immersive slow reef experience allows participants to learn about and experience the beauty and wonder of corals, marine life and ecosystems in Australia's Great Barrier Reef. Exploration in the virtual Great Barrier Reef is through deliberate and slow movement intended to focus and sharpen concentration so participants experience and reflect on the beauty and tranquility of the coral reef and marine life. In addition, during their journey through the ocean and amongst reefs, corals and marine life, sprinklings of evidence of human activity that is harmful and disruptive to the reef (e.g. pollution, litter, contamination) are discovered. These devices are subtle reminders intended to stick in the participant's mind and provoke thought and questioning that may linger, resonate or bleed out from the game [1]. As demonstrated in counter movements (to our ever-advancing and faster world) that promote a slower pace of life through slow technology, slow food, slow families and slow fixes, there are advantages to slowing down. The VR immersive slow reef experience is composed of slow serious interactions, gameplay and exploration. Movements through the environment are in a leisurely, gentle and unhurried manner that is similar to performing, or *dancing with technology* [2].

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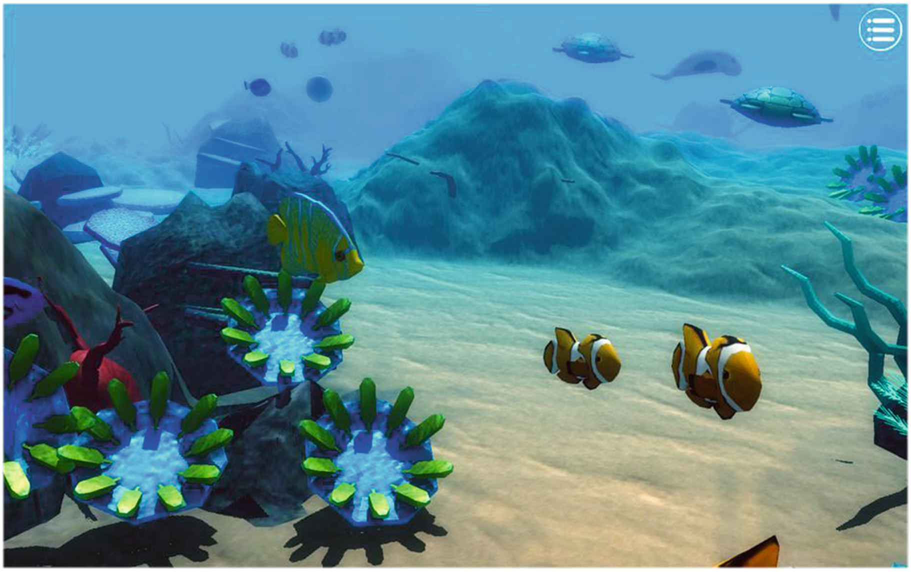
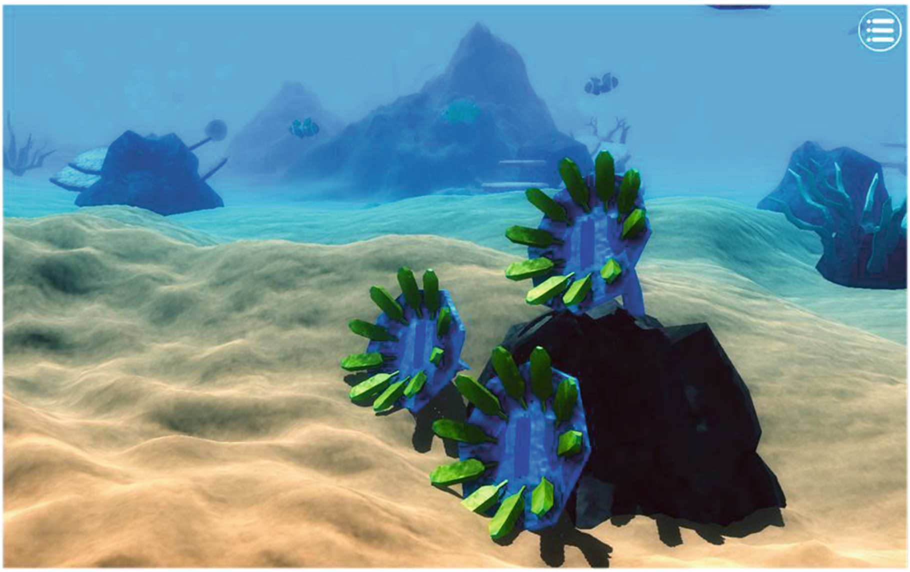


Screen shot of immersive VR slow reef experience

This design strategy is intended to create a sense of calm and peacefulness to clear one's mind and so open opportunities for reflective thought, contemplation, and learning, and to captivate participants' interest and attention to learn about and experience the beauty and wonder of corals and marine life.



Screen shot of immersive VR slow reef experience

While many ocean and reef games and VR 360 degree experiences are being developed, the difference with our VR reef experience is the exploration in slow movement, gameplay, interaction, stories and experience.

What makes this experience unique is it allows the user to learn at their own pace, this is achieved by allowing the player to interact with the environmental elements. This interaction prompts information to appear about the element the player is interacting with. For instance, when looking and interacting with various fish information is displayed to the player about that particular fish, including name, and a brief summary about them.

This is part of continuing work to explore design strategies and devices to articulate and manipulate time and space and narrative in interactions, games, VR and serious games to stimulate thought and for the shaping of experience between positive and negative experience [3]. Our previous work focused on tablet and touch screen devices [2] while the focus of our current work is on immersive VR experiences and in particular exploration of slow interactions and gameplay to create opportunities and openings for reflection and contemplation.

Original concept art by Rob Donaldson

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A Game of Horseshoes for the Ineffectual Martyr 2.0

Madeleine Boyd[1(✉)] and Jason Haggerty[2]

[1] Freelance Artist, Queensland, Australia
madeleinejeanboyd@gmail.com
[2] Griffith University, Brisbane, Australia
Jason@jason-haggerty.com

Abstract. A Game of Horseshoes for the Ineffectual Martyr (GOH) is a concept game with the intention of encouraging human empathy with racehorses. Racehorses are documented as being subject to treatment that does not reflect the public interest to protect animal welfare in Australia. Based ideologically in new materialism, the game 'works' through drawing attention to comparative human and horse physical performance in real space time, rather than being played entirely in virtual space time. GOH V1.0 was exhibited as a semi-interactive prototype in 2013 (playable without actual digital interactivity of display). An academic paper was published on the animal justice research grounding the game conceptually during 2015. This current paper reports on GOH V2.0 development progress as of July 2016. The primary progress concerns actual interactivity of horseshoe placement in the horseshoe pit with game result display. Technology used is software TouchDesigner 088 by Derivative, triggered by hardware computer vision via Pixy (CMUcam5) by Charmed Labs. For GOH V.02 the horseshoe pit is conceived as the 'controller' rather than the 'game', and the physical design is amenable to rapid prototyping, open source sharing and transportability.

Keywords: Empathy · Animal justice · Horse racing · Interactive game · Anthropocene · Contemporary art · TouchDesigner · Pixy · Arduino

1 Digital Media and Social Justice

In breaking news July 7, 2016[1] the New South Wales Premier Mike Baird announced the banning of the sport of Greyhound dog racing in the state. While Thoroughbred horse flat racing or jumps racing[2] has a varied set of animal justice factors compared with Greyhound racing, the association of gambling based profit with animal physical performance tests is a strong motivator for illegal activities and under regulation. Public awareness of Greyhound cruelty via digital videos recorded by whistle blowers and shared by television and online media eventually drove the political reforms when

[1] Penglilly, A.& Robertson, J.: NSW Premier Mike Baird announces ban on greyhound racing after Special Commission of Inquiry. http://www.smh.com.au/ (July 7, 2016) [Accessed July 8, 2016].

[2] For more details on jumps racing see the website of The Coalition for the Protection of Racehorses. http://www.horseracingkills.com/the-issues/jumps-racing/ [Accessed July 8, 2016].

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backed up by the evidence reported by a Special Inquiry. Therefore, there exists a strong case for the benefits of awareness raising for animal justice concerns, and this current project works towards this goal through a serious video game, a Game of Horseshoes.

2 Games Engaging Animal Justice

Games that specifically engage animal justice, Whiplash [1] and PETA (People for the Ethical Treatment of Animals) games[3] are representatives of this 'serious game' genre. A perplexing feature of these vegan video games is the focus on violent solutions to animal welfare problems. Killing of laboratory scientists, raining down of 'heavy' revenge on Big Top circuses and fighting one's way towards animal justice outcomes is the *modus operandi* for game play. This approach reflects PETA's direct action over negotiation approach to animal justice issues in the physical world. The interactive video game introduced in this paper takes another route. It is suggested that comparative experiences are a method for encouraging interspecies empathy. Empathy is a nuanced phenomenon that can be understood most simply as the ability to understand the lived experiences of the 'other' in a way that evokes a similar rational and emotive response in the 'self': to feel the other's pain, not only to sympathise (feel sorry for), but to empathise (to share pain). New materialism referencing material-affective exchange is the theoretical basis for this perspective [2].

3 Game of Horseshoes 1.0

During 2012/3 'A Game of Horseshoes for the Ineffectual Martyr' (GOH) was conceived by Dr. Madeleine Boyd as part of a doctoral project investigating horse-human interactions across various scales [3]. The game's genesis was two chance encounters, first with a bucket of used racehorse shoes and second with Thoroughbreds on their way to the knackery. A detailed paper on this process was published in a collection of animal studies papers in 2015 under the title of 'A Game of Horseshoes for the Anthropocene' [4]. In summary, the paper detailed the ethical issues of over breeding and mistreatment in the racing industry, and highlighted topics of 'wastage' (kill off of unwanted racehorses) and 'nanny mare foals' (kill off of foals bred to produce milk in mares). Corruption and profiteering in the gambling and gaming industry was identified as driving these phenomena along with a lack of knowledge and empathy in the general populace, who are rather beguiled by the pomp of race day carnivals. GOH V1.0 was exhibited as a prototype in a gallery setting during the Australian Animal Studies Conference, 2013, University of Sydney. V1.0 was playable in the sense of being a regulation sized horseshoe pit, with plans taken from the National Horseshoe Pitchers Association (USA) [5].

[3] View and play PETA games here: http://www.peta.org/features/games/ [Accessed July 14, 2016].

A Showwx pico laser projector (version 1) by MicroVision playing off an iPhone3[4] was hidden under the sand, and the display surface was the horseshoe pit backboard. The sentiment of the game was revealed through the random sequence of still images that displayed alternately images of horses at the horse sale yards or race carnival pomp and ceremony with game result slides. Slide slogans included 'Outside the Box. You're a nanny mare foal: Killed & Discarded', or 'Perfect Throw. You're Lucky: A teenager rescues you for pony club' (Fig. 1a-b.).

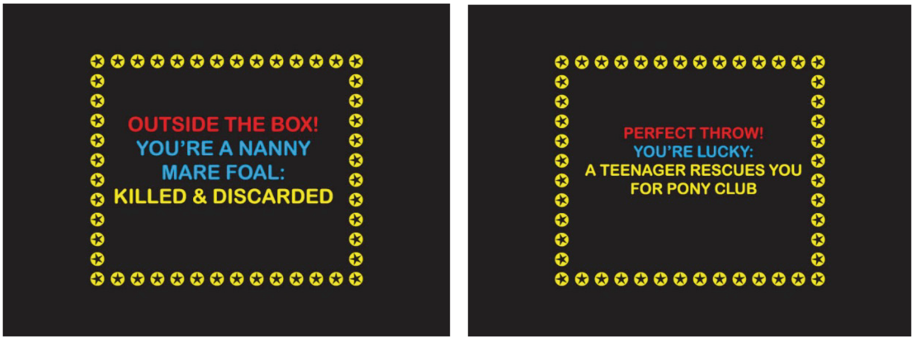

Fig. 1a-b. Game performance responses for GOH V0.1

4 Game of Horseshoes 0.2

Development of GOH V.02 was put on hold until the completion of the more extensive doctoral project at the end of 2015. A suitable collaborator with knowledge of interactive digital programming was an essential requirement for moving forward, as was as an opportunity for exhibition and testing of V.02 in a responsive user environment, such as JCSG 2016. Jason Haggerty, a Queensland based multi-media artist with an established practice in digital projection mapping and interactive installation, was invited to collaborate on the technical basis for interactivity. The primary improvement to V2.0 compared with V1.0 in progress is the interactivity between horseshoe landing spot in the pit and game result as displayed on a digital screen (details below). Other improvements are aesthetic and ease of transport and replication in the home player environment. The image display from the pico laser projector used in V1.0 was not sufficiently visible under normal indoor lighting conditions. A digital screen will be used in V2.0 to display game results.

Wood was used to construct the V1.0 horseshoe pit as per the NHPA plans. Actual used racehorse shoes forged from steel were the horseshoes on offer for play. The authenticity of this approach intended to convey realism to the game and connection to

[4] The Showwx pico projector version 1 was quickly superseded in usability due to lack of useful output plugs for the rapidly changing personal device sector, and limited playback format recognition. Significant 'wasted' time was dedicated to finding a method for projecting a looping video from a personal device while both devices could charge continuously.

the material-realities experienced by racehorses. However, this heavy construction detracted from the contemporary quality of the aesthetics and made transportability difficult. GOH V1.0 construction will be approached with the aesthetic of rapid prototyping, ease of replication, and transportability and with main components being constructed from new cardboard. GOH V2.0 will be shareable through open source programming in the form of a TouchDesigner file. Home users will need the pre-fabricated horseshoe pit, also known as the controller, the shared program file, a free downloaded copy of the TouchDesigner trial program, and a PC laptop or desktop computer for use with the computer vision component currently under development. Conceiving of the pit as a 'controller' rather than the 'game' was a breakthrough in design thinking that is intended to bring GOH V0.2 more into line with other video game platform development.

5 GOH 2.0 Technological Challenges

The game will continue to exist as a physical test via the pit controller system rather than an entirely digital experience. The Kinect V2 system in this project was tested as a means to record the placement of horseshoes in the physical pit. TouchDesigner 088 from Derivative was adopted as the development software platform. Blob tracking methods for object mapping have been well established in the programming environment, and so provides segue between suitable computer vision cameras and TouchDesigner programming. Game performance results will be determined by placement of the horseshoes in allocated zone bands as shown in Fig. 2. An ongoing challenge is to differentiate a near hit to a full placement hit on the horseshoe pole. A network in TouchDesigner was created that takes object tracking video from a camera and passes it through an OpenFrames blob tracking system. This system picks out certain elements of the video, in this case the horseshoe, and determines its co-ordinates in relation to the camera's field of vision. These coordinates are used to trigger values that pin-point the area where the horseshoe has landed, and whether it has landed successfully over the peg. The horseshoe will trigger images and sounds from a library of files that relates to the landing position. See screenshot Fig. 3 for indication of the programming environment and parameters. Initial challenges included mapping the position of up to three horseshoes in a single player turn. Following initial tests with the Kinect 2, limitations were detected in differentiation of the three horseshoes that a player would use in each turn. In particular, if a throw resulted in two overlapping horseshoes, then the Kinect 2 system could not differentiate these as two separate objects, and instead amalgamates both into one blob triggering false game results. For this reason the Kinect 2 will be substituted with the Pixy (CMUcam5) in conjunction with an Arduino clone microprocessor. The camera by Charmed Labs is recent release hardware developed to address needs for high performance computer vision and object sensing in DIY robotics and computing projects[5].

[5] http://charmedlabs.com/default/products/ [Accessed July 15, 2016].

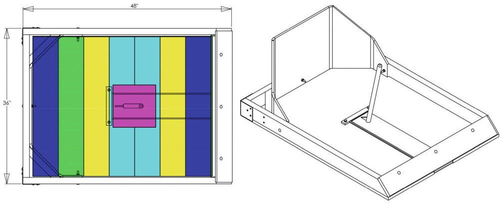

Fig. 2. Game performance zones with colour indicating areas stimulating same response to horseshoe landing location. Pit layout plans sourced from NHPA pit construction plan document

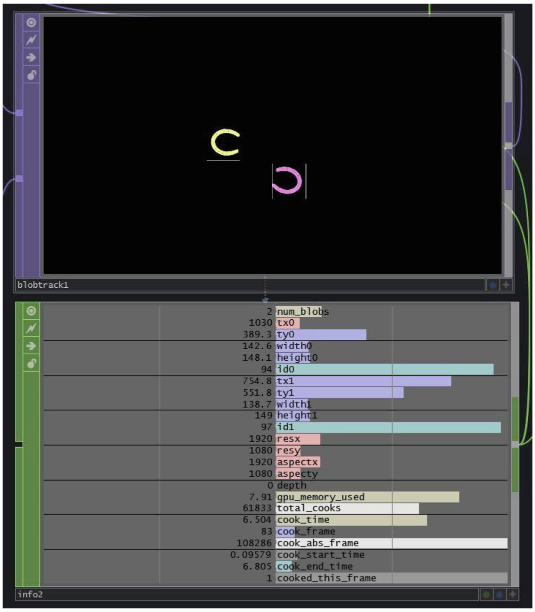

Fig. 3. Programming environment (in progress) for tracking horseshoes in TouchDesigner

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DE.FORM

Tyson Foster(✉)

Griffith Film School, Griffith University, South Brisbane, Australia
t.foster@griffith.edu.au

Abstract. Breathing life into the digital void is the core goal of my practice. As a technical artist I use 3D software and interactive real-time graphics to generate responsive performance for stylized 3D characters in virtual worlds. Working with stylized form allows me to explore the essence of motion. This practice is a symbiosis of code and aesthetics. Virtual Reality (VR) has [re]emerged as an artistic medium that fuses game mechanics and interactivity with active storytelling and character performance. The tranquil first person experience in *DE.FORM* presents the player with various creatures floating around the player while tracking the players gaze and head position. *DE.FORM* examines the importance of player immersion and how presence is maintained while interacting with responsive stylized 3D characters in VR. This has been achieved by employing rules of non-verbal communication and plausible motion in order to maintain player immersion.

Keywords: Virtual reality · Rigging · Motion · Immersion · Presence

1 Exhibition Details

This proposed artwork is an exploration into gesture, organic motion, and algorithms used to create a sense of empathy with stylized procedural creatures. Working with VR and procedural generation techniques, I create amorphous digital creatures that I use to explore the link between the materiality of virtual form and anatomical deformation derived from the natural world. My practice is VR based and I wish to share this experimental medium with as many people as possible. VR transports the viewer to other worlds that appear as perceptually real to the player. This phenomenon is known as presence[1], it is this sense of presence which makes VR a powerfully immersive experience.

By utilizing virtual reality as an artistic medium, this work challenges the audience's prior assumptions of the real and the virtual, the corporeal and the incorporeal, and

[1] "A variety of stimuli provided by a virtual reality system can cause the user to perceive that s/he is moving through and interacting with the environment created by the technology rather than the user's actual physical environment. Because a virtual reality system provides immersive, high resolution, three-dimensional images and high fidelity, dimensional sound, a virtual reality system can cause the viewer to perceive that s/he is in an environment that looks and sounds as the viewer believes it does or would in the physical world" [1].

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audience as observer and audience as participant[2]. Based on Laurel's explanation of interface as theater she explains that the virtual world is created by populating the virtual world with representations of human and computer-generated agents to create an authentic feeling virtual space [2].

1.1 Play

In *DE.FORM* the audience is invited to navigate around various virtual spaces that showcase various procedurally created and animated stylized creatures.

Each space is connected using a portal gateway that allows observation of the next space before committing to enter (Fig. 1). Once the player has teleported to the new game space, the creatures will begin to engage with the player.

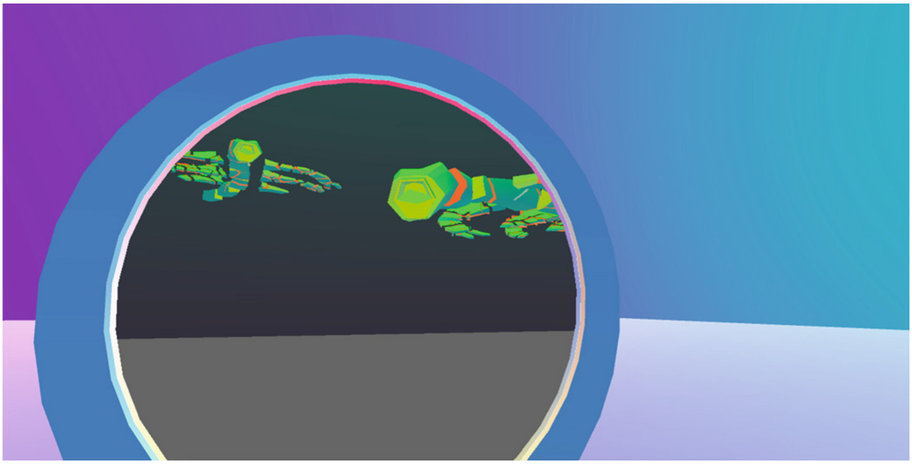

Fig. 1. Player looking through portal gateway to another environment containing two flying creatures on patrol in their own world.

1.2 Mechanics

The mechanics of the interactions are based around game worlds that are fundamentally changed with the use of VR. The experiences are presented as series a short gameplay atoms. These gameplay atoms create a game-like environment to showcase the procedural creatures in context, without the requirement for complex gameplay sequences.

This above example (Fig. 2) allows for animation to propagate along a character's joint chain such as the spine or limbs, enabling motion to be generated and performed by the procedural character's mesh.

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[2] Brenda Laurel explains, "[people who are participating in the representation aren't audience members anymore. It's not that the audience joins the actors on the stage; it's that they become actors—and the notion of "passive" observers disappears" [2].

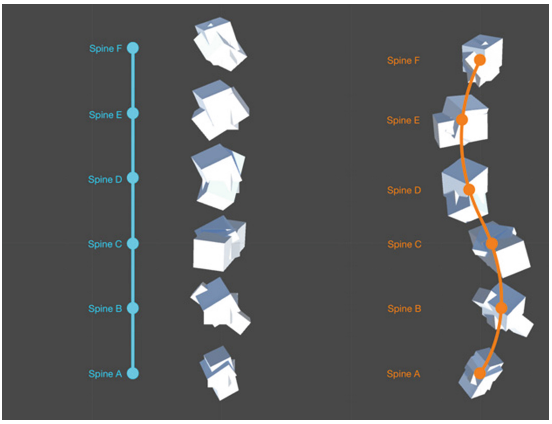

Fig. 2. Top view of abstract spine joint hierarchy created in Unity with unshaded mesh (left) same joint hierarchy with a serpentine animation applied (right).

1.3 Interaction

Inspired by VR demos such as *Showdown Cinematic VR Demo* (2015) by Epic, *Lost* (2015) and *Henry* (2015) by Oculus Story Studio, and *Sightline: The Chair* (2013) by Frooxius, interactions in *DE.FORM* are kept simple, utilizing tap-based input for teleport locomotion with gaze-based input for the interactions with the characters. Laurel suggests that players learn how to interact in the game world by playing with the interactions and observing what happens as a result [2]. Therefore, the interactions in *DE.FORM* are kept simple in order to facilitate playful exploration of the gaze-based input with the creatures.

By implementing gaze-based and motion-based inputs players utilize head tracked interaction based on their own body movement as the input in the virtual world without abstracting any of the interactions through the use of controller buttons or sticks. This is an attempt to allow audience of varying degrees of prior game experience to naturally interact with the virtual world in order to sustain the perceptual realism[3] of the VR experience.

Each creature reacts to different and surprising ways to the player's gaze and the player avatar's physical presence within the virtual world. The creature reacts to the player's gaze, such as acknowledging eye contact, and also the player's physical presence in the game world (Fig. 3). Each experience is crated to give a unique perspective

[3] "Sensory presence," "perceptual realism," "naturalness," "ecological validity", and "tactile engagement" occur when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that s/he is in a physical location and environment in which the sensory characteristics correspond to those of the physical world, i.e., s/he perceives that the objects, events, and/or people s/he encounters look, sound, smell, feel, etc. as they do or would in the physical world [1].

on the different creatures that have been created, ranging from passive behaviors to aggressive predatory behavior.

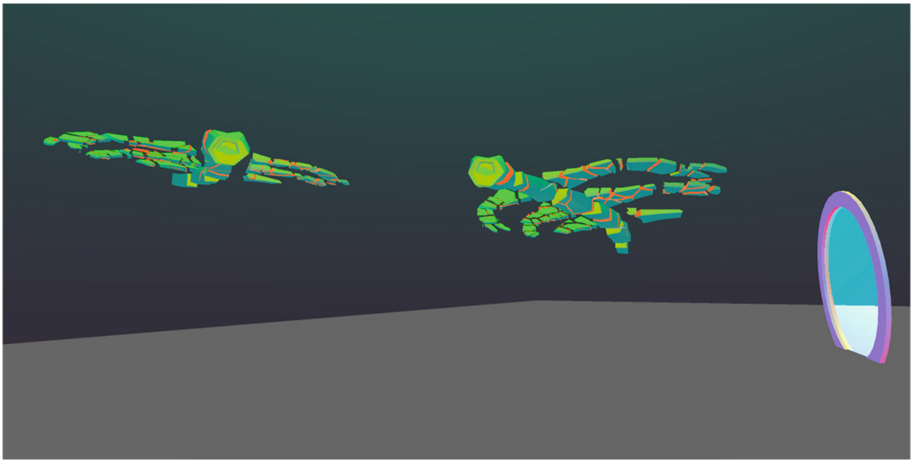

Fig. 3. Creatures reacting to both the player's gaze and the player's position in the world.

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