Evaluating Scaffolding in Serious Games with Children

By

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ABSTRACT

In scaffolding, full support (guidance) is given to the learner to support weakness and withdrawn bit by bit as learner knowledge fortifies (fading) (Martens & Maciuszek, 2013). According to Puntambekar & Hubscher (2005), the attributes of scaffolding include diagnosis, calibration and fading. Research work on scaffolding in serious games – games with other purposes other than entertainment, has mainly focused on diagnosis and calibration often referred to in this field as player modelling and adaptivity respectively. There is barely any empirical study investigating fading this in these games. Instead of fading which is the gradual removal of scaffolding, an all-or-nothing approach is often used. The all-or-nothing could lead to cognitive overload in children. For children to have a pleasurable gameplay, it is important the cognitive load is managed effectively. The fundamental question asked in this thesis is "To what extent can scaffolding-fading improve children's gameplay experience and knowledge gain?" This is broken down to four research questions – 1. Does the gradual removal of guidance improve children's gameplay experience? 2. What dimensions of gameplay experience are impacted and to what extent are they impacted by the gradual removal of guidance? 3. Would guidance fading during gameplay improve knowledge gain? 4. What effect would inappropriate guidance-fading have on gameplay?

A game in which the scaffolding can be manipulated is designed for this study. A comparative study methodology with a controlled experiment, comparing gameplay in both the gradual removal and the all-or-nothing mode, is employed with the aim of measuring gameplay experience and knowledge gain in these modes. Analytics was also employed to capture performance-related gameplay metrics. These methods were combined for a more substantial explanation of findings.

The key contributions made include – 1. Appropriately implementing guidance-fading for the first time in a game AND highlighting the relevance of this scaffolding mode to serious gameplay

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Above all, I am grateful to the Almighty God for giving me the spirit and wisdom to shine through.

DEDICATION

This work is dedicated to my parents Mr and Mrs J.N Obikwelu for their unwavering support and love

CHAPTER 1

THESIS OVERVIEW

1.1 Background

The use of games in education started with edutainment which according to Van Eck (2006) failed to harness the power of games for learning (and has been described as an offspring that inherited the worst characteristics of both parents in this case, boring games and 'drill-and-kill' learning (Papert, 1998). Edutainment evolved to serious games which are described as 'games for purposes other than entertainment' (Tarja, Johanesson, & Backlund, 2007).

> "We are concerned with serious games in the sense that these games have an explicit and carefully thought out purpose and are not intended to be played primarily for amusement"
>
> (Abt, 1970)

Serious games use instructional and video game elements for non-entertainment purposes (Charsky, 2010). They do more than add window-dressing or fun to an otherwise serious (and potentially dull) learning task (Quinn & Neal, 2008). Several definitions of serious game exist, some of which include the definition by Michael and Chen (2006, p.21) "serious games are games that do not have entertainment, enjoyment, or fun as their primary purpose" also PIXELearning (n.d, p.1) define serious games as "the use of computer game and simulation approaches and/or technologies for primarily non-entertainment purposes". Corti (2006) is more elaborate. He describes serious games as Game-Based Learning (GBL) which he emphatically states is all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as to develop new knowledge and skills.

To date, studies on serious games and children have focused on flow and pedagogical principles which include constructivism, experiential learning theory, discovery learning theory and cognitive apprenticeship.

1.1.1 Flow and Constructivism

The majority of studies on serious games and children centre on psychology and pedagogy (Örtqvist & Liljedahl, 2010) focusing on flow and constructivism respectively. Flow is a major dimension of game-play experience. Other dimensions of gameplay experience according to Wijnand Ijsselsteijn et al. (2008), include immersion, challenge, competence, tension, positive affect and negative affect.

Replicas of the chart shown in figure 1 frequently accompany discussions of learning in the context of games (J. M. Thomas & Michael, 2010). The Csikszentmihalyi (1990) theory of flow demonstrates that in order for flow state to be achieved, the level of challenge must match the player’s abilities as his or her skills increase. If the challenge is too great, the player will become frustrated and may give up; If the challenge is too little, the player will quickly become bored and may quit playing (J. M. Thomas & Michael, 2010). Flow has been used by designers, teachers, and coaches in such wide-ranging fields as sports, tutoring, and increasingly video game design.

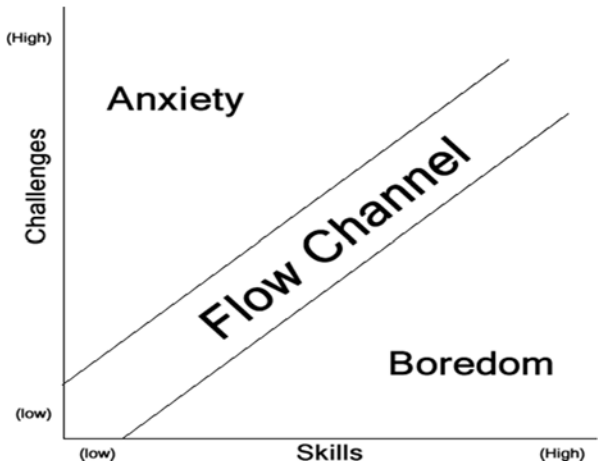

Figure 1 A diagram showing the flow channel - the channel of optimal experience (Csikszentmihalyi, 1990)

With regards to cognition, constructivism is widely discussed - attention is drawn to the need for social interaction in the learning process, promoted by Vygotsky. This according to Driscoll (as cited in Robinson, Molenda, & Rezabek, 2008, p.33) is based on the assumption "that knowledge is constructed by learners as they attempt to make sense of their experiences". Driscoll highlighted these essential constructivist elements: learning in relevant environments, social negotiation opportunities (collaboration), the need for multiple perspectives/representations, encouragement of ownership of learning and self-awareness (reflection) (Driscoll, as cited in Amarin & Ghishan, 2013).

The basic tenets of constructivism are often implemented in the design of serious games. The basic tenets of constructivism include an individual representation of knowledge; active learning through exploration; and learning through social interaction or collaboration addressed in turns in relation to serious games. In contrast to behaviourism, which views learners as active recipients of information, in constructivism, the learner is an active processor of information. The constructivist view of learning is being embraced by the video game world. We are currently witnessing a dwindling interest in drill and practice games and an overwhelming acceptance of serious games consistent with the constructivist view of learning.

Flow has often been associated with Zone of Proximal Development (ZPD) which is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978). – “Readers, familiar with learning theory, may recognize the similarity between the ‘optimal game play corridor’ and Vygotsky’s ZPD” (Thomas & Michael, 2010, p.329). Kiili (2005) added ZPD to the flow model with the claim that the optimal game-play corridor (flow channel) can be extended by providing some guidance to the player or by providing the possibility of solving problems with the help of other players.

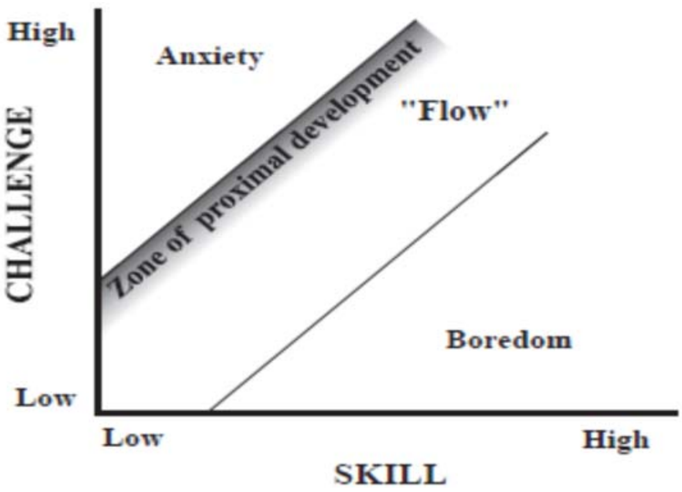

Figure 2 ZPD added to the flow channel (Kiili, 2005)

1.1.2 Experiential Learning

“Egenfeldt-Nielsen (2005) applied experiential learning theory to develop a serious game called ‘Global Conflicts: Palestine’ to educate players about Palestinians’ and Israelis’ conflict. Experiential learning, which is simply defined as using learner experiences to facilitate learning, has been a common ground for both traditional educators as well as designers attempting to integrate game-based learning with education” (Appelman, 2005; Crawford, 1984; Gee, 2003; Prensky, 2001; Salen & Zimmerman, 2004 cited in Kebritchi & Hirumi, 2008, p.1734).

1.1.3 Discovery Learning Theory

"Discovery learning is an approach to instruction in which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments" (Ormrod, 1995, p.442). The idea is that students are more likely to remember concepts that they discover on their own (Kebritchi & Hirumi, 2008). The discovery learning approach has been used to design 'The Monkey Wrench Conspiracy' (M.Prensky, personal communication, June 12, 2006 cited in Kebritchi & Hirumi, 2008), a role playing simulation game. "The objective of 'The Monkey Wrench Conspiracy' is to teach industrial engineers how to use new 3-D design software. The players assume the role of secret agents dispatched to space to rescue the Copernicus station from Alien hijackers. To succeed in the game, the players need to design everything for their missions, starting from designing their gun triggers to their spacewalks, bad-guys and traps" (Kebritchi & Hirumi, 2008, p.1735). "The game models problem solving in a way that involves users multiple senses. The game provides constant feedback and hands-on practice. In addition, the game situates the learners in an environment where they are challenged to complete the tasks to further advance in the game" (Kebritchi & Hirumi, 2008, p.1735).

1.1.4 Cognitive Apprenticeship

"The term 'apprenticeship' used in this approach emphasizes the context-dependent nature of knowledge where learning is promoted through (a) situated modelling tasks, (b) coaching and scaffolding to complete the tasks, and (c) fading support" (Kebritchi & Hirumi, 2008, p.1737). "First, instructors make their tacit knowledge explicit by modelling their strategies to complete a given task. Second, instructors support the learners to complete the tasks and third, they encourage the learners to complete the tasks independently" (Brown et al., 1989 cited in Kebritchi & Hirumi, 2008, p.1737).

"Modelling the authentic activities, coaching and scaffolding, and fading support have been used to design simSchool" (Zibit & Gibson, 2005 cited in Kebritchi & Hirumi, 2008 p.1737). "simSchool is a simulation game that prepares educators for teaching by enhancing their classroom management skills and ability to adapt instruction to learners with different cognitive abilities" (Kebritchi & Hirumi, 2008)

1.2 Scaffolding Problem-Solving in Serious Games

Problem-solving is initiated with the generation of a problem. The generated problem is usually a challenging real world one. In classroom settings, problems are usually generated in a verbal or written format. Digital games offer an alternative which is more engaging than the verbal and written formats. This representation is closer to the real world problem scenario. Unlike real world scenarios where mistakes can be costly, in the microworld, mistakes can be made without real consequences. For example Peace Maker, a game inspired by real events in the Israeli-Palestine conflict allow the player to assume the role of either the Israeli prime minister or the Palestinian president – thus he is required to make decisions. These decisions could lead to disaster. But because it's a microworld it is safe and the player can try again and he is allowed to take a different action. Real world scenarios don't offer these chances. In games, the overall problem is often broken into mini-tasks and assembled in increasing order of complexity.

1.2.1 The Scaffolding Mechanism

In learning to play games and in learning new concepts, children typically require more support/guidance than adults – this may be in the form of explanatory feedback or corrective feedback (Moreno, 2004). A scaffold is by definition, a temporary entity that is used to reach one's potential which is then removed when learners demonstrate their learning (Lajoie, 2005). Scaffolding is the guidance required in bridging the gap between what a child knows and what he is supposed to know. As the child demonstrates learning (higher level of achievement), the guidance is reduced.

1.3 Research Motivation

In scaffolding, full support (guidance) is given to the learner to support weakness and it is withdrawn bit by bit (fading) as learner knowledge fortifies. Research involving children has often emphasized that children's working memory capacity could easily be overloaded. Kirschner & Sweller (2006) emphasize the importance of providing novices in an area with extensive guidance because they do not have sufficient knowledge in long-term memory to prevent unproductive problem-solving search, that guidance can be relaxed only with increased expertise as knowledge in long-term memory can take over from external guidance (Kirschner & Sweller, 2006). However Kalyuga et al (1998) and Yeung et al (1998) proposed that, for experienced learners, eliminating redundant material is advantageous because it reduces the cognitive load associated with processing redundant information in working memory (WM) (Kalyuga, Ayres, Chandler, & Sweller, 2003). It has also been proposed in relation to the novice learner that learning in children with low WM capacity is hindered by frequent WM overload in learning activities (Gathercole & Alloway, 2008 cited in Holmes, Gathercole, & Dunning, 2009, p.1). These studies emphasize the importance of scaffold fading to novice learners. There is thus need for a correct and complete application of scaffold fading in serious games which are the essence of this study. Other attributes of scaffolding include diagnosis and calibration. These have been the focus of game-play scaffolding-related research work. They have been referred to as player modelling (diagnosis) and adaptivity (caliberation) respectively. There has currently been a lot of research on scaffolding game-play and barely any empirical studies investigating scaffolding-fading in serious games. To be more explicit Stone in (Lee & Songer, 2004, p.12) stated that there are no clear guidelines for fading in existing literatures and hence a need for greater specification in this regard. In addition, Sweller (2008) summed up the effectiveness of fading in his proposed guidance-fading effect, emphasizing its potential to enhance the effectiveness of learning technologies in general. Very little is known about the implementation of fading in serious games and its effect on player cognition and game-play experience.

In serious games, fading can be within scenario (micro-level) or across scenarios (macro-level). Again, there is currently a lack of clarity on what effective micro-level fading entails in relation to serious games. Previous research has shown that the main challenges include identifying a scaffolding element that could be faded and figuring out when and how to fade it.

1.4 Definitions and Scope

1.4.1 Gameplay Experience

The amount of pleasure or displeasure derived from gameplay determines the quality of the gameplay experience. There are various dimensions of game-play experience. The dimensions as specified in (Wijnand Ijsselsteijn et al., 2008), (Poels, de Kort, & Ijsselsteijn, 2012) are immersion, flow, competence, challenge, tension, positive and negative affects. Of these dimensions, flow is prominent in serious game literatures.

1.4.2 Cognition: Reflective Learning

Game-play experience can be turned into learning through reflection. This is referred to as reflective learning. Reflection according to Boud, Keogh, & Walker, (1985) "is an important human activity in which people recapture their experience, think about it, mull over and evaluate it. It is this working with experience that is important in learning" (p.43). 'We learn through critical reflection by putting ourselves into the experience and exploring personal and theoretical knowledge to understand it and view it in different ways' (Tate & Sills, 2004, p.126). Reflective learning emphasizes learning through investigation and observation.

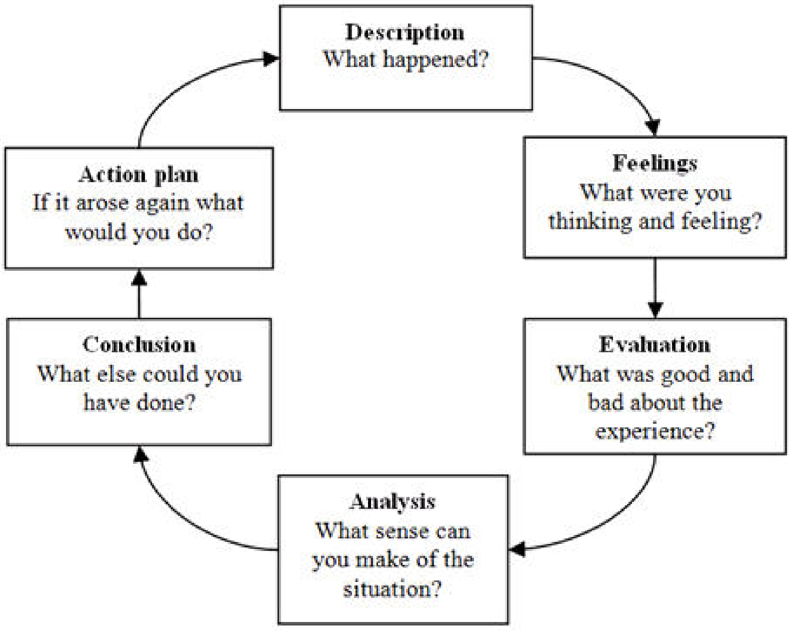

Figure 3 Gibbs' reflective cycle

During reflective learning, learners are able to understand their strengths and weaknesses in addition to identifying underlying values, deficiencies and areas for improvement (Henderson, Napan, & Monteiro, 2004). Park & Son, (2011) , emphasized that "Reflective learning aims to reinforce deep learning and practice, not to focus on reflection itself" (Park & Son, 2011). Gibbs' reflective cycle as shown in figure 3, summarizes reflective learning (Gibbs, 1988).

1.4.3 Scaffolding

The Zone of Proximal Development (ZPD) is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under guidance (Vygotsky, 1978, p.86). According to Wells (1999), scaffolding is a way of operationalizing this notion of working in the zone. Scaffolding is described as the process of bridging the gap between an individual's present level of knowledge and his/her potential level of knowledge(Lipscomb, Swanson, & West, 2004). As the individual approaches his/her potential level of knowledge the scaffolding is gradually removed – a process called fading. "The cognitive constructivism of Piaget views learners as active constructors of their world view and discoverers of knowledge, on the other hand Vygotsky's social constructivism which is built on

Piaget's ideas of active learners focuses on social interaction in learning and development" (Shabani, Khatib, & Ebadi, 2010, p.241). Suffice it to say, scaffolding is often described in relation to flow, constructivism and ZPD

Molenaar & Roda (2008) argue that "scaffolds are often implemented in a too static and generic manner and attention-related, fine-grained aspects of timeliness and fitness are normally disregarded" (p.1). There is need for an evolving support during gameplay thus the calibration and fading aspects of scaffolding should be implemented. "Several studies have provided evidence that students learning about complex topics in computer-based learning environments experience various types of difficulties in the absence of scaffolding. These studies show the students' poor ability to regulate their learning and their failure to gain a conceptual understanding of the topics" Azevedo & Hadwin cited in (Molenaar & Roda, 2008, p.2). Scaffolding entails diagnosis, calibration and fading (Puntambekar & Hubscher, 2005). "The ability of the learner must be diagnosed continuously in order to define appropriate scaffolding. This diagnosis supports the careful calibration of the scaffolds and the eventual fading of the support provided" (Molenaar & Roda, 2008, p.2).

According to Barzilai & Blau (2014), "we need a better understanding of the cognitive and affective effects of scaffolding game-based learning in order to successfully design scaffolds which promote learning while maintaining enjoyment and flow" (p.3). The aim of this work is to investigate the effect scaffolding game-play (with emphasis on fading) has on player experience (e.g. immersion and flow) and reflection ("encouragement of ownership of learning and self-awareness" (Amarin & Ghishan, 2013, p.52)). The attribute of scaffolding emphasized in this work is fading – this is investigated on a micro-level (within game scenario – in a single task) not on a macro-level (across game scenarios – across multiple tasks). Fading is one of the three attributes of scaffolding – the others are diagnosis and calibration. It is expected that an appropriate implementation of fading (the gradual removal of scaffolding) and fading rates in serious games would enable a smooth transition from a state of dependency on the game's scaffolding to a state of independency on this scaffolding. Fading can be fine-tuned for different player groups; hence the need to consider the player groups and rate of fading. Furthermore, this work is centred on single-scenario scaffolding – micro-scaffolding.

An effective scaffolding mechanism is expected to engage children in the game's problem-solving activity, hence helping them gain problem-solving skills and a positive attitude toward learning.

1.5 Micro, Macro and Meso – Scaffolding

During game-play the player is required to complete various tasks. These tasks are often presented to the player in order of increasing complexity. While there is scaffolding across these tasks, there is also scaffolding within a task. Scaffolding across tasks could either be macro or meso scaffolding. Macro-scaffolding relates to the order in which the content to be learned is presented (Boblett, 2012). This Engin (2014) referred to as sequencing of tasks. However meso scaffolding entails appropriately structuring the tasks and activities in such a way that these activities and tasks are "gradually made more complex" (Boblett, 2012, p.10). The scaffolding within a task is referred to as micro-scaffolding. Scaffolding within tasks is a moment-by-moment guidance during gameplay. It operates at the level of interaction through prompts, questions, cues etc. (Engin, 2014). Attentional cues are an example of micro-scaffolding. In games, "Attentional cues are a way of guiding the attention of the player to the relevant material, or away from the irrelevant material, by means of subtle sensory stimuli" (van der Spek, Oostendorp, Wouters, & Aarnoudse, 2010, p.1). These could be visual or auditory. Scaffolding elements such as pointers and colours have been used as visual attentional cues.

In summary while macro and meso scaffolding relate to the presentation of tasks and incremental difficulty respectively (task focused), micro scaffolding emphasize the player-interactions during gameplay (player focused).

1.6 Scope and Research Questions

This research emphasizes the need for an effective scaffolding mechanism for children's game-play. It has been established that children possess a relatively small working memory capacity and thus require extensive scaffolding in problem-solving scenarios – this entails an appropriate fading mode. Scaffolding (diagnosis, calibration and fading) is effective when it engages the player, triggers reflection and yields knowledge.

1.6.1 The fundamental question to this research is:

To what extent does scaffold-fading improve children's game-play experience and knowledge gain?

In order to design effective scaffolding for serious games, there is need for a better understanding of its cognitive and affective effects, thus the fundamental question was broken down into four research questions:

RQ1: In comparison to the all-or-nothing (switch) guidance-fading approach, does gradual removal of guidance (in micro-scaffolding) improve children's gameplay experience?

RQ2: What dimensions of gameplay experience are impacted and to what extent are they impacted by the gradual removal of guidance (in micro-scaffolding) during gameplay?

RQ3: Would guidance-fading (gradual removal of scaffolding) during gameplay improve knowledge gain?

RQ4: What effect would inappropriate guidance-fading have on game-play?

Together, these questions aim at answering the primary question, by designing scaffolding (guidance) for pleasurable gameplay experience (Question 1) by impacting gameplay experience dimensions (Question 2) for knowledge acquisition and progression (Question 3), in addition to identifying inappropriate guidance-fading and its impact on game-play (Question 4). These questions highlight specific aspect of the research. The subsequent section highlights the research method applied in tackling each aspect.

1.7 Contribution to Knowledge

There is a major contribution to knowledge in two areas. Firstly, there is the introduction of a 'gradual removal of scaffolding' (in micro-scaffolding) approach to scaffolding in serious game – this would be the first time scaffold-fading is implemented in serious game. Secondly the efficacy of the gradual removal of scaffolding was established in relation to gameplay experience.

Other contributions include an analytics approach to measuring the effect of different modes of scaffolding on gameplay.

This thesis is scoped towards instructional design and thus could be useful to instructional designers, it is particularly targeted at teachers and schools where young children are encouraged to learn through game-play.

1.8 Research activities

According to L. Nacke, Schild, & Niesenhaus (2010) “you play games for the experience itself, thus you have creative freedom in designing the experience itself, while in software tools you are trying to design a pleasant way of achieving a goal efficiently” (p.4).

This study uses the quantitative method of data collection and analysis in the investigation of the research questions. For the collection of data, a subjective approach is employed – measuring the children’s self-reported experiences. Self-report measures for this study include the concise version - in-game Game Experience Questionnaire (iGEQ) (W. Ijsselsteijn, Poels, & de Kort, 2008). Game analytics are also employed in the investigation of the research question

Scaffolding could be considered an element of serious games that sustains a player’s cognitive and experiential involvement in gameplay. Scaffolding is expected to assist the player in his/her transition from a state of scaffolding dependence to a state of scaffolding independence. Thus this research is focused on designing an effective micro - scaffolding approach in serious games – one that is able to keep the player cognitively involved during game-play. Using the subjective approach described here, this new approach is compared with existing approach to ascertain its level of effectiveness.

1.9 The Application

The all-or-nothing and ‘gradual removal’ approaches to scaffolding could be linked to worked example and guidance-fading effect respectively. The former is supposedly the status quo in serious games. According to Sweller (2008), worked example effect should enhance learning because extraneous cognitive load (this increases as a result of the complexity created by poor instructional design. It is considered detrimental to the learner) should be minimized due to the potential to limit the load on a limited-capacity working memory. This according to the Sweller (2008) has been backed empirically by researchers in the 1980s and 1990s. Sweller (2008) also believes there is no reason why this effect should not apply to technology-based instructions. A comparison study by Pedersen & Min (2001), comparing a cognitive modelling version, a didactic version and a help version of the Alien Rescue game might have proven this effect in technology-based instructions – results from the study suggest that the cognitive modelling version of the support is the most effective of the three. Assuming the cognitive modelling version represents the worked-out example version.

For the ‘gradual removal’ the emphasis is on the transition from worked examples to partial solutions before the final problem. In contrast, the ‘all-or-nothing’ is a switch from worked example to final problem. With the ‘gradual removal’ comes the guidance-fading effect. According to Sweller (2008), “this sequence is predicated on the assumption that what constitutes an extraneous cognitive load depends not just on the nature of the instruction, but on an interaction between the instructional procedures and learner characteristics in the form of levels of expertise”(p.378). He stated that this can be applied to technology by initially showing the learner “what exactly they need to do with minimal action required on their part. With increases in expertise, determined by rapid assessment techniques, learner activity should be increased and guidance decreased. Ultimately, it should be possible to remove all guidance with the learner simply practicing the skill” (Sweller, 2008, p.378).

Interestingly, Rowe, Lobene, Mott, & Lester (2013) considered applying ‘gradual removal’ to their game-based learning environment. The game ‘Crystal Island’ – an open-ended Narrative-Centered Learning Environment, required that students complete associated concept matrices (basically graphic organizers) with relevant information extracted from information texts encountered, in order to diagnose and treat a seriously ill patient in the game (Rowe et al., 2013). The ‘gradual removal’ approach considered by the authors entailed gradually making the concept matrices less structured. Thus the initial structured concept matrices with multiple choice, columns and rows became the worked example; the partial solutions would include the less structured concept matrices without the multiple choice response menu, then the lesser structured concept matrices without headers for the columns and rows – giving the learner a chance to name his columns and rows, then finally it would get to the point where the columns and rows are removed leaving the learner to specify the number of columns and rows they would require. It is envisaged that this would be problematic and overly challenging to implement as according to the authors “automated assessment and feedback would raise interesting computational challenges” (Rowe et al., 2013, p.72) .

1.10 Thesis Structure

There are eight chapters in this thesis. This section contains a brief description of each chapter and describes how each fit into the research project.

Chapter 2 contains a Review of literature on scaffolding in serious games and the underlying pedagogical principles, drawing on work in the fields of ‘child development and learning’, “constructivism and scaffolding’ and scaffolding game-based learning. This chapter is a background to the thesis, setting the scene for this work.

Chapter 3 contains a description of the designed serious game scenario and the scaffolding structure it embodies with emphasis on the fading approach being implemented. The feedback types present in the game are highlighted with emphasis on how they could be **gradually** rather than abruptly removed (appropriately faded) to make the game task more manageable and achievable for novice learners particularly children.

Chapter 4 covers the research methodology. The methodological approaches applied are explained, explored and justified. The hypotheses to be tested together with the research questions are highlighted. There is also a general overview of what the research entails including the analytical procedure for data collection.

Chapter 5 highlights the various ways the quality of gameplay experience could be measured. Every method has its limitation – this is discussed in this section. A method is chosen for the player experience measure and reason for our choice specified.

Chapter 6 describes the first comparative study carried out. This chapter describes the controlled experiment that was undertaken with children. The study aimed at ascertaining the effect of a gradual removal of scaffolding on gameplay experience and knowledge gain. The effect of a gradual removal of scaffolding on various gameplay experience dimensions is compared to the effect of an abrupt removal (all-or-nothing) of scaffolding on the same dimensions of gameplay experience. The effect of these approaches to scaffolding on knowledge gain is also deduced.

Chapter 7 highlights the statistical tests and the results. From the study reported in chapter 6.

Chapter 8 describes the second comparative study. This chapter describes the telemetry data collection of relevant player trace data. The study aimed at comparing player behaviours resulting from playing in the different scaffolding modes. The effect of the scaffolding modes on player behaviour is analysed with the aim of substantiating the findings from the controlled experiment.

Chapter 9 is a conclusion to the thesis. It contains a summary of the discussions in the previous chapters. The findings from the comparative studies are also discussed in this section. The limitations of the research methodology employed in this work are highlighted here. Also highlighted in this section are the contributions to knowledge arising from this work. The future directions for this research are also considered in this section.

CHAPTER 2

SCAFFOLDING TRENDS IN SERIOUS GAMES

2.1 Introduction

Scaffolding in games has invariably been described as learning support, thus very little emphasis is placed on its fading attribute. For a better understanding of what game designers know about scaffolding and what they still need to know, there is a need to delve into the literature with the aim of unpicking various viewpoints. From literature, various forms of scaffolding are identified and one is able to see scaffolding from the lens of various researchers in this field. The studies that have been carried out, give an insight into forms of scaffolding that have been investigated; how they have been investigated and the findings. With the literature reviewed, the need to examine the fading attribute of scaffolding arises.

2.1.1 Objective

This chapter describes scaffolding in serious games by analysing various games and researches that have previously been carried out in relation to scaffolding in and with games, with the aim of identifying the research approaches used in previous researches and the aspect of scaffolding that has not been researched.

2.1.2 Scope

In addition to the fact that scaffolding have attributes – diagnosis, calibration and fading, there are various techniques/types/forms of scaffolding. These techniques/types/forms of scaffolding are often a combination of scaffolding elements, described here in relation to 'scaffolding building blocks'. In this chapter various games are analysed with the aim of unpicking the various scaffolding elements. In addition, the manner in which these elements are embedded in games give rise to the various game scaffolding techniques. In addition to unpicking and categorizing the elements of scaffolding, a conceptual model of the scaffolding mechanism in games (based on literatures) is proposed. Furthermore, there is also a conceptual model of the learning process often associated with scaffolded game-based learning. This chapter also highlights scaffolding studies and emphasizes the lack of research investigating the fading attribute of scaffolding in games.

2.1.3 Structure

This chapter begins in section 2.2 by investigating the various scaffolding techniques that have been used in serious games with the aim of revealing and categorizing the scaffolding elements into 'scaffolding building-blocks' – 'exposition, coaching, collaboration, debriefing and reflection'. Section 2.3 describes a generic combination of the elements of scaffolding based on literature, leading to the elucidation of a conceptual model of the scaffolding mechanism in games. Section 2.4 describes the learning environment for serious gameplay with emphasis on constructivism. Section 2.5 describes the approach other researchers have used in the evaluation of scaffolding in serious games with children. In addition to the evaluation approach, the form of scaffolding evaluated and the findings are highlighted. In Section 2.6 the gap in research is identified and insights into steps that could be taken towards the implementation of fading provided.

2.2 The building blocks of pedagogical scaffolding in Serious Games

According to Zyda (2005), a video game is “a mental contest, played with a computer according to certain rules for amusement, recreation, or winning a stake” (p.25). This mental contest is often scaffolded. The scaffolding building blocks of serious games include ‘the type of instructional interventions present in the game. The intervention types that have been associated with games according to Gugerty & Arnold, (1994) have been categorized into the following – ‘*exposition, coaching, asking and answering questions’*. Other categories include *collaboration, debriefing and reflection*. The category and type of intervention used at any particular time is often dependent on an assessment of the player-learner’s progress, motivation or learning style (Gugerty & Arnold, 1994). Miller, Lehman, & Koedinger, (1999)stated that “the learning outcomes achieved through microworld interaction depends largely on the surrounding instructional activities that structure the way students use and interact with microworlds (p.306).

The table 1 below, the serious games that have been investigated in relation to Exposition/Cueing, Coaching, Collaboration, Debriefing and Reflection breaks are described

Serious Games	**Brief Game Description**
Quest Atlantis	“The core of QA is the narrative about Atlantis, a world in trouble in the hands of misguided leaders” (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005p.161). In QA “children contribute information and ideas to the activists of Atlantis based on their real-world experience” (Barab et al., 2005, p.161).
Civilization IV	This is a turn-based strategy simulation in which players attempt to “lead a civilization from 4000 B.C to 2050 A.D, winning through a combination of military, political, cultural, or scientific quests” Squire cited in (Barrow, n.d.)

BiLAT	BiLAT is virtual game environment that runs on a single computer (Kim et al., 2009). It "is designed to allow students practice conducting meetings and negotiations in a cross-cultural context". (Kim et al., 2009, p.292)
Foodforce	In Foodforce, "children are asked to place themselves virtually in a rural area where they build their homes, invest resources, time and energy for their day-to-day living" (Singh & Gupta, 2010, p.5) and crisis management.
Prime Climb	"In Prime-Climb students in 6th and 7th grade practice number factorization by pairing up to climb a series of mountains. Each mountain is divided into numbered sectors, and players must try to move to numbers that do not share common factors with their partner's number, otherwise they fall" (Manske & Conati, 2005, p.1)
Cyberciege	"Cyberciege is a video game designed to confront students with computer security decision points within an environment that encourages experimentation, failure and reflection" (Thompson & Irvine, 2011, P.1)
KM QUEST	In KM QUEST players work together as a team of knowledge managers assigned with the task of improving the efficacy of a fictitious company's knowledge household. Players play their role for three consecutive years in the life span of the company (Leemkuil, de Jong, de Hoog, & Christoph, 2003)
Sim City	In simcity, the player manipulates power, water, taxes, pollution, education, unemployment etc. and observes the effect of his/her action. The effect can be compared with other sims (Arts, n.d.)

Tactical Learning and Culture Training System (TLCTS)	"TLCTS is designed to help learners quickly acquire basic communication skills in foreign languages and cultures. Learners acquire knowledge of foreign language and culture through a combination of serious lessons and serious games that give trainees concrete contexts in which to develop and apply their skills" (Johnson, 2010, p.175). In TCLTS "there are simulated conversations with non-player characters, and continual feedback on learner performance within a game scenario context" (Johnson, 2010, p.175)

Table 1 A description of some serious games

2.2.1 Exposition/ Cueing

"Cueing is a general method of giving advice, usually as text or speech, without being "personalized"" (Alessi & Trollip, 2000). Gugerty & Arnold (1994) referred to it as exposition. They categorized explanations, examples of concepts and modelling of procedures under exposition (Gugerty & Arnold, 1994).

In BiLAT a game designed to allow students practice conducting meetings and negotiations in cross-cultural context (Kim et al., 2009), the negotiation behaviour is modelled using PsychSim (a social simulation tool) (Kim et al., 2009).Psychism according Kim et al. (2009) to generates the behaviour of the entities and provides explanations of the result in terms of each entity's goals and beliefs – this I have categorized as the exposition aspect in the BiLAT game.

Theming is a cueing approach used in QA. The various virtual worlds the students are expected to be visiting in QA have themes. Students read about and listen to these themes (Barab et al., 2005).

Furthermore there is the data visualization approach to cueing extensively used in Simcity. The player can easily access the description of various game-play elements.

There is also KMQUEST which has a starting point that describes a fictitious company Coltec – this contains general information about the company e.g. history, products, market, and the structure of the organization (Leemkuil et al., 2003). There is also a simplified organization chart that gives access to this static information about Coltec. Also included in the game are books that give access to additional information, the indicators in the business model, and interventions that can be implemented (Leemkuil et al., 2003).

Another game Cyberciege has an online help facility in the form of an encyclopaedia for cueing. This includes a description of security concepts from the game perspective; the encyclopaedia also includes a dozen animated tutorial videos that cover security topics (Thompson & Irvine, 2011). Furthermore, there is a student lab manual that describes the concepts covered by the scenario and instructions to guide the student through the scenario (Thompson & Irvine, 2011).There are an introductory scenario walkthrough for students. This is expected to expose the students to the game mechanics (Thompson & Irvine, 2011). Also in this game are scenarios that are separately provided to instructors. These scenarios have instructor notes – an instructor cueing system. There are also "extensive pop-up help that guides students to the proper game screens and interfaces to configure policies, train users and adjust physical security" (Thompson & Irvine, 2011, p.4).

TCLTS has a skill builder where there is a web wizard providing reference materials, including glossaries and explanations of the grammatical structure of the phrases used in the lesson material (Johnson, 2007).

Also for cueing, prime climb uses a magnifying glass that allows the players to view the factorization for any number (primeclimb) (Manske & Conati, 2005).

2.2.2 Coaching

"A coach is an advisor who appears when the learner either asks for help or the program detects events signifying the learner is having difficulty" (Alessi & Trollip, 2000). "A coach can give advice about the use of learning strategy tools such as electronic notebooks, cognitive mapping, taking multiple viewpoints, visualizations etc."(Alessi & Trollip, 2000). The coach enables the player-learner make progress within a scenario or across scenarios in a game. Coaching includes hints and explanation during problem solving (Gugerty & Arnold, 1994). According to Hjert-Bernardi (2012), the hint technique are implemented in many digital game-based learning tools for the purpose of scaffolding the player-learner's game-play experience. Coaching within a scenario is often referred to as microadaptivity while coaching across scenarios is referred to as macroadaptivity. The concept of microadaptivity has been centred on presenting adaptive hints to the learner depending on the progress he/she is making in a particular game-based learning scenario (Albert, Hockemeyer, Kickmeier-Rust, Peirce, & Conlan, 2007) – this is basically a combination of diagnosis and calibration within scenario. It has now been generalized to adaptive interventions (within a scenario) which could either be dependent on the learner's skill state or not (Albert et al., 2007). Albert et al., (2007) have categorized these adaptive interventions into Skill activation adaptive intervention; Skill acquisition adaptive intervention; Motivational adaptive interventions; Assessment clarification adaptive interventions. They described the skill activation adaptive intervention as those applied when the player-learner gets stuck and is required to use a skill he/she is expected to possess (Albert et al., 2007). The skill acquisition adaptive intervention is applied as a pointer to the skill the player-learner is expected to acquire to enable him/her progress (Albert et al., 2007). The motivational adaptive intervention is applied to encourage the player-learner to continue gameplay (Albert et al., 2007). Unlike microadaptivity, macro-adaptivity refers to "adaptations of the next game scenario to be played (based on the learner's performance in the previous one), i.e. macro-adaptive principles are applied between two consecutive game scenarios" (Bedek, Seitlinger, Kopeinin, & Dietrich, 2012, p.174). The Cyberciege game employ both microadaptivity and macroadaptivity within and across scenarios respectively. Feedbacks and in-game explanation are provided to help the student across the scenarios (Thompson & Irvine, 2011) – macroadaptivity. In KMQUEST microadaptivity is implemented where the players are given immediate feedback on their behaviour (Leemkuil et al., 2003). In addition the players are given process worksheets and presented with prompts and hints about what to do and how to do it (Leemkuil et al., 2003)

Four categories of coach messages are highlighted in (Kim et al., 2009)

- Hints: forward-looking suggestions on what action might be appropriate next

- Warnings: forward-looking suggestions to avoid a certain action or class of actions
- Negative feedback: is backward referring, describing a problem with the player's last action
- Positive feedback: is backward referring and praises the student's last action

In prime-climb there is a pedagogical agent that provides individualized support, both on demand and unsolicited. In foodforce, chats are used. They are mainly used to teach children how to respect their elders, to care for the poor etc. (Singh & Gupta, 2010).

The TCLTS uses hints to guide the player-learner through the dialog in active dialogs (part of Skill Builder). These hints are absent in the Mission Game but can appear if the player-learner request it.

Coaching is often based on the cognitive apprenticeship model-scaffold-fade algorithm (Kim et al., 2009). "Here the coach provides forward-looking guidance and feedback very frequently at first (the modelling and scaffolding) then pulls the support away gradually over time" (Kim et al., 2009).

2.2.3 Collaboration

"Collaborative learning, in which learners work together on joint projects with common goals, facilitates all the purposes of learning strategies: metacognition, searching and navigation, orientation, encoding, recall, comprehension, and application" (Alessi & Trollip, 2000). Learners act as each other's coach during collaboration (Alessi & Trollip, 2000). During collaboration, the player-learners are motivated and often actively involved in the game-play process. This is evident in the multi-player games. "The learning potential in multiplayer games is currently attracting a growing academic attention" (Magnussen & Misfeldt, 2004, p.2). "Learning needs to be collaborative; studies have shown that most children learn faster in groups rather than in an isolated environment" (Singh & Gupta, 2010, p.4). "Multiplayer games enable players to communicate and collaborate in joint game sessions" (Manninen, 2003, para.5). "The level of communication supported in these games varies greatly" (Manninen, 2003, para.5). "Most of them support textual chatting, some of them enable communicative gestures, while others concentrate on interaction forms that are highly action-specific and goal oriented" (Manninen, 2003, para.5). Unlike co-operative learning, there is always a common goal in collaborative learning. For instance in Prime Climb, "students in 6th and 7th grade practice number factorization by pairing up to climb a series of mountains. Each mountain is divided into numbered sectors, and players must try to move to numbers that do not share common factors with their partner's number, otherwise they fall (Manske & Conati, 2005, p.2). This encourages collaboration, as the pair have a common goal – both fail when one fails and succeeds when both succeeds.

There's also collaboration in Foodforce which is a multiplayer game where "children are asked to place themselves virtually in a rural area, where they build their homes, invest resources, time and energy for their day-to-day living and crisis management" (Singh & Gupta, 2010, p.5). In foodforce "children participate in a collaborative environment to enhance their team working skills, and therby improve their leadership qualities. They are able to learn from wise decisions made by their peers and are also warned about the wrong decisions taken by them" (Singh & Gupta, 2010, p.4).

Collaboration during game-play could include helping a fellow player-learner navigate the virtual environment. In addition there is also collaborative work on tasks embodied in the game. Quest Atlantis (QA) - a 3D multi-user virtual environment (MUVE) used to frame educational activities called Quests which are nested to form unit plans, involves a globally distributed community of participants in various learning quests (Barab et al., 2005). QA uses a MUVE to immerse children under the age of thirteen in the educational tasks it embodies. "The students, called Questers, visit virtual worlds, perform educational activities, text-chat with other students and teachers, and develop virtual identities"(Gerstein, 2009, p.4). "QA has a real time chat board and email capabilities"(Gerstein, 2009, p.12). In addition "By using their avatars, students move through these virtual worlds, meet the avatars of other students, participate in virtual activities, and explore different quests" (Gerstein, 2009, p.4).

In KMQUEST, the players have to reach an agreement on the correctness of the intervention they have chosen to implement – for this purpose there is a voting tool. In addition there is also a chat facility for communication during collaboration. Furthermore there are the process worksheets that can be completed by all the team members - the purpose of these worksheets is to trigger discussion and articulation among the team members (Leemkuil et al., 2003). “The content of the worksheet and the related discussion are saved together and are always available for inspection” (Leemkuil et al., 2003, p.103).

2.2.4 Debriefing and Reflective Breaks

Debriefing is the ‘occasion and activity for the reflection on and sharing of the game experience to turn it into learning’(Crookall, 2010, p.907). He emphasized the importance of ‘debriefing’ in the gaming process. He also pointed out that the learning often comes from the debriefing not from the game itself (Crookall, 2010b). Games have “tools and modules of various kinds that collect data transparently during play. The data can then be processed to provide material for feedback during play, as in-game debriefing, and also made available as part of the end-of-game debriefing” (Crookall, 2010, p.908). According to Loh (2009) in-game debriefing sometimes referred to as After Action Review (AAR) have been used in military training games. This is usually in the form of a visual graphical indicator of the player’s game-play activities with recommendations mapped to various indications. Dewey (1933) emphasized the need for reflection which is often triggered by debriefing by stating that *“we do not learn from experience, we learn from reflecting on experience”* (p.78)

The concept of debriefing has also been referred to as reflective break (Qi, 2013). According to Qi (2013), reflection breaks embodies, generation of questions by the player-learner; replaying/ recalling actions taken during gameplay and self-assessment.

In QA there’s a teacher toolkit through which teachers assign quests to students and receive the completed quests from students. “Interestingly, as part of the back story, students believe that their quest assignments and reflections are being submitted to the Atlantis Council for review” (Gerstein, 2009, p.12). The assigned reviewers evaluate the children’s response and present customizable rewards to them (Gerstein, 2009). The children’s email and chats are also monitored.

Indicators which are a form of self-assessment also trigger debriefing/ reflective breaks. This is the case in serious games such as civilization, foodforce, simcity, TCLTS and KMQUEST. In TCLTS, "as the learner works with the software, the software automatically tracks instances when the learner applies a skill, and uses it as probabilistic evidence of mastery of the skill, akin to knowledge tracing" (Johnson, 2007, p.3). In KMQUEST, the players are able to inspect the status of their business process and knowledge process indicators (Leemkuil et al., 2003). Also KMQUEST also provides historic data about the player's own behaviour in the twelve quarters of the game (Leemkuil et al., 2003) – this often triggers reflection. Furthermore, "after the players have finished the simulation game, a debriefing session will be planned in which they can look back at the three reflection reports they made" (Leemkuil et al., 2003, p.104) – to this regard an external tutor or advisor is appointed to each team.

In BiLAT, a game designed to allow students practice conducting meetings and negotiations in cross-cultural context (Kim et al., 2009), the student's scoreboard is the self-assessment feature. This scoreboard consists of a textual summary; scores by learning object category; and a list of all the actions taken during the meeting (Kim et al., 2009). This is followed by a chronological ordered review of the meeting by a reflective tutor (Kim et al., 2009). "The role of the reflective tutor is to engage learners in an serious review of their meeting, that includes reviewing specific actions, reasons for the character responses and meeting outcome, and ways the learner can sustain or improve performance in the future" (Kim et al., 2009, p.300) – this is the core of debriefing. Also part of the meeting is replayed in a playback window (Kim et al., 2009) to help the player-learner recall the actions they took during gameplay – this will trigger a reflection break. Furthermore in BiLAT, there's the trust-meter which also triggers reflective break. The trust-meter shows the strength of the relationship the player-learner has with the character in the course of the meeting (Kim et al., 2009). BiLAT also has a debriefing/ reflection break triggering preparation phase when the student is expected to obtain background information about the meeting partner in addition to organizing his/her thought using a leader preparation worksheet (Kim et al., 2009) – this I would associate with the 'question generation' aspect of reflective break.

In TCLTS, the Skill Builder is the debriefing enabler, “lessons and exercises in the Skill Builder progressively prepare the learner for employing their communication skills in the free-play mission game” (Johnson, 2007, p.2).

2.3 A description of the scaffolding mechanism (coaching) in serious games

This section was published in the fun and games workshop 2012 (Obikwelu, Read, & Sim, 2012)

In recent times, the notion of scaffolding has been an issue of debate. Originally, scaffolding was described by Bruner (as cited in Puntambekar & Hubscher, 2005) as “interactions between a parent and a child or between a tutor and a student” (p.1). “The adult (parent, tutor) provided just enough support based on the progress made by the child on an ongoing basis” (Puntambekar & Hubscher, 2005, p.1). “Scaffolding is no longer restricted to interactions between individuals - artefacts, resources, and environments themselves are now also being used as scaffolds” (Puntambekar & Hubscher, 2005, p.1). Annetta (2010) stated that “Scaffolds develop learners’ Zone of Proximal Development (ZPD)” (p.110). “Vygotsky defined ZPD as the difference between a child’s actual and potential levels of development (i.e., what a child can do alone and with the assistance of an expert/computer agent)” (Annetta, 2010, p.110). According to Zydney (as cited in Melero, Hernandez-Leo, & Blat, 2011, p.1) regarding “learning process, providing guidance to students has been necessary to enhance their learning experience. In that sense, scaffolding techniques are often needed to help students succeed in their learning and to achieve the expected learning outcomes”

2.3.1. The techniques and elements of scaffolding

The effective application of scaffolding elements in serious games should challenge the children when they are correct, explain their missteps when they are wrong, and provide prompts and supplementary information if children have difficulty following the task (Fisch, 2005).

Melero et al. (2011) stated that the techniques of scaffolding include "Social-guidance and System-guidance scaffolding, depending on whether an individual or a tool is responsible for providing support to students" (p.1); macro-scaffolding when pedagogical methods define activity flow or micro-scaffolding when the support is provided to perform specific activities; and tool-enveloped scaffolding - when a tool is used as part of a scaffolded learning process and tool embedded scaffolding – when the scaffolding is applied within a specific supporting tool" (p.1).

The main scaffolding techniques are Micro-scaffolding and Macro-scaffolding. "Micro-level scaffolding occurs within the broader macro scaffold" (Hammond, 2001, p.62). It occurs during an ongoing interaction (Hammond, 2001), while macro scaffolding is the activity flow resulting from the synchronization of the tasks aimed at the learning objective. "Macro-level scaffolding is related to larger issues such as program goals and the selection and sequencing of tasks" (Hammond, 2001, p.18). The scaffolding mode associated with these techniques include formative feedback and hints (for micro-scaffolding) and summary feedback and debriefing (for macro-scaffolding). These are further explained in the following:

2.3.1.1 *Feedback:*

From an educational perspective, feedback provides an opportunity to support children's learning of unfamiliar educational content by "scaffolding" them into successfully solving a problem. "To scaffold children's performance and learning, feedback for each wrong answer should be designed to provide a bit of additional support for children as they continue to try to figure out the right answer" (Sikiniotis, Kapros, & Kordaki, 2008, p.31). "Good feedback can significantly improve learning processes and outcomes if delivered correctly" (Shute, 2007, p.2). There are two distinct types of feedback, the task-level feedback and general summary feedback (Shute, 2007) which are often referred to as the formative and summary feedback respectively.

2.3.1.2 Formative feedback:

"This typically provides more specific and timely (often real-time) information to the student about a particular response to a problem or task compared to summary feedback, and it may additionally take into account the student's current understanding and ability level" (Shute, 2007, p.3).

Summary Feedback: In order to produce feedback that is relevant and informative teachers themselves need good data about how students are progressing (Nicol & Macfarlane-Dick, 2005, p.14). The "summary feedback is useful for teachers to modify instruction for the whole class and for students to see how they are generally progressing" (Shute, 2007, p.3).

2.3.1.2. Hints: Hints like automatic feedback, should support both game-play and children's learning of underlying educational content; rather than simply revealing the solution, they should lead children in the right direction to help them discover the solution for themselves (Fisch, 2005)

2.3.2 The scaffolding model in games

Any scaffolding model must take into account the process of bridging the gap between the child's initial competence level and target competence level. Teachers should be able to monitor the player-learner's game progress, in order to take action towards closing this gap.

Figure 4 presents a conceptual model of the scaffolding mechanism that synthesizes current thinking by researchers into this topic (Garris, Ahlers, & Driskell, 2002), (De-Freitas & Jarvis, 2009), (van Staalduinen & de Freitas, 2011).

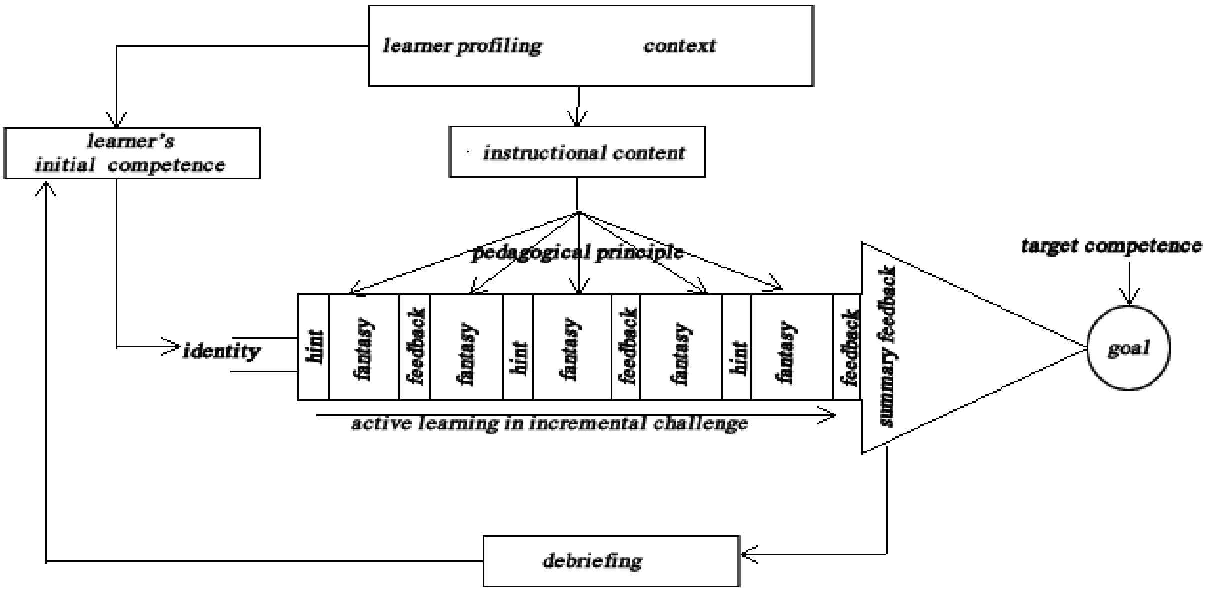

Figure 4 The Scaffolding Model in games (Obikwelu et al., 2012)

In the model, learner profiling (in the context of use) is the starting point for the scaffolding cycle. This is important because the learner's initial competence in relation to the required competence is vital to the determination of the level of guidance required by the player-learner. This guidance is given through the game-play and coaching. The player-learner also requires an identity prior to an immersion into the game fantasy onto which the instructional content has been embedded. This instructional content is embedded based on suitable pedagogical principles. Researches in pedagogical approaches with regards to video games reveal that well designed video games adhere to the constructivist principle (Dondlinger, 2007). Constructivism, which has its root in the ideas of Jean Piaget, takes the point of view that individuals actively construct the knowledge they possess (Dondlinger, 2007). The focus is on knowledge construction rather than knowledge transmission. The ability of games to assist in knowledge construction lies in its potential to modify the player's existing mental model. This is often by altering the experience of the player by incorporating the experience in the game world. Active learning is a part of the constructivism principle. Active learning assumes that meaningful learning occurs when learners engage in active cognitive processing, which includes attention to incoming words and images, mentally integrating them with prior knowledge (Mayer, 1997). With the player having acquired an identity and immersed in game-play, they look out for hints that could lead them to finding answers they need in order to conquer the game. These hints should support the learning of underlying educational content (Fisch, 2005). There is also the feedback which provides an assessment of progress toward goals that drives the motivated performer (player) to expend more effort, to persist, and to focus attention on the task (Garris et al., 2002). Also in this model is debriefing which is an external process of the scaffolding mechanism in games. This usually entails the teacher's feedback response (based on their monitoring and assessment of student performance). Ivanic *et al.* cited in (Juwah et al., 2004) state that this must be internalised by the student before it can influence subsequent action. On re-entry into game-play, the student draws on the knowledge acquired from the debriefing and previous game-play and construct a personal interpretation of the requirements for game progression. The summary feedback shows the student's game-play performance upon which debriefing is based. This summary feedback is an indication of how close the player is to the game/learning goal.

2.4 The Serious Games Constructivist framework for children's learning

This section was published in the proceedings of VS-game 2012 (Obikwelu & Read, 2012)

Recent studies have shown adoption of basic tenets of constructivism in the design of learning environments. Individual representation of knowledge; active learning through exploration; and learning through social interaction or collaboration make-up the basic tenets of constructivism that is addressed in turns in relation to games. In contrast to behaviourism which views learners as active recipients of information, in constructivism, the learner is an active processor of information. The constructivist view of learning has been embraced by the video game world.

The constructivist theory or philosophy is based on "the assumption that knowledge is constructed by Learners as they attempt to make sense of their experiences. Learners therefore are not empty vessels waiting to be filled, but rather active organisms seeking meaning" Driscoll (as cited in Seitz, 1999). Constructivist is the view that involves the learner building on and modifying their existing mental models. The focus is on knowledge construction rather than knowledge transmission. The ability of serious games to assist in knowledge construction lies in its potential to modify the learner's existing mental model that alter the experience of the learner to incorporate the experience in the game world. The focus is on learner activity rather than teacher instruction (Dalgarno, 1996). According to Dalgarno, (1996), the principles of constructivism include individual representation of knowledge in which each person builds on his/her experiences. Also part of the constructivism principle, is active exploration and learning by interaction. "A constructivist method for helping novices acquire expertise is cognitive apprenticeship" (Kerka, 1997, para.5). "Cognitive Apprenticeships uses many of the instructional strategies of traditional apprenticeships but emphasizes cognitive skills rather than physical skills" (Seitz, 1999, para.10). "Traditional apprenticeship have three primary components - Modelling, coaching and fading - utilized as the master craftsman models real world activities in sequence geared to fit the apprentice's level of ability" (Seitz, 1999, para.12). "The master models expert behaviour by demonstrating how to do a task while explaining what is being done and why it is being done that way. The apprentice observes the master, and then copies her actions on a similar task, with the master coaching the apprentice through the task by providing hints and corrective feedback. As the apprentice become more skilled in the task, the master gives more and more authority to the apprentice by "fading" into the background" Johnson (as cited in Seitz, 1999, para.11). With regards to cognitive apprenticeship, cognitive rather than physical skill is emphasized (Seitz, 1999).

2.4.1 The principles of constructivism

According to Dalgarno, (1996), the principles of constructivism include an individualized representation of knowledge: each person builds on his own individual experiences.

i. "Attributed to Piaget: people learn through active exploration, and that learning occurs when the learner's exploration uncovers an inconsistency between their current knowledge representation and their experience" (p.9)

ii. “Attributed to Vygotsky: learning occurs within a social context, and the interaction between learners and their peers is a necessary part of the learning process” (p.10)

These principles emphasize the need to enable learners connect an activity into their existing mental models.

According to Rieber (as cited in Dalgarno, 1996) Simulations and microworlds are popular with constructivists for the following reasons

“

i. Simulations (and some microworlds) provide a realistic context in which learners can explore and experiment with these explorations allowing the learner to construct their own mental model of the environment.

ii. The interactivity inherent in microworlds (and usually in simulations) provide for immediacy of feedback as the learner create models or try out their theories about the concepts modelled” (para.25).

2.4.1.1 Modelling

The learning process in the construction of knowledge for children usually begins with Modelling. “Modelling is a form of demonstration followed by imitation, frequently used as a way of helping the learner progress through the ZPD” Tharp & Gallimore (as cited in Endeley, 2014, p.4) This involves providing the child with background knowledge of the learning objectives of the game. This could be through demonstration, illustrations or videos, as these captivate children. The children are able to observe and build a conceptual model of the process required to attain the learning objectives through game-play.

2.4.1.2 Reflection

This "involves enabling children to compare their own problem solving processes with those of an expert, another child, and ultimately, an internal cognitive model of expertise" (Collins, 2006, p.51). According to Bandura's learning theory, "observers function as active agents who transform, classify and organize modelling stimuli into easily remembered schemes"(Bandura, 1971). During reflection there is a check on the correctness of the learner's thinking based on these generated schemes. Reflection on the basis of articulation (usually referred to as social verification (Bandura, 2001)) occurs when people evaluate the soundness of their views by checking them against what others believe (Bandura, 2001). People organize their thoughts so that they make sense, separating the more important thoughts from the less important ones as well as connecting one idea to another (Hargis, 2001). The outcome of the reflection phase may be personal synthesis of knowledge, validation of hypothesis laid or a new playing strategy to be tested (Kiili & Ketamo, 2007).

2.4.1.3 Strategy Formation

When playing the game, the child tries to form appropriate playing strategies in order to solve the problems that the game provides to her (Kiili, 2007). It could be argued that strategy formation encompasses changing in intellectual organization to somewhat adjust to new ideas (accommodation-attributed to Piaget). In accommodation the intellectual organization has to change somewhat to adjust to the new idea. Berger (as cited in Hargis, 2001).

2.4.1.4 Scaffolded Exploration

In scaffolding, "the ultimate goal is the removal of scaffolds, since we want students to be able to complete the task independently" (McNeill, Lizotte, & Krajcik, 2006, p.18). In serious games, the players are able to perceive the impact and consequences their actions in the game world and thus are informed about how they are performing, check their progress continuously, and eventually adjust their actions (Torrente et al., 2011) - new information is simply added to the cognitive organization already there (assimilation Piaget).

Note that strategy formation and Scaffolded Exploration is all about the child adapting his thinking to include new ideas. And since adaptation (in Piaget's view) occurs in two ways: through accommodation and assimilation logically linked to strategy formation and scaffolded exploration respectively, strategy formation and scaffolded exploration is depicted as a two way process.

2.4.1.5 Debriefing

"Many consider debriefing to be the most critical part of the simulation/ microworld experience" (Garris et al., 2002, p.454). "The debrief is critical because it helps learners explore what went on, talk about their experiences, develop insights, reduce negative about aspects of the activity and connect the activities to their real-life situations" (Preprint of Nicholson, 2012, p.2). Suffice it to say "debriefing may include a description of events that occurred in the game, analysis of why they occurred, and the discussion of mistakes and corrective actions" (Garris et al., 2002, p.455). Debriefing is "a fundamental link between game experiences and learning" (Garris et al., 2002, p.455). "Without this debriefing time, the effectiveness of the activity may be greatly diminished, as some learners will see the activity as a standalone event and not properly connect it to other aspects of the class" (Preprint of Nicholson, 2012, p.2). "If presented appropriately, debriefing helps the students deconstruct the activity and then connect it into their mental models (Preprint of Nicholson, 2012, p.2)". Effective debriefing is learning oriented not performance oriented (Dweck, 1986). This is important because research indicates that with performance goals, "the entire task choice and pursuit process choice and pursuit processes is built around children's concerns about their ability level" (Dweck, 1986, p.1041). "In contrast, the learning goals the choice and pursuit processes involve a focus on progress and mastery through effort" (Dweck, 1986, p.1041). Also revealed is the tendency to withdraw from the challenge if the focus is on ability judgment, whereas a focus on progress through effort creates a tendency to seek and be energized by challenge (Dweck, 1986).

2.4.1.6 *Articulation*

There's need for a forum (preferably online) where children can share their game experiences and acquired knowledge. In this forum, children get the chance to interface with their peers. Piaget argued that peer interaction is both qualitatively different from and superior to adult-child interaction in facilitating cognitive growth (Tudge & Winterhoff, 1993). Criticism is born of discussion, and discussion is only possible among equals: co-operation alone will therefore accomplish what intellectual constraint failed to bring about Piaget (as cited in Tudge & Winterhoff, 1993). As children engage in game-play, they share their ideas and findings in the forum. Children should also be able ask questions and peruse each other's comments and ideas. "Social negotiation of meaning is a primary means of solving problems, building personal knowledge, establishing an identity, and most other functions performed in teams" (Jonassen & Strobel, 2006, p.6). Articulation emphasizes "progress toward collective goals of understanding, rather than individual learning and performance" (Collins, 2006, p.57).

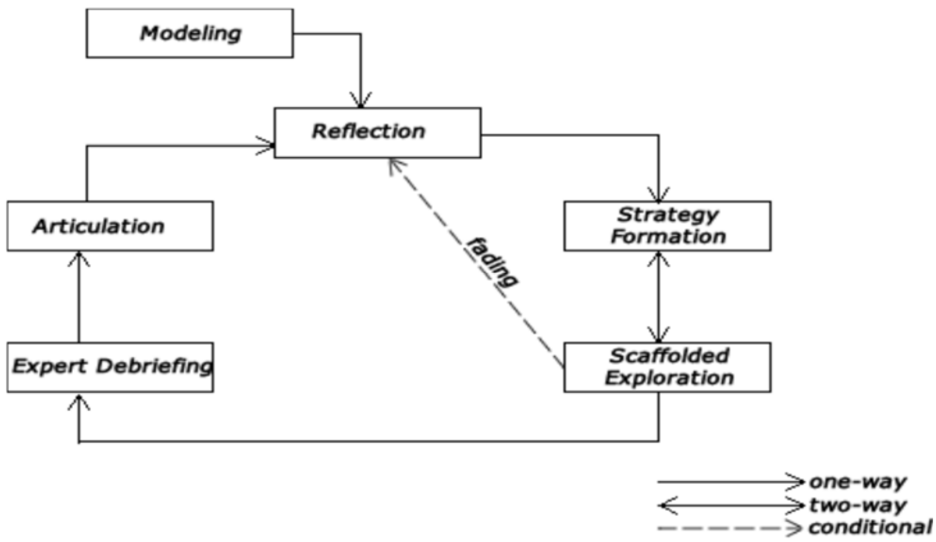

Figure 5 proposed game constructivist framework for children (Obikwelu & Read, 2012)

The child reflects on the background knowledge of the topic or learning objectives dished out through Modelling - he organises his thoughts so that they make sense, separating the more important thoughts from the less important ones as well as connecting one idea to another (Hargis, 2001). The Modelling and reflection phase help the child form his representation of knowledge. This initiates the strategy formation for the game experience. The child now goes on to explore the scaffolded game world where he is able to perceive the impact and consequences of his actions and in the process he is continuously informed of his performance and progress. In the course of exploration the child is able to uncover inconsistencies between his current knowledge representation and the experience referred to by Piaget as a state of disequilibrium (Dalgarno, 1996). In the process the child may change his knowledge representation to incorporate the experience this is referred to as accommodation which could be linked to strategy formation- making the strategy formation and scaffolded exploration a two-way process. If the child is able to conquer the game hence attain all the learning objectives, the learning support is faded for subsequent game-play (exploration). If the child is unable to conquer the game then he interfaces with experts and peers through debriefing and articulation respectively. He reflects on his finding and re-strategizes for subsequent exploration based on these findings. This is a cyclic process involving the child re-entering the game-world for continued exploration and scaffold fading as the child gains mastery at different scaffolding level.

2.5 User studies on Scaffolding

Researchers are currently investigating different forms of scaffolding and their effect on learning, ‘motivation to learn’ and engagement. The data are often gathered from Pre and post-game scores (summative assessment), in-game actions (formative assessment) and surveys.

2.5.1 Related Studies

Barzilai & Blau (2014) investigated external (bridging) scaffolds. They described external scaffolds as scaffolds that attempt bridging informal and formal knowledge representations in game-based learning - scaffolds that help learners make connections between knowledge learned in the game and disciplinary knowledge (Barzilai & Blau, 2014). Children between the ages of 6 and 14 (Mage = 10.10) participated in this study. The study showed that adding an external conceptual scaffold before gameplay results in significantly better post-game scores (summative assessment) than playing without the scaffold or presenting the scaffold after the game (*Shakshouka Restaurant* game) (Barzilai & Blau, 2014). This according to the researchers is a "positive indicator of the potential efficacy of external scaffolds for helping learners form connections between game knowledge and formal school knowledge" (Barzilai & Blau, 2014, p.33).

Another study investigated the delivery of support in games. Cates & Bruce (2000) categorized support delivery into Non-intrusive, intrusive, prescriptive and non-prescriptive. This was a mixed methods study - It resulted in the collection of both qualitative and quantitative data. While a video-based screen capture program recorded the interactions of the children (to provide the qualitative data), a revised version of the Instructional Material Motivation Scale (IMMS) (Keller, 1987), (Keller, 2010) was administered to capture the quantitative data. The findings from this study suggests that "more prescriptive support (regardless of intrusiveness) may have provided the students with the confidence and self-efficacy they needed to stay engaged"(Weppel, Bishop, & Munoz-Avila, 2012). According to the researchers, "levels of intrusiveness may have been less important because students seemed to seek out the support they needed whether it was offered or not" (Weppel et al., 2012). In addition, the researchers discovered that less intrusive support may have led to higher level of frustration and less satisfaction with the task (Weppel et al., 2012). The study also showed that compared to the non-prescriptive group, the prescriptive group wanted to figure out what the game was about on their own (Weppel et al., 2012).

Furthermore, a study by Pedersen & Min (2001) compared cognitive modelling version, didactic version and a help version of support in the Alien Rescue game with elementary school students. "The modelling was delivered in video format "just-in-time" to students as they were working within the section of the program where the modelling was useful" (Pedersen & Min, 2001, p.360); "The didactic condition was designed to provide students with all the same information provided in the modelling condition, but without expert modelling" (Pedersen & Min, 2001, p.361). According to the researchers here, the main purpose of including this condition is to isolate the effects of modelling from the effects of providing useful strategies (Pedersen & Min, 2001); "In the help condition, the expert explained the functionality of the tools provided in the program as students accessed them" (Pedersen & Min, 2001, p.361). "As in the other conditions, there were four help sessions" (Pedersen & Min, 2001). The result showed that the cognitive modelling version offered a more effective support to the player-learner than the other two versions (Pedersen & Min, 2001, p.361). This was extrapolated from the actions of the participants within the game environment –audit trail (formative assessment) – including the use of tools and note organization within the game (Pedersen & Min, 2001).The result also showed that students in the modelling group had a more positive attitude toward the experts than students in the other treatment conditions (Pedersen & Min, 2001).

Again, a study by Charsky & Ressler (2011) examined students' motivation to learn history concepts while playing Civilization III. The study investigated the effect of using conceptual scaffolds to accompany game-play (Charsky & Ressler, 2011). "Students from three ninth grade classrooms were assigned to one of the three groups: one group used an expert generated concept map, one group constructed their own concept map, and a control group used no map" (Charsky & Ressler, 2011, p.604). According to (Charsky & Ressler, 2011), concept-mapping encourages students to reflect on their knowledge in order to re-evaluate their learning. They state that concept maps can be used as instructional content or as scaffolds – "When used as instructional content, concept maps are typically created by expert/ instructor and given to students for analysis" (Charsky & Ressler, 2011, p.605). But when used as instructional scaffolds, concept maps are typically constructed by students after the students have begun learning about the topic or content area Schnid & Telaro (as cited in Charsky & Ressler, 2011). The result of this study suggested that using a conceptual scaffold can decrease student's motivation to learn classroom material through gameplay. Keller's Instructional Materials Motivation Scale (IMMS) (Keller, 1987)was reworded and used for the survey.

There is also a study with an iteration of the CRYSTAL ISLAND game (a narrative-centred learning environment). The study emphasize that the scaffold is the non-player characters in the storyworld. According to the researchers, "the primary goal of the experiment was to investigate the impact of different scaffolding techniques on learning and engagement in the game" (Rowe, Shores, Mott, & Lester, 2010, p.4). Children between the ages of 12 and 15 participated in the study. There was a pre and post-game test in addition to the questionnaires administered – Perceived Interest Questionnaire and Presence Questionnaire (Rowe et al., 2010). In addition CRYSTAL ISLAND calculated a numerical score to assess student's progress and efficiency in completing the science mystery (Rowe et al., 2010). Of interest is the fact that the investigation of learning revealed that on average, "students answered 2.35 (SD=2.75) more questions correctly on the post-test than they did on the pre-test. Matched pair t-tests (comparing post-test to pre-test scores) indicated that students' learning gains were significant" (Rowe et al., 2010, p.5). The findings also indicated that student engagement with the CRYSTAL ISLAND environment was associated with improved learning outcomes (Rowe et al., 2010).

In addition, there was a study by (van der Spek et al., 2010), aimed at ascertaining if the implementation of auditory cues would lead to significant learning gain from game-play. 21 participants took part in this study with the average age being 21.48. 11 played with auditory cues while the rest played without it. Before game-play the participants engaged in a pathfinder exercise to gauge their mental model. This was followed by the answering of a ten-item multiple choice paper questionnaire with combined conceptual and procedural questions. Just prior to game-play, the participants received basic instructions on how the game environment could be navigated, no information regarding the auditory cues was given. During the game-play, there was a 17-minute countdown when the participant got to a certain point in the game (subway platform) with an assumption that at that point he should have been conversant with navigations within the environment. After gameplay an engagement questionnaire was administered. The engagement questionnaire used was a subset of the ITC-SOPI questionnaire – "a Likert-like questionnaire that is significantly designed to measure all types of presence that any multimedia setting can evoke" (van der Spek et al., 2010, p.123). This was followed by the pathfinder and paper test (administered again) – the paper test having the items in a different order. The findings show that there was no significant difference in in-game score between the cueing group and the control group. Though the results show that the auditory cues did not have a negative impact on engagement, it did show that it worsened the mental model.

2.6 Scaffold-fading

The fundamental technical restriction identified with regards to scaffolding is the absence or lack of systematic scaffold fading techniques in serious games designed for children. This faults the scaffolding trend in games. It is a crucial limitation to overcome. A systematic scaffold-fading technique could have a positive impact on the transition of the player (child) from his dependency on the game's guidance to his independency of this guidance – it could foster a smooth transition. Applying the principle of fading to serious games is a workable solution for scaffolding multiple ZPDs found in the classroom.

According to Vygotsky's (1978) ZPD, learners should be assisted with scaffoldings and be progressively made more and more independent. As they improve their skills, less and less help is provided. Learners' independence and metacognitive skills are improved gradually (Felicia, 2009). "The temporary support (e.g. a scaffold) can come in the form of instructional strategy or tool. In a ZPD, the learning process gradually evolves from interaction to internalization – a type of responsibility transfer. The overall goal is to help students get a better grasp of their own knowledge construction" (Sun, Wang, & Chan, 2011, p.2119) .

The only attempt at systematically applying the scaffolding-fading concept to games is by (Rowe et al., 2013) in the CRYSTAL ISLAND game. This attempt is across scenarios – macro scaffolding. Though they specified how they could incorporate levels of fading, they emphasized that it would be challenging. In addition they did not attempt elucidating rate of fading. According to Pol, Volman & Beishuizen (2010) fading rate help determine a child's competence and developmental level. Of importance also is the fact that fading can either be adaptive or static (Reisslein, Reisslein, & Seeling, 2006)– these need to be investigated in relation to serious games. Adaptive fading entails a gradual removal of the scaffolds with increasing expertise of the player-learner while static fading entails the gradual removal of the scaffolds at a pre-determined rate – no attention is paid to the changing level of player-learner's expertise (Reisslein et al., 2006). Teachers may choose static fading over adaptive fading in the classroom where there are multiple ZPDs.

The fading decision can either be made by the teacher, child or an internal decision process. Based on the fading decision, fading rate can be categorized into two major types: Perceived Fading Rate and Actual Fading Rate.

2.7 Systematic scaffolding/scaffold-fading

Systematic scaffolding may not apply to adults as much as it does apply to children. For children, emphasis is drawn to their relatively small working memory capacity (Kirschner & Sweller, 2006). For this reason, there is a need to create systematic and intentional scaffolds of their understanding, rather than leaving them alone to discover information independently (Fisher & Frey, 2010).

2.7.1 Developing Systematic Scaffolding

Systematic scaffolds are often developed in layers. These scaffolds can be within or between tasks. For every task, there is a beginning, middle and end. In this case, systematic scaffolding entails ordering layers of scaffolding, so there is a layer for the beginning, a layer for the middle, and a layer for the end. The fading is then systematic when the scaffolding layer at the beginning is faded first, then the middle layer fades before the end layer of scaffolding. Fading can be after a successful attempt (adaptive fading) or after an attempt whether successful or unsuccessful (static fading) (Reisslein et al., 2006).

2.7.2 Systematic scaffolding considerations

1. Identify the gameplay/ learning goal
2. Identify the target level of competence and experience required to reach the goal
3. Add all assistance or support
4. Specify fading criteria
5. Specify fading rate
6. Implement fading
7. Collect Data
8. Fade assistance or support as specified (criteria and rate)

Systematic scaffold-fading has been effected in non-gaming contexts. The considerations listed in this section are often a part of the systematic scaffold-fading approach in the non-gaming context. This is a guide to implementing fading in a gaming context.

CHAPTER 3

THE GAME

3.1 Introduction

A conceptual model describing the status quo in serious games design with regards to scaffolding, was introduced in Chapter 2. The two key parts of the conceptual model (related to scaffolding) being micro scaffolding and macro scaffolding. Micro scaffolding, referring to within scenario scaffolding AND Macro scaffolding, referring to between scenarios scaffolding. The scaffolding approach in the Alien Chef game (to be described in details in this chapter) is micro-scaffolding (formative feedbacks), as all the scaffolding is within scenario and not between scenarios. There are no levels in the game and thus no macro-scaffolding (found between levels often in the form of summative feedback).

The serious game constructivist framework also described in Chapter 2, highlights the core of this research. The emphasis is on the fading linking the scaffolded exploration to reflection. Fading has been implemented in non-gaming contexts but is yet to be implemented in gaming contexts. The serious game constructivist framework indicates how this can be implemented.

3.1.1 An overview of the Alien Chef game ('gradual removal' mode) based on the serious game constructivist framework for children

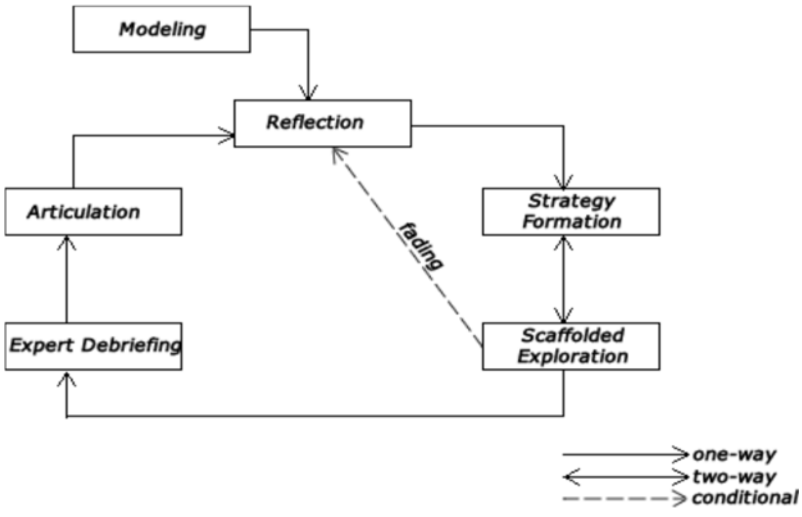

Figure 6 The serious game constructivist framework

The Alien Chef game has four attempts, the gameplay is timed for these four attempts. The player is expected to complete the four attempts in fifteen minutes. Gameplay in the first attempt is fully scaffolded. This is depicted in the framework (see figure 19) as Modeling. So the Alien Chef game is designed with all demonstrations 'poured' in the first attempt (in the form of modelling).

As shown in figure 19, the gameplay is expected to begin with some reflection based on the level of modelling present. Reflection would then lead to strategy formation and scaffolded exploration. It is then expected that after every scaffolded exploration (attempts in the case of the game), fading occurs. Fading is simply a reduction in the demonstration (depicted as modelling in the framework). This form of fading is referred to as static fading (Reisslein et al., 2006) – fading regardless of the outcome of the scaffolded exploration (attempt in the case of the Alien Chef game). It would be adaptive fading if the fading was based on the outcome of the scaffolded exploration.

Gameplay metrics are logged in the course of the scaffolded exploration for use in the expert debriefing. The expert debriefing is expected to take place after the last attempt (the fourth attempt in the Alien Chef game). The debriefing should trigger articulation and subsequently lead to reflection for the start of another cycle.

3.2 Background

> "A game is a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" - Zyda, 2005 p.26

Ostenson (2013) argue that even the simplest video games could be considered narrative. The backstory often embody the central narrative conflict. As stated by Dickey (2005), a backstory is the background of a storyline. The essence of a backstory is to give a dramatic context to the interactions and actions associated with gameplay (Crawford, 2003). In the course of gameplay, there are various challenges. The various types of challenges are described in (Rollings & Adams, 2003). The main challenges found in the Alien Chef game are conceptual challenges and memory challenges. These are applied and pure challenges respectively. Conceptual challenge has been described as the challenge that helps the player grasp new notions (Rollings & Adams, 2003) while memory challenges demand the memorization of a recent event in the game (Rollings & Adams, 2003).

There are also hooks in games. These are basically choices the players are expected to make in the course of gameplay. The hooks are often associated with what to do, status and time restrictions and are referred to as action, resource and time hooks respectively.

A key aspect to the game design, is the instructional design aspect. In instructional design, scaffolding is a key concept. Scaffolding and Zone of Proximal Development (ZPD) are inseparable. While ZPD is the gap between what the learners can learn without assistance and what they can potentially learn with assistance, scaffolding is the mechanism expected to bridge this gap. It often involves the gradual transition from the worked example to the actual problem state. The instructional design in the Alien

Chef game is centred round the fading concept which is the aspect of scaffolding where there is a gradual transition to the problem state from an initial worked example. Instructional designers have always been faced with the problem of designing this transition.

3.2.1 Alien Chef as a serious game

According to Charsky (2010), serious games use instructional and video game elements for non-entertainment purposes. In the Alien Chef game, children are expected to learn to run a new restaurant (though fictitious). The player is expected to be able to source ingredients for the orders placed, mix these ingredients, prepare and serve the order (section 3.3 describes the game in detail) from gameplay – a procedure training for running a different kind of restaurant. Thus instructional and video game elements such as the backstory, hooks, rules and challenges are used to provide procedure training for running this restaurant. Hence the Alien Chef game is regarded as a serious game.

This game is designed for children aged 7 – 11. Children within this age group find would struggle with understanding abstract or hypothetical concepts but are well capable of logical reasoning. (Piaget, 1972), (Schonberg, 2013)

3.3 The Alien Chef Game – The Instructional and Game Elements

3.3.1 The Plot: Backstory

Alien guests arrive an Alien restaurant placing Alien orders. The Alien Chef in this restaurant in expected to prepare these Alien dishes before the guests leave. The Alien guests are sat in the guest zone while the Alien Chef prepare the Alien orders. The Alien Chef must get the ingredients from the garden just outside the restaurant – the ingredients must be really fresh.

3.3.2 The Gameplay: Rules and Challenges

> "The interaction within the gameplay is rule bound. Rules define what the player-character can do. They also define victory and loss conditions" - (Dickey, 2005)

Alien Chef is a game aimed at helping children learn the substances of some Alien mixtures. The player has to prepare predetermined mixtures (Alien dishes) by adding the right substances to the cooking pot. The predetermined mixtures are orders placed by some guests in the restaurant. The player whose character is the Alien Chef is expected to prepare these mixtures before the guests leave. There are two predetermined mixtures (orders placed). These orders are shown in figure 6.

Figure 7 The Order placed with one of the order already prepared

In this game, the player is timed. All the guests would have left by the time the player runs out of time. At this point the player is unsuccessful.

The player – the Alien Chef, has a preparation zone where the mixtures are prepared. He goes to the garden just outside this zone to get the required substances (fruits) for this mixture (food). He can only get one substance at a time. He is expected to drop the substance into the cooking pot on return to the preparation zone.

Figure 8 showing the preparation and the guest zones

The player character's (Alien Chef) health level is also monitored during gameplay. 'Red hearts' show health level. There are five 'red hearts at the start of each attempt. A 'red heart' disappears whenever a wrong substance is put in the pot. The player is unable to continue an attempt and its game over on this attempt, when all the five 'red hearts' disappear.

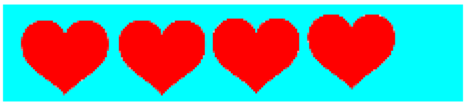

Figure 9 The Player Lives with four lives remaining

The challenge in the Alien Chef game is mainly conceptual. Rollings & Adams (2003) described conceptual challenges as those aimed at helping the player understand something new. According to them conceptual challenges are applied challenges (Rollings & Adams, 2003). There is also the memory challenge in the game where the player is expected to remember substances of a particular mixture that are currently concealed but were revealed in a previous attempt. According to Rollings & Adams (2003), "memory challenges tax the player's memory of recent game events". Memory challenges are pure challenges (Rollings & Adams, 2003).

3.3.3 The Gameplay: Hooks

"A game is a series of interesting choices" –Sid Meier

Players make choices in the course of gameplay. These choices are described as hooks (Dickey, 2005). There are different types of hooks. They include action hooks, resource hooks and time hooks (Dickey, 2005). "Players encounter a multitude of hooks throughout a game" (Dickey, 2005).

> "Central to the design of gameplay is choice. Players continually make choices as to who to be, where to move, what to do and how to allocate resources." (Dickey, 2005)

The main action hooks in the Alien Chef game include deciding

- what tree to pick from and when to pick from it
- where to drop the substance when it is picked
- when the dish is ready and should be taken to the guests

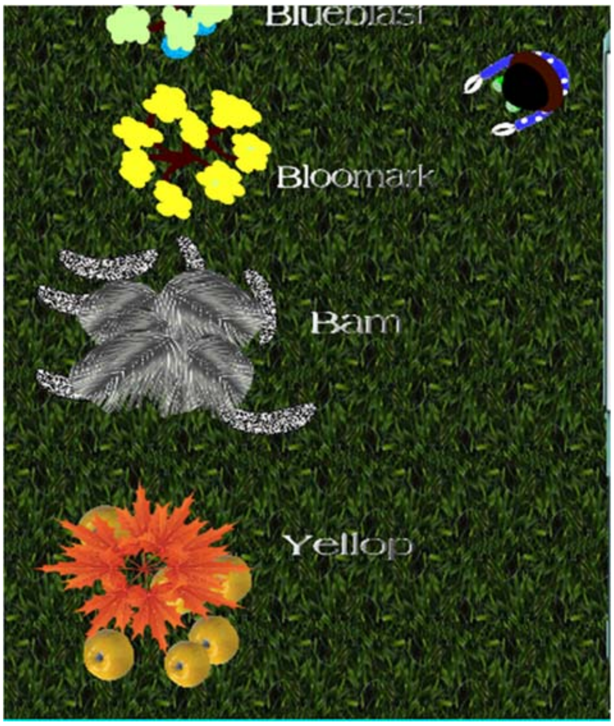

Figure 10 The player character deciding what to pick

The resource hook include the number of lives (red hearts)

There is also the time hook. It is a race against time in the Alien Chef game. The player is expected to prepare the predetermined mixtures (the orders placed by the guests) within a prescribed time frame.

3.4 The Instructional Design: Scaffolding

> "Scaffolding enables learners to do more advanced activities and to engage in more advanced thinking and problem solving than they could without such help. Eventually, high-level functions are gradually turned over to the students as the teacher (or computer system) removes the scaffolding and fades away" - (Shute, 2008)

The Alien Chef game (the gradual removal mode) employs a goal-directed approach to learning. This is an approach associated with scaffolding (Shute, 2008). It has been highlighted by Shute (2008) that with this approach,

- The learner's interest in relation to the task is motivated
- The task is simplified so it is more manageable and achievable
- Direction is provided to help the learner focus on achieving the goal
- There is an indication of the differences between the learner's work and the standard or desired solution
- Frustration and risks are reduced
- Expectations (goals) of the activity to be performed are modelled and clearly defined

3.4.1 Feedback

According to Shute (2008), feedback can be either a 'verification' or an 'elaboration'. Verification simply confirms if an action/response is correct or incorrect. It could be implicit or explicit. Explicit means simply highlighting or marking a response to indicate its correctness (Shute, 2008). It is implicit when a "response yield expected or unexpected results" (Shute, 2007 p.158). Elaboration addresses a response/action or a collection of responses/actions. In elaboration 'worked example' or 'gentle guidance' could be applied (Shute, 2008).

According to Shute (2008) , "researchers appear to be converging toward the view that effective feedback should include elements of both verification and elaboration". Elements of both approaches are applied in the Alien Chef game.

3.4.2 'Verification' in the Alien Chef Game

There is a checkmark against the right fruit the Alien Chef has picked at any point. This is an explicit verification.

Figure 11 Checkmarks indicating the correct substance has been picked

The black transparent arrows point to the checkmarks indicating right fruits picked

There are a couple of implicit verifications in the game. They include

- The appearance of the correct dish when successfully prepared.
- The disappearance of a 'red heart' when the wrong substance is dropped in the pot.

3.4.3 'Elaboration' in the Alien Chef Game

3.4.3.1 Feedbacks in the Alien Chef game

#1 - A feedback bubble, describing what the Chef is thinking to do with the fruit picked.

#2 – A message displayed with the typing effect, presented to the player the start of the game.

#3 – An instruction telling the player what to do.

#4 - An arrow pointing to where the ingredients can be sourced.

#5 – A circled message explaining what the arrow is pointing at

#6 – An arrow pointing to where the ingredients can be sourced

#7 – An arrow pointing to the pot where the fruit picked should be dropped

#8 – A circled message telling the player where to drop the fruit

#9 – A circled message telling the player where to pick the fruit

#10 – A feedback bubble alerting the player of the wrong fruit dropped in the pot

#11 – A try again button prompting the player to try again

#12 – A feedback bubble appearing when the food is ready and should be taken to the guest. It is an alert appearing only when the mixture is right and ready to be served.

#13 – An arrow appearing when the food is ready and should be taken to the guests. It points to where the guests are sat; where the food should be taken.

#14 –A circled message telling the player where to source the ingredients

#15 – A feedback bubble prompting the player to prepare the second order; appearing after the first order has been prepared.

In the Alien Chef game Hints/cues/prompts – a type of elaborated feedback, is used exhaustively (Shute, 2008). Shute (2008) described this type of feedback as guidance in the right direction; "it avoids explicitly presenting the correct answer" (Shute, 2008 p.160).

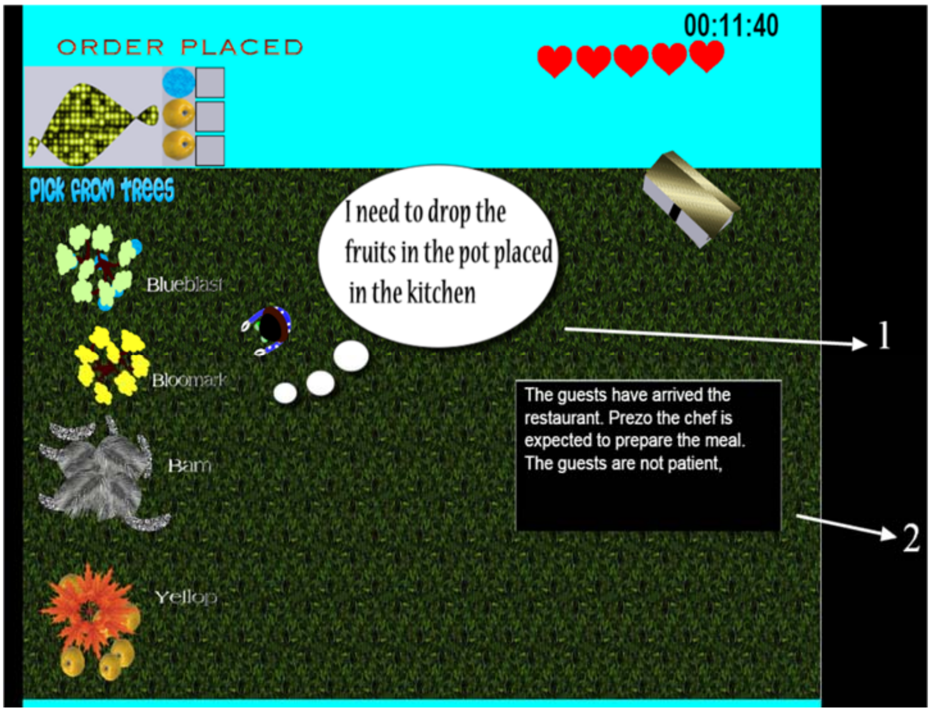

Figure 12 Feedbacks 1, 2

Feedbacks 1 and 2 in the figure above introduces the player to the game. They contain the backstory – the rationale for the gameplay (Derryberry, 2007). The feedbacks at this point are mainly informative

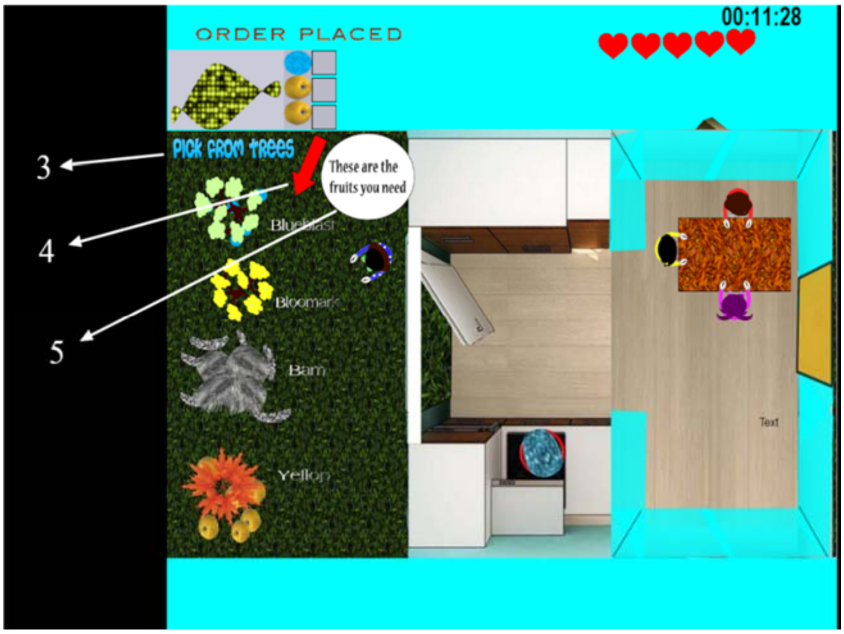

Figure 13 feedbacks 3, 4, 5

Feedbacks 3, 4 and 5 in figure 12 are hints/cues/prompts guiding the player in the right direction. According to Shute (2008), it avoids explicitly presenting the correct answer. With these the player is expected to know what to do next. Feedback 3 disappears as soon as the player picks a fruit from the tree.

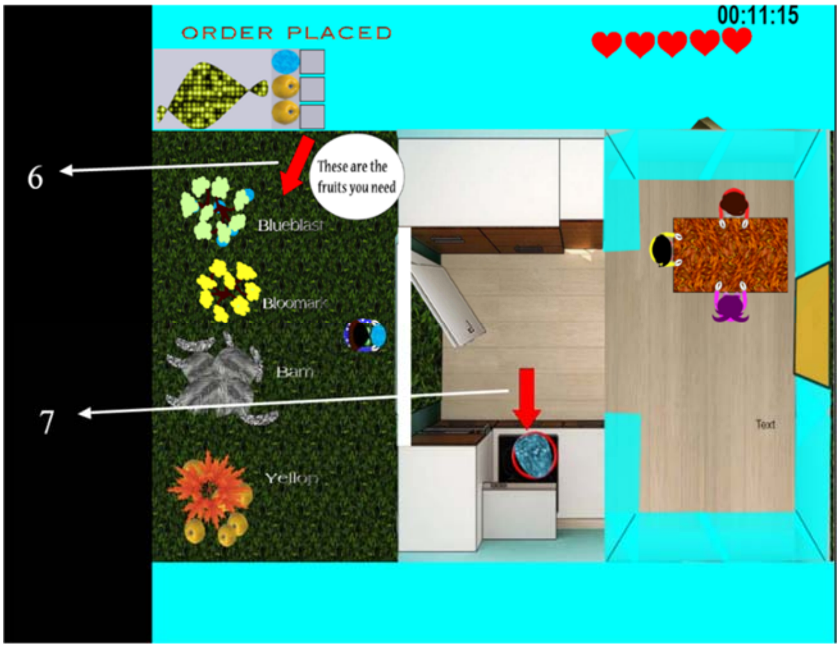

Figure 14 Feedbacks 6, 7

The arrows in figure 13 are hints/cues/prompts also pointing the player in the right direction. Feedback 7 (see figure 13) appears as soon as the player picks a fruit from the tree.

Figure 15   Feedbacks 8, 9

Feedbacks 8 and 9 in figure 14 above, are hints/cues/prompts. Feedback 8 appears as soon as the player enters the food preparation zone – prompting the player to drop the fruits. Feedback 9 hint the player on the fruits required.

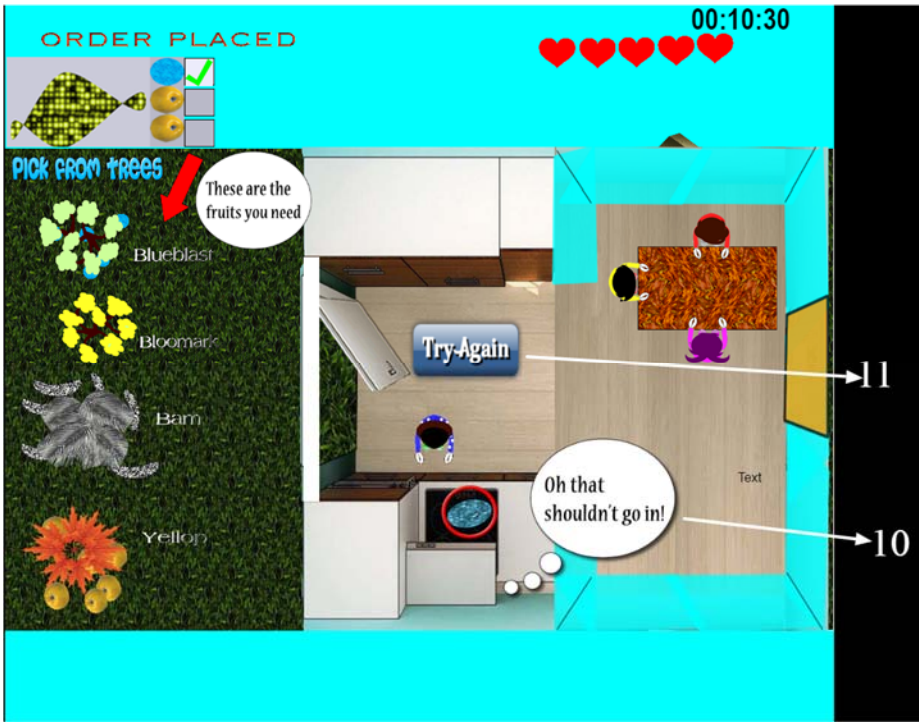

Figure 16 Feedbacks 10, 11

Feedback 10 in figure 15 above, is simply verification. This only confirms that the action/ response is incorrect and doesn't say why. There is also the Try Again feedback (feedback 11 in figure 15) informing the player of an incorrect action/ response and allowing for more attempts to get it right.

Figure 17 Feedbacks 12, 13

In the figure 16 above, feedback 12 and 13 are hints/cues/prompts simply guiding the player in the right direction – in this case the arrow (feedback 13) is pointing to where the guests are sat while feedback 12 is prompting the player to take the prepared dish to the guests.

Figure 18 Feedback 14, 15

Feedback 14 in the figure 17 above is feedback 9 moved to a different location. While feedback 14 is hinting the player (indicating the fruits needed), feedback 15 prompts the player to prepare the second order.

3.5 Scaffolding, Working Memory and Fading

Menon, Shakya, & Kumar (2005) stated that scaffolding structures can support the learning process by engaging the learner. They can help young children solve problems, accomplish tasks and meet set targets (Puntambekar & Hubscher, 2005). Puntambekar & Hubscher (2005) also emphasized that this support can be easily removed when it is no longer required by the learner.

“A worked–out example includes problem formulation, solution steps and final solution” (Schworm & Renkl, 2006 p.427). A worked-out example is the full scaffolding level. It is made up of layers of partial scaffolding (fading levels) often referred to as solution steps. The gradual removal of these layers is referred to as fading. The lesser the fading levels, the closer the learner is to the problem formulation. According to Renkl, Atkinson, Maier Uwe H., & Staley (2002) “Research has shown that it is effective to combine example study/ worked-out example and problem solving in the initial acquisition of cognitive skills” (p.293). Gradually transiting from worked-out example to problem help prevent working memory (WM) overload during the learning process.

Ashby, Ell, Valentin, & Casale (2005) described WM as “the ability to maintain and manipulate limited amounts of information during brief periods of cognitive activity” (p.1728). “It is heavily used in reasoning and problem-solving, and because of this, is often associated with a wide variety of cognitive tasks” (Ashby et al., 2005 p.83). According to Holmes, Gathercole, & Dunning (2009), it has been proposed that low WM capacity hinders learning in young children by recurring WM overload from learning activities. Gathercole & Alloway (2007) stated that WM capacity increases with the age of the child. “Young children typically have very small capacities that increase gradually until the teenage years, when adult capacities are reached that are more than double that of 4-year-old children” (Gathercole & Alloway, 2007 p.7).

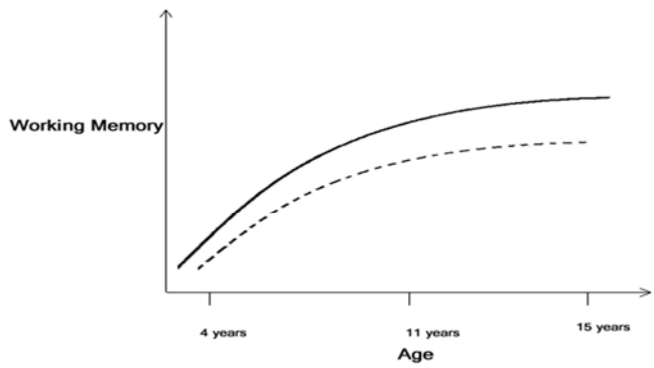

Figure 19 The changes in working memory capacity with age (Gathercole & Alloway, 2007 p.8).

“The changes in working memory capacity with age for an average child are shown by the solid line. Scores of a child with a low working memory capacity are represented by the broken line” (Gathercole & Alloway, 2007 p.8)

The switch from worked-out example to problem formulation is often abrupt (all-or-nothing) and thus burdensome for young children. “There should be a smooth transition from modelling (complete example) over coached problem solving (incomplete example) to independent problem solving” (Renkl et al., 2002 p.298). According to Renkl et al. (2002), the implementation is as follows

“

1. First, a complete example is presented (model).

2. Second, an example is given in which one single solution step is omitted (coached problem solving).

3. Then the number of blanks is increased step-by-step until just the problem formulation is left, i.e. a problem-to-be-solved (independent problem solving)” (p.298).

In (Renkl et al., 2000), a fading condition is described as one in which the problem-solving demands on the learner gradually increases. This according to Pol, Volman, & Beishuizen (2010) is because there is a gradual withdrawal of the learning support. When and how the learning support should be withdrawn should be dependent on the target learners’ Zones of Proximal Development (ZPDs).

3.6 ‘Elaboration’ in the Alien Chef game – The fading mechanism

There is the ‘worked example’ at the start where the substances that make up each of the order placed by the guests are revealed. In addition, there is also the ‘gentle guidance’ in the form of clues, hints and feedbacks. The substances are gradually concealed (the gradual removal mode) as the number of attempts increases until all the substances are concealed. The ‘guidance’ is also continuously reduced as the number of attempts increases. It is expected that by the time all the substances are concealed and the ‘guidance’ completely removed, the player should be able to play the game without assistance – including knowing how the Chef operates and the content of each order.

The elaborated feedbacks in the game are gradually removed (gradual removal mode) as the number of attempts increases.

- Full Scaffolding: On attempt 1, all the feedbacks are present.
- Partial scaffolding 1: On attempt 2, feedbacks 1 and 2 (see figure 11) containing the backstory and expected to give the rationale for gameplay is removed.
- Partial scaffolding 2: On attempt 3, feedbacks 3, 4, 5 (see figure 12) expected to guide the player in the garden – pointing to the right fruit are then removed.
- No scaffolding: On attempt 4, the rest of the elaborated feedbacks (this is including feedbacks expected to guide the player in the food preparation and guest zone) are removed except for the try again. The verifications are not removed.

For the all-or-nothing mode

- Full Scaffolding: On attempt 1, all the feedbacks are present.
- No scaffolding: On attempt 2, the rest of the elaborated feedbacks (this is including feedbacks expected to guide the player in the food preparation and guest zone) are removed except for the try again. The verifications are not removed.
- No scaffolding: On attempt 3, the rest of the elaborated feedbacks (this is including feedbacks expected to guide the player in the food preparation and guest zone) are removed except for the try again. The verifications are not removed.
- No scaffolding: On attempt 4, the rest of the elaborated feedbacks (this is including feedbacks expected to guide the player in the food preparation and guest zone) are removed except for the try again. The verifications are not removed.

In the all-or-nothing mode gameplay is without scaffolding right after the full scaffolding.

For the ‘no scaffolding’ mode:

There was no scaffolding in all four attempts; not even the worked example presented first in the all-or-nothing mode.

3.7 The goal-directed feedback concept

The Alien Chef game demands more effort as the number of attempts increases. It is expected that with this approach, the player would remain motivated and engaged. Shute (2008) highlights the importance of keeping the learner motivated and engaged by ensuring that the learner’s goals are matched with his or her expectation that these goals can be met (Shute, 2008). Shute (2008) emphasizes that feedback can be a strong motivating agent “when delivered with goal-driven effort”.

For each correct mixture prepared, a sub-goal state is attained. The goal state is attained when the three different orders are prepared.

3.8 Feedback as a cognitive support mechanism

Though It has been proposed and proven that the gradual fading of worked steps fosters skill acquisition, the structuring of this “transition from example-based learning in the early stages of skill acquisition to problem-solving in the later stage” is unclear (Renkl & Atkinson, 2003). In the Alien Chef game, there is an attempt to structure this transition within a game-based learning domain. The intrinsic load (which is the complexity of the learning material (Renkl et al., 2002; Renkl & Atkinson, 2003)) is high in this case because the player has no prior knowledge associated with the games learning objective. For player-learners with prior knowledge, beginning with worked example would increase the extraneous load which is often as a result of redundant information – pointless information for the learner. Cognitive Load Theory principle aims at keeping the extraneous load as low as possible while increasing the germane cognitive load (mental activities related to learning(Renkl & Atkinson, 2003)). The germane cognitive load increases as the player-learner self-explains the learning objectives. This self-explanation is fostered in the Alien Chef game by introducing annotations drawing the player-learner's attention to the games learning objectives.

3.9 Modelling

A modelling phase is important for children to progress through their ZPD in serious gameplay. This phase is a demonstration of what the game entails. The child would be assisted in the acquisition of the required background knowledge of the game's learning objective. The Alien Chef game assists the child in acquiring this background knowledge with the full scaffolding - including arrows and annotations.

3.10 Analytics for Debriefing

Debriefing is the activity involving a reflection on the gameplay experience with the aim of turning it into learning (Crookall, 2010a). In the Alien Chef game, the analytics captured are linked to the learning objectives. Linking the analytics to the learning objectives is basically aligning the captured analytics with the expected debriefing session. Debriefing entails a description of the events that occurred in the game, an analysis of why these events occurred and a discussion of potential solution to mistakes made. Through the analytics, the events occurring in gameplay are described.

Data being tracked include

- Correct mixture made
- Wrong mixture
- Time substance is dropped in the cooking pot
- Duration of gameplay
- Game end state

- Disappearance of ‘red hearts’

This is expected to trigger the discussion on why the events occurred and potential solution to mistakes made.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

In this chapter the research methodology is explained, explored and justified.

This research employs deductive reasoning. Unlike inductive research approach associated with interpretivism, the deductive research approach is associated with positivism. Positivism is often linked to quantitative research methods. “Quantitative methodology is routinely depicted as an approach to the conduct of social research which applies a natural science, and in particular a positivist, approach to social phenomena” (Bryman, 1984, p.77).

Quantitative design uses deductive reasoning - a hypothesis is formed followed by the collection of data in the course of investigating a problem. The data collected is then used to prove if the hypothesis is either false or not.

Suffice it to say, this is a quantitative research.

4.2 The Positivist Paradigm

With Positivism, “science proceeds through a process of hypothesizing fundamental laws and then deducing what kinds of observations will demonstrate the truth or falsity of these hypotheses” (Easterby-smith, Thorpe, & Lowe, 1994, p.77). Shanks & Parr (2003), state that hypotheses should be testable in addition to providing opportunities for confirmation and falsification. The identification of theories based on status quo or current trend would give birth to hypotheses. Hypotheses are formed when these concepts are "operationalized in a way which enables facts to be measured quantitatively" (Easterby-smith et al., 1994, p.77) . The empirical testing of hypotheses should be replicable. There is also a need for generalization which according to Holden & Lynch (2004b) would lead to prediction, explanation and understanding. "The researcher and the phenomena being investigated are assumed to be independent, and the researcher remains detached, neutral and objective. Any reduction in independence is a threat to the validity of the study, and should be reduced by following prescribed procedures" (Shanks & Parr, 2003, p.77). Quantitative and scientific methods are often associated with this paradigm.

4.3 Quantitative research

Unlike qualitative research, quantitative research involves the collection and analysis of numerical data. The outcome of this research would help game instructional designers make informed decisions with regards to serious game's scaffolding mechanism. Though a qualitative approach could lead to information describing the effect of various scaffolding-fading approaches on children's gameplay experience, it can be expensive and time-consuming especially with a large sample size. Since this research is expected to involve up to fifty participants, it would be considered impracticable to carry out a qualitative research, instead a quantitative approach is applied. Quantitative research can either be comparative or descriptive. While descriptive research aims at measuring one variable, comparative research measures two and compares. This work is basically comparative. Furthermore, quantitative research can either be quasi-experimental or experimental. Unlike experimental research, quasi-experimental research is often described as unscientific and unreliable. This is because the approach is not scientific – primarily because the sample selection is not random and there are no control treatments. This research is experimental. Considering the fact that this work is experimental, effort is made to identify and control all other variables. Subjects are randomly assigned to experimental treatments. In the 'Gameplay experience aspect' and 'cognition aspect' of this research, the independent variables are 'gradual removal' mode and 'all-or-nothing' mode, the control treatment is the 'no scaffolding' condition.

To sum it up, this research is a comparative research comparing the effect of the modes under investigation (gradual removal' mode and 'all-or-nothing'), on gameplay including player experience dimensions and knowledge gain.

4.4 Questionnaire

To capture gameplay experience in a quantitative way, the in-game Game-Experience Questionnaire (iGEQ) was used. This is a self-report instrument for assessing gameplay experience. This questionnaire consists of seven gameplay experience dimensions – competence, immersion, flow, challenge, tension, negative affect and positive affect. Each gameplay experience dimension is measured for each of the gameplay scaffolding modes under investigation using this instrument.

4.5 Experimental Research/Scientific Method

The scientific method is employed in experimental research. According to Boundless (2014) "The scientific method is the process by which new scientific knowledge is gained and verified. First you must identify a question and, after some preliminary research, form a hypothesis. After designing an experiment to test the hypothesis and collecting data, a scientist will use this information to draw a conclusion. The conclusion will either support the hypothesis or refute it. Based on this information, the scientist will then either reformulate the hypothesis or build upon the original hypothesis. The scientific method cannot prove a hypothesis, only support or refute it." (para.10). Figure 20 below explains the process

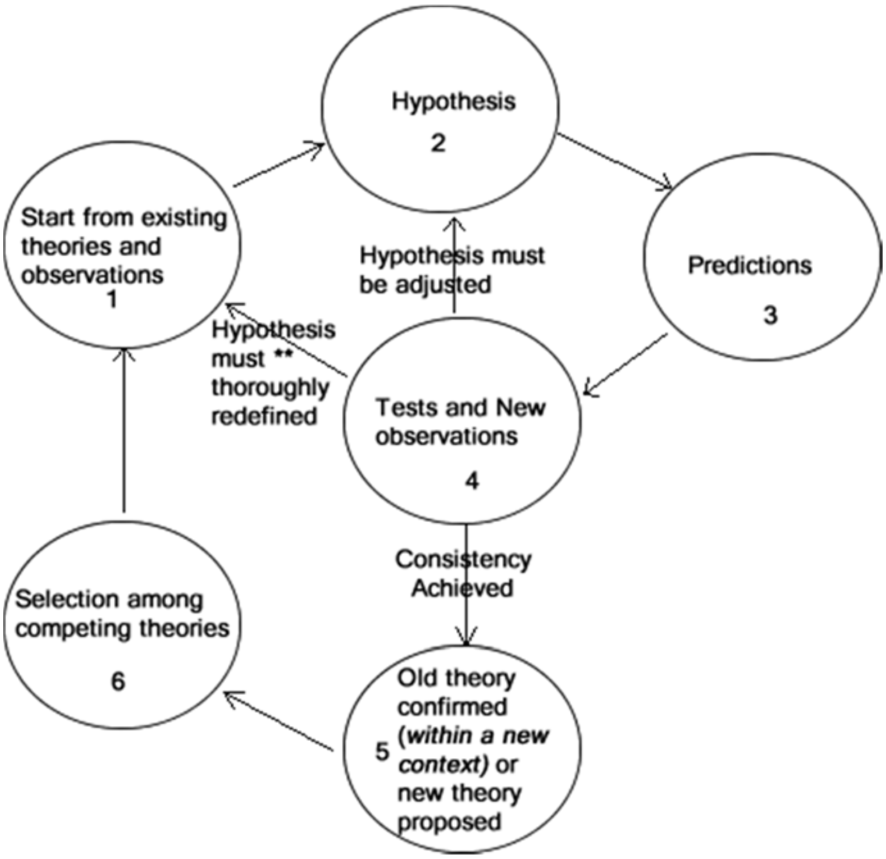

Figure 20 The Scientific Method (Dodig-Crnkovi, 2002)

4.6 The Age Group for this Research

According to Hanna, Risden and Alexander (1997), children in the 6-10 years age group can perform tasks successfully following directions from adults. “They will answer questions and try out new things with ease, and they are not very concerned about being observed when they play with the computer”(Hanna, Risden, & Alexander, 1997, p.10). “The youngest children of this age group (6-7 years old) may be a little shy or inarticulate when talking about the computer” (Hanna et al., 1997, p.10).

(Piaget, 1972) and (Piaget, 1990) proposed a theory of cognitive development in childhood in which he discerned four main stages of child development: 0-2 years (sensorimotor stage), 2-7 years (pre-operational stage), 7-11 years (concrete operational stage), and 11 years and older (formal operational stage).

In the “concrete-operational stage (elementary and early adolescence), operational thinking develops (mental actions that are reversible)” (Huitt & Hummel, 2003, para.8) while in the “pre-operational stage (toddler and early childhood), thinking is done in a non-logical, non-reversible manner” (Huitt & Hummel, 2003, para.8). Though children in the concrete-operational stage are not able to engage in abstract reasoning like those in the formal operational stage, they are capable of logical thought under concrete circumstances (Schonberg, 2013). At this stage they would have developed the ability to classify objects based on a variety of characteristics (e.g. colour) (Schonberg, 2013).

The evaluations in this research would be centered on classifications and some logical reasoning hence children in this stage of development were involved in the evaluation.

4.7 Controlled Experiment

Controlled experiments are conducted to test hypotheses. In this experiment, there are independent and dependent variables. Independent variables are variables that are manipulated – the scaffolding mode is manipulated. Dependent variables are the variables measured after changes have been made to the Independent variable – these include the dimensions of gameplay experience and knowledge gain.

The primary goal of this research is to ascertain the extent to which a gradual removal of scaffolding would affect a child’s game-play in relation to experience and knowledge gain.

> “Games and simulations can offer scaffolding, providing learners with cues, prompts, hints and partial solutions to keep them progressing through learning, until they are capable of directing and controlling their own learning path” (Scientists, 2006).

Scaffolding gameplay is expected to improve the level of sensory, challenge-based and imaginative immersion in addition to enhancing the appropriateness of the challenge(s) and increasing the flow-like experience.

4.8 Dependent Variables (gameplay experience)

The dependent variables in this research are the various dimensions of gameplay experience and knowledge gain. The dimensions of gameplay experience are specified in the Game Experience Questionnaire (GEQ) (Poels et al., 2012)(W. Ijsselsteijn et al., 2008)(Kent, 2013). Competence, challenge, flow, immersion, positive affect, negative affect and tension make up the game experience dimensions.

4.8.1 Competence

> "Game play competence involves the ability to (1) decode the audio-visual sensory and perceptual information delivered by the game media (e.g., the computer screen and speakers) into the apprehension of a local situation within the synthesized game world (or game space); (2) evaluate this understanding of the local in-game situation in terms of the overall objectives of play, current goals and tasks, the state of the player character within the game (e.g., capabilities, health, and other statistics), and anticipation of various rewards of playing the game; (3) make decisions about which in-game tactics and action(s) to perform next, based upon the perceived situation and its evaluation; and (4) perform action(s) based upon competence in interaction mechanics and semantics." (Lindley & Sennersten, 2008)

In the context of games, competence can be categorized into two groups – Motor competence and cognitive competence.

4.8.1.1 Motor Competence:

This subdivides into motor skills and motor knowledge (Kretschmann, 2010).

According to Kretschmann (2010), motor skills include eye-hand and eye-foot co-ordination. While Eye-hand coordination includes screen action in coordination with mouse/keyboard/joypad/steering wheel (Kretschmann, 2010), Eye-foot/ eye-leg coordination includes dance mats and acceleration pedals (Kretschmann, 2010). In addition to eye-hand and eye-foot coordination, there is the gross motor skill. Gross motor skills are associated with imitation/ copying of movements of controlled character(s) on the screen (Kretschmann, 2010).

Motor knowledge is required in improving motor skills. Motor knowledge could mean knowing technical equipment dealing with the game and platform e.g. special joypads (Kretschmann, 2010). Selecting mouse and keyboards for particular games also require motor knowledge (Kretschmann, 2010).

4.8.1.2 Cognitive Competence

In the context of games, cognitive competence is associated to metacognition. According to Kretschmann (2010), this is the player's awareness of audio visual information transmitted by the game media (screen and speakers) in addition to an awareness of various in-game situations as it relates to the overall game objective. These awareness would enable the player strategize and employ different tactics in the course of gameplay.

4.8.2 Immersion

"Immersion is mostly used to refer to the degree of involvement or engagement one experiences with a game" (Wijnand Ijsselsteijn et al., 2007, p.3). According to Ermi & Mayra, (2005b), Immersion can be sensory-based, challenge-based or imaginative-based. They stated that Sensory immersion is related to the audio-visual execution of the game; imaginative being an area in the game where the player is offered a chance to use his/her imagination to empathise with the characters, or just enjoy the fantasy of the game; and challenge-based immersion is the feeling of immersion that is at its most powerful when one is able to achieve a satisfying balance of challenges and abilities. According to L.

E. Nacke & Lindley(2010), challenge-based immersion is very close to what Csikszentmihalyi describes as flow experience. “Challenge-based immersion describes the emergent gameplay experience of a player balancing his abilities against the challenges of the game in so far as gameplay is related to motor and mental skills.” (L. E. Nacke & Lindley, 2010, p.2).

Brown and Cairns (2004) identified three levels of immersion – Engagement, Engrossment and Total immersion. Engagement they referred to as the point the player is investing time, effort and attention in overcoming barriers, such as learning the controls and understanding the game environment. Engrossment they referred to as the point the game captures the player’s attention with the player becoming emotionally invested. At the point of total immersion, the player experiences presence – they are totally absorbed (E. Brown & Cairns, 2004).

4.8.3 Flow

“This is an optimal state of enjoyment where people are completely absorbed in the activity” (Wijnand Ijsselsteijn et al., 2007). “Flow may gradually increase over the course of the game in a homeostatic positive feedback loop, until either the challenge becomes too great (frustration) or the player’s skill outpaces the challenges the game can offer (boredom)” (Wijnand Ijsselsteijn et al., 2007, p.2). Games generally aim at keeping the player in a flow state for as long as possible. This according to Wijnand Ijsselsteijn et al.(2007) is often achieved by creating difficulty levels and advancement models. “Descriptions of Flow experience are identical to what players experience when immersed in games, losing track of time and external pressure, along with other interests” (J. Chen, 2007, p.32).

“Most flow experiences occur with activities that are goal-directed, bounded by rules, and require mental energy and appropriate skills” (Sweetser & Wyeth, 2005, p.3).

4.8.4 Challenge

"Concerning video games, different players have different skills and expect different challenges" (J. Chen, 2007 p.33). Heeter, Lee, Magerko, & Medler (2010) stated that tuning optimal levels of challenge is a big deal for game design and thus could be of necessity in games. "As skill increases, the optimal amount of challenge goes up" (Heeter et al., 2010, p.7). "Optimal levels of challenge (not too hard, not too easy) are likely to be associated with the experience with flow during gameplay and with learning" (Heeter et al., 2010, p.7). According to Heeter et al. (2010), players who feel the game is pleasantly challenging are more likely to acquire the intended impacts of a serious/ serious game.

4.8.5 Tension

"Tension and release form a cornerstone in all branches of art. Whether we're making movies, buildings, stories, songs, or games, these concepts are two sides of the same important coin. Creators use them to engage us in both obvious and subliminal ways, absorbing us emotionally" (Rose, 2016a)

> "No matter what arena you choose, tension is the state of mental or emotional strain. Conflict, stress, pressure, and anxiety are all ways to describe this very animal emotion. It usually has a negative connotation -- people generally try to keep their tension at a minimum. Paradoxically, tension is a must-have in any artistic experience. People absolutely need it in order to enjoy a movie, book, or game. We all know that icky feeling at the end of a movie's second act, when everything is going great but we know something bad has to happen. Deep down we need that horrible thing to happen; we need our character to overcome it. It's the same with the rest of art -- tension is crucial". (Rose, 2016b)

"Tension is present in forms of art as a means for creating emotional hooks and games are especially good at delivering that feeling of being on edge" (Alexiou, Schippers, & Oshri, 2012). Players are emotionally attached to "tension and release" in games (Rose, 2016b), thus it is highly desirable (Rose, 2016b). Game developers only need to manage this phenomenon in games (Alexiou et al., 2012). "A game's goal propel the player through tension; the game's mechanics are the source of its release" (Rose, 2016b). The tension in games can be influenced by players and released through the game mechanics. In most games, a period of particularly high tension often precedes a heightened feeling of triumph (Rose, 2016b).

4.9 Dependent Variables (Learning outcome)

There are three major types of knowledge. They are

1. Declarative knowledge
2. Conceptual Knowledge
3. Procedural knowledge

4.9.1 Declarative knowledge

This is also known as factual knowledge. It is the knowledge of Terminology; specific details and elements (Anderson et al., 2001)

4.9.2 Conceptual knowledge

This is 'knowing that' (Rittle-Johnson & Schneider, 2015) knowledge. It is rich in relationships (Rittle-Johnson & Schneider, 2015). It is the knowledge of classifications and categories; principles and generalizations; and of theories, models and structures (Anderson et al., 2001).

> "Conceptual knowledge is characterized most clearly as knowledge that is rich in relationships. It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information. Relationships pervade the individual facts and propositions so that all pieces of information are linked to some network" (Hiebert, 1986 p 3).

4.9.3 Procedural knowledge

This is the 'know how to do it' knowledge (Rittle-Johnson & Schneider, 2015). It is defined by (Rittle-Johnson & Schneider, 2015) as action sequences for solving problems – the knowledge of subject-specific skills and algorithms; subject-specific techniques and methods; and criteria for determining when to use appropriate procedures (Anderson et al., 2001)

> "The procedures can be (a) algorithms – a predetermined sequence of actions that will lead to the correct answer when executed correctly, or (b) possible actions that must be sequenced appropriately to solve a given problem (e.g., equation-solving steps). This knowledge develops through problem-solving practice, and thus is tied to particular problem types" (Rittle-Johnson & Schneider, 2015)

4.10 Causal Relation between Conceptual and Procedural knowledge

Conceptual and procedural knowledge are "assumed to be distinct, yet related"; they cannot always be separated (Star, 2005)

According to Rittle-Johnson & Schneider (2015), the theoretical viewpoints for the causal relation between conceptual and procedural knowledge include

4.10.1 Concepts-first view:

This view "posits that children initially acquire conceptual knowledge (e.g. through explanations from parents), and then build procedural knowledge from this through repeated practice problem solving" (Rittle-Johnson & Schneider, 2015 p.1124).

4.10.2 Procedures-first view:

This view” posits that children first learn procedures through exploratory behaviour and then derive conceptual knowledge from them by abstraction processes” (Rittle-Johnson & Schneider, 2015 p.1124).

4.10.3 Inactivation view:

This view “posits that conceptual and procedural knowledge develop independently” (Rittle-Johnson & Schneider, 2015 p.1124).

4.10.4 Iterative view:

This view “posits that as conceptual knowledge increases, procedural knowledge increases and vice versa (Rittle-Johnson & Schneider, 2015 p.1124).

Rittle-Johnson & Schneider (2015), emphasize that the iterative view is the most recognized/ accepted view (Rittle-Johnson & Schneider, 2015)

It is “difficult for an item to measure one type of knowledge to the exclusion of the other. Rather, items are thought to predominantly measure one type of knowledge or the other” (Rittle-Johnson & Schneider, 2015).

4.11 Research Questions and Hypotheses

In order to examine how different rates/modes of fading (in micro-scaffolding) in serious games may affect the gameplay experience (challenge, competence, immersion, flow, tension, positive affect and negative affect) and reflective learning, the hypotheses and research questions are:

4.11.1 Hypotheses: Gameplay Experience

H0: The quality of gameplay experience in the 'gradual removal' mode (in micro-scaffolding) will not be significantly better than the quality of gameplay experience in the 'all-or-nothing' mode (in micro-scaffolding).

H1: The quality of gameplay experience in the 'gradual removal' mode (in micro-scaffolding) will be significantly better than the quality of gameplay experience in the 'all-or-nothing' mode (in micro-scaffolding).

4.11.2 Hypotheses: Knowledge gain

H0: The learning gained from gameplay would be significant in the 'all-or-nothing' mode (in micro-scaffolding).

H1: The learning gained from gameplay would not be significant in the 'all-or-nothing' mode (in micro-scaffolding).

4.11.3 Research Questions

RQ1: When compared with the all-or-nothing (switch) guidance-fading approach, does gradual removal of guidance (in micro-scaffolding) improve children's gameplay experience?

RQ2: What dimensions of gameplay experience are impacted and to what extent are they impacted by the gradual removal of guidance (in micro-scaffolding) during gameplay?

RQ3: To what extent would the guidance-fading (gradual removal of scaffolding) during gameplay help children with the acquisition and advancement of competence?

RQ4: What effect would inappropriate guidance-fading have on game-play?

Research Question 1 (RQ1), Research Question 2 (RQ2) and Research Question 4 (RQ4) were answered by first collecting Likert scale data with the In-game Experience Questionnaire (iGEQ) - a concise version of the Game Experience Questionnaire (GEQ). iGEQ has been used in various research work, including –

Correlation between heart rate, electrodermal activity and player experience (Drachen, Nacke, Yannakakis, & Pedersen, 2010) AND Methods for evaluating gameplay experience in a serious gaming context (L. Nacke, Drachen, & Gobel, 2010).

The data collected with the iGEQ was then analysed by performing an Analysis of Variance (ANOVA) to calculate the difference between the gameplay in the 'gradual removal' of scaffolding mode, 'all-or-nothing' mode and the 'no scaffolding' mode. A follow up test was then performed where there was a significant difference from the ANOVA. The aim of this follow up test (Tukey HSD (Honest Significant Difference)) was to identify where the significant difference was i.e. between which two groups (of the three).

Further to answering these questions, there was another study where user activity traces were logged using a yahoo analytics tool – flurry. The user metrics from this log was then used to explain the statistical findings from the initial study.

Research Question 3 (RQ3) was answered by gauging the extent to which the children were able to memorize and retain information. There was an external assessment, where the children answered a set of Multiple Choice Questions (MCQs) after their gameplay. According to Kapp (2012), MCQs "can accurately gauge memorization and retention" Connolly, Hainey, Boyle, Baxter, & Moreno-Ger (2014) state that assessment can either be embedded in gameplay or can be external to gameplay. Games such as 'Trivial Pursuit', 'Who wants to be a Millionaire' and CHERMUG Quantitative game, have all used embedded assessment in the form of MCQs (Michael & Chen, 2005) (Hainey et al., 2014). External assessment is the traditional approach to assessment often with the MCQs. MCQs "can be an effective and efficient way to assess learning outcomes" (Brame, 2013). MCQs can be assess “various levels of learning outcomes, from basic recall to application, analysis, and evaluation” (Brame, 2013) – they would not be suitable for testing creative ideas or articulate explanations (Brame, 2013). MCQs are “less susceptible to guessing than true/false questions, making them a more reliable means of assessment” (Brame, 2013). The scoring of MCQs is quick and accurate. For these reasons, MCQs were used to answer RQ3. The external assessment approach was used i.e. quizzes were not embedded in the game.

The iGEQ data was also relevant for RQ3 as it contains the competence dimension of gameplay experience. Hence its Likert scale data and the ANOVA were useful in answering this research question.

In the table below the data collection and data analysis methods used in answering each research question are highlighted.

	Data Collection Methods			Data Analysis Method	
Research Questions:	iGEQ	MCQ	Flurry	ANOVA	Charts
RQ1	X		X	X	X
RQ2	X		X	X	X
RQ3	X	X			
RQ4	X		X	X	X

Table 2 Highlighting the Data Collection and Data Analysis Methods for each research question

iGEQ – In-Game Experience Questionnaire

MCQ – Multiple choice questions related to the games learning objectives

Flurry – A yahoo app for logging activity traces

ANOVA –Analysis of Variance

4.12 Triangulation

"Relying entirely on a single method of collecting player feedback can be insufficient to understand what motivated player behaviour" (Hazan, 2013). Player feedback can be collected on different methods. The convergence of these methods for the purpose of comparing results has been described as triangulation (Hazan, 2013).

4.12.1 Types of Triangulation

4.12.1.1 Data Triangulation

Sets of data from different people, from different places and from different times are approached with the same methodological approach (Nokleby, 2011).

4.12.1.2 Investigator Triangulation

In this form of triangulation, more than one research is involved in a research – they are often involved in different ways (Nokleby, 2011). For instance one could be observing and the other interviewing. These researchers then analyse together and discuss in order support or contrast each other's findings (Nokleby, 2011)

4.12.1.3 Theory Triangulation

This involves employing different theoretical analyses unto the same set of data (Nokleby, 2011) – this according to Nokleby (2011) may lead to the emergence of new theories.

4.12.1.4 Methodological Triangulation

There are two variations of methodological triangulation – the within method and the between method triangulation (Nokleby, 2011).

Within method triangulation

This entails collecting data in different ways with the same method (Nokleby, 2011). Subscales assessing different dimensions can be used within the same questionnaire. This is the case with the instrument used in this study - the iGEQ (explained in Chapter 5). Different aspects of gameplay experience are assessed with this questionnaire. In the real sense of it only one method is being used (Denzin, 1978).

Between Method Triangulation

This entails combining different methodological approaches (with different strengths and weaknesses) (Denzin, 1978)(Nokleby, 2011). It has been described as the "real methodological triangulation" (Denzin, 1978).

The controlled experiment is triangulated with game telemetry and analytics – a between method triangulation. According to Canossa, Seif El-Nasr, & Drachen (2013), game telemetry and analytics appropriately supplement other methods such as usability testing and playability testing. In game telemetry, an installed game client transmit user-game interaction data to a collection server where the data is transformed and stored in an accessible format to facilitate quick and easy analysis and reporting (Drachen, Seif El-Nasr, & Canossa, 2013). Canossa et al. (2013) state that game analytics show how the game under examination is being played by providing clear and concise hints (Canossa et al., 2013). These hints add substance to conclusions drawn via a different method (Canossa et al., 2013) . Play experience data (quantitative player data) from playtest sessions are captured using a telemetric system (flurry (Flurry, 2014)).

Triangulation enhances confidence in conclusions (G. Thomas & Meffert, 2010).

CHAPTER 5

MEASURING THE QUALITY OF GAMEPLAY EXPERIENCE

5.1 Introduction

The serious nature of games, focusing particularly on gameplay experience has recently drawn significant attention (Örtqvist & Liljedahl, 2010). If we want to understand what a game is, we need to understand the player and the experience of gameplay (Ermi & Mayra, 2005a). Game-play experience is often described as the level/degree of involvement in a game (Bianchi-Berthouze, Kim, & Patel, 2007). It is a generic indicator of game involvement (Brockmyer et al., 2009).The level of involvement describes a player's focus and interest during game-play (Gajadhar, de Kort, & Ijsselsteijn, 2008). This is described in terms of flow, immersion and engagement (Gajadhar et al., 2008). (Gajadhar et al., 2008) also state that in addition to involvement, there is the player enjoyment dimension of player experience. In their work, they described player enjoyment as a generic term that indicates the amount of pleasure or displeasure (Gajadhar et al., 2008), emphasizing that it includes concepts such as positive affect, competence, challenge, frustration and aggression (Gajadhar et al., 2008). According to (Ermi & Mayra, 2005b, p.91), game-play experience can "be defined as an ensemble made up of the player's sensation, thoughts, feelings, actions and meaning-making in a game-play setting". In (Örtqvist & Liljedahl, 2010), it is emphasized that gameplay experience is the core of any game development. The term 'engagement' has also been used by Brockmyer et al. (2009) to describe game-play experience.

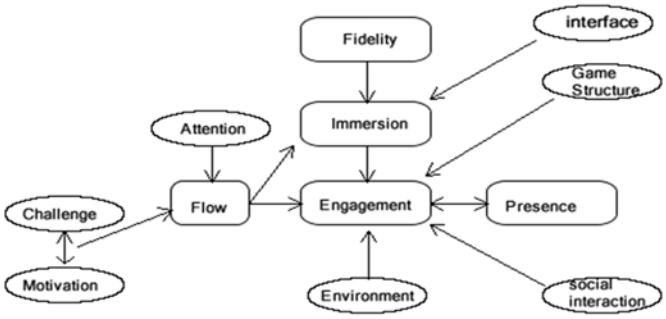

Figure 21 Engagement model summarizing various theories (Bianchi-Berthouze et al., 2007)

Engagement has been defined by O'Brien & Toms (2008), as the quality of user experiences with technology that is characterized by challenge, aesthetic and sensory appeal, feedback, novelty, interactivity, perceived control and time, awareness, motivation, interest, and affect. Furthermore, game-play experience is often linked to the enjoyable aspect of game-play, but according to (L. Nacke, Drachen, et al., 2010) recent developments have included negative aspects such as tension and frustration. Game-play, or game experience as it is often called, has become an important concept in recent academic research concerning games (Frederik, Jan, & Cedric, 2010). It is being examined both theoretically and empirically. To this effect game experience dimensions are being investigated by developing models and self-report questionnaire for measurement purposes. Previous researches have categorized the different dimensions of game-play experience into immersion, flow, competence, attitude, engagement, motivation, curiosity, presence etc. Thus game-play experience is multifaceted. Poels et al., (2012) described it as a "multi-dimensional and multi-layered concept" (p.6). It is also context dependent. Game-play experience is therefore a multi-faceted phenomenon describing the extent to which a player is physically and mentally involved in game-play in any given context.

5.1.1 Objective

The purpose of this chapter is to establish an appropriate method for measuring the quality of game-play experience in our study, considering cost, sample size, time, available resources, context and participants (viz. children).

5.2 Measuring Game-play Experience

Game-play experience is often made up of physical and mental activities. These activities are measured to determine the quality of the experience. The measures for game-play experience can be either direct or indirect. The direct measure is made up of direct observation and monitoring while self-reporting is the indirect measure.

5.2.1 Direct Measures

According to Prince et al. (2008), direct measures consists of physiological markers, motion sensors, monitors (i.e. accelerometers, pedometers, heart rate monitors), **and** direct observation. They state that in addition to being more precise, direct measures would remove issues such as recall and response bias (Prince et al., 2008). They also emphasize that despite these advantages, this method is often expensive and time consuming (Prince et al., 2008). The method can also be intrusive and difficult to apply where there is a large population (Prince et al., 2008). Furthermore, they point out the need for specialized training and the physical proximity of participants for data collection (Prince et al., 2008).

5.2.2 Direct observation

In direct observation, a specific child's game-play is observed by the researcher, either in real-time or on a videotape, for a certain length of time or over a period of time (Kohl, Fulton, & Caspersen, 2000). These data are captured and analysed to determine player experience (Kohl et al., 2000). This form of direct measure can be used in both home and school settings (Kohl et al., 2000). "Direct observation techniques, although not practical for large population studies of physical activity because of a relatively high cost per observation, can be useful for smaller methodological studies" (Kohl et al., 2000, p.S56).

5.2.3 Monitoring

Game-play can be monitored by monitoring devices. These devices have different modes of action (Kohl et al., 2000). These modes of action are described as psycho physiological player testing. This is often deployed in laboratories to capture physical reactions of players (L. Nacke, Drachen, et al., 2010). According to L. Nacke, Drachen, et al.(2010) Electromyography (EMG), Electro dermal Activity (EDA) and Electroencephalography (EEG) capture/ measure the electrical activation of muscles, sweat gland activity (linked to arousal and brain waves respectively). There is also the eye tracking with eye trackers which according to L. Nacke, Drachen, et al.(2010) visualizes cognitive and attention processes during the game-world exploration.

5.2.4 Indirect Measure (Self-Report)

Self-reports are the most commonly employed technique in the measurement of experience (Kohl et al., 2000). It can be either interviewer-administered or self-administered (Kohl et al., 2000). In contrast to the direct methods, "self-report methods are generally relatively inexpensive, quick to administer, unobtrusive, and versatile" (Kohl et al., 2000, P.S59). According to Prince et al. (2008), questionnaires, diaries/ logs, surveys and interviews are forms of self-report (subjective) measures, often used to measure physical activity/ player experience at the population level. “Using a self-report method, study participants are often asked to recall information or physical activity participation during a period in the recent past or, alternatively, they may be asked about their usual or “habitual” activity behaviour” (Kohl et al., 2000). Self-reports are often made of a variety of items administered to measure different constructs. Paulhus & Vazire (2010) pointed out that there is a general rule that prohibits single-item assessment, because it often leads to lower reliability than multi-item composites. In addition, they stated that because of the variety of items administered to assess each construct, it may be less obvious what the test is designed to assess.

The relationship between the various approaches to measuring gameplay experience is depicted in figure 22 below

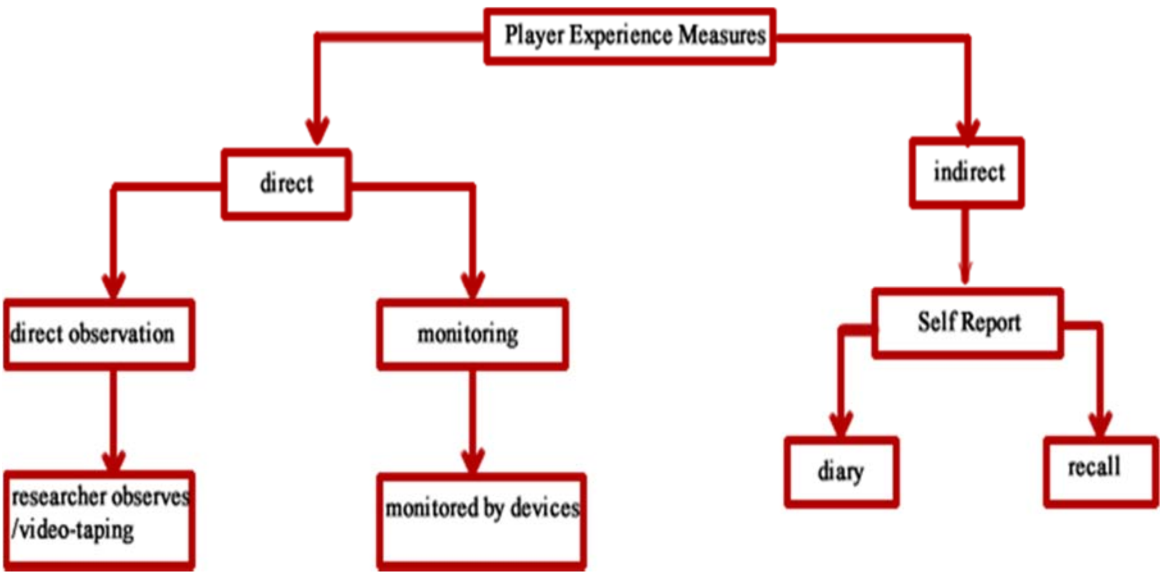

Figure 22 Conceptualizing Player Experience Measures

5.2.5 Hybrid Measure

A hybrid measure is any combination of two techniques in the measurement of experience. The indirect measure (self-report) is often validated with a direct measure. According to Kohl et al.

(2000), “validation efforts must rely on a more precise method as the choice of a criterion against which to measure a test method” (p.S55). Prince et al. (2008) stated that direct measures are commonly used to increase precision and accuracy in addition to validating the self-report measures.

5.3 Factors affecting the choice of Player Experience Measure

In order to determine the appropriate method for measuring player experience, there is need to consider factors such as the number of participants, available time and finances (Prince et al., 2008) and context. In this study, self-report questionnaires have been chosen over the psychophysiological testing approaches such as electromyography (EMG), electro dermal activity (EDA) and electroencephalography (EEG) because of its cost effectiveness, the possibility of dealing with multiple variables at a time; the potential of reaching larger sample size; and the possibility of administering it in the right context, for example in classrooms instead of labs. Currently most researchers are opting for self-report questionnaires to measure more game experience dimensions. Thus current researches often focus on standardizing questionnaires for this purpose. These researches have led to the development of self-report questionnaires like the Game Experience and Game Engagement questionnaires (Kent, 2013). The self-report’s measure technique range from brief study designed question set to more currently, formally developed questionnaires (Nair, 2012)

There is the core and concise version of this questionnaire (Poels, de Kort, & Ijsselsteijn, 2008). The concise version is referred to as the In-Game Experience Questionnaire (iGEQ) (Poels et al., 2008). The concise version is made up 14 items while the core version has 42 items. The concise version (iGEQ) is made up of two items for each construct (a total of 7 constructs) while the core version consists of six items for each of the seven constructs. GEQ has been validated with psychophysiological methods (see L. E. Nacke & Lindley, 2010). In addition, GEQ has also validated with educational games (see (Oksanen & Hamalainen, 2011)). The Game Experience Questionnaire (GEQ) and iGEQ (Poels et al., 2008); (W. Ijsselsteijn et al., 2008); (Wijnand Ijsselsteijn et al., 2007) are chosen for this study. Based on the number of items, the iGEQ would be more suitable for children than the GEQ with 14 and 42 items respectively.

Furthermore these questionnaires offer the opportunity to measure multiple dimensions of gameplay experience at the same time.

5.4 Game-play experience self-report questionnaires

Several game-play experience questionnaires have been empirically developed and validated. This section explores two major game-play experience self-report questionnaires – Game Experience (Wijnand Ijsselsteijn et al., 2008); (Wijnand Ijsselsteijn et al., 2007) and Game Engagement (Brockmyer et al., 2009) Questionnaires. These questionnaires were developed by first identifying relevant game-experience constructs from literatures (theoretical findings) and then carrying out several tests with focus groups (and expert reviews in the case of the Game Experience Questionnaire) to either add to or remove from these constructs (focus group exploration) (Kent, 2013).

According to Brockmyer et al. (2009), "an initial version of the Game Engagement Questionnaire was constructed after the measurement literature on immersion, presence, flow, psychological absorption, and dissociation were reviewed and focus groups were conducted with child and adult video game players" (p.624). The Game Engagement Questionnaire was initially a 10-item version. This became a 15-item version and finally the validated 19-item version. The increments in items were mainly based on findings from focus groups.

Similar to the Game Engagement Questionnaire, the development of the Game Experience Questionnaire started with the theoretical findings from literatures, then findings from focus group exploration (in-game and post-game). This was followed by an expert review of these findings. The outcome was a comprehensive categorization of game experiences. This is shown in a table (Poels et al., 2012) :

Dimension	In-game Experiences	Post-game Experiences
ENJOYMENT	*fun, amusement, pleasure, relaxation*	*energized, satisfaction, relaxation*
FLOW	*concentration, absorption, detachment*	*jetlag, lost track of time, Alienation*
IMAGINATIVE IMMERSION	*absorbed in the story, empathy, identification*	*returning to the real world*
SENSORY IMMERSION	*presence*	returning to the real world
SUSPENSE	*challenge, tension, pressure, hope, anxiety, thrill*	*release, relief, exhausted, euphoria*
COMPETENCE	*pride, euphoria, accomplishment*	*pride, euphoria, accomplishment, satisfaction*
NEGATIVE AFFECT	*frustration, disappointment, irritation, anger*	*regret, guilt, disappointment, anger, revenge*
CONTROL	*autonomy, power, freedom*	*Power, status*
SOCIAL PRESENCE	*Enjoyment with others, being connected with others, empathy, cooperation*	*Accomplishment in a team, bonding*

Table 3 - Table showing the categorization (Poels et al., 2012)

Poels et al. (2012), stated that this table was a frame of reference to the development of the Game Experience Questionnaire and the Social Presence in Gaming Questionnaire. The core Game Experience Questionnaire consists of thirty three items which according to Kent (2013) are scored to obtain measures of seven different components labelled: competence, sensory and imaginative immersion, flow, tension/annoyance, challenge, negative effect and positive effect. According to Gajadhar et al. (2008), “the GEQ includes player enjoyment-related scales of positive affect, competence, challenge and frustration (besides more involvement-oriented scales probing flow immersion, and boredom)" (p.107). Wijnand Ijsselsteijn et al. (2008) states that the Game Experience Questionnaire (GEQ) has been developed and validated under the FUGA project, funded under the EU FP6 NEST 'Measuring the Impossible' initiative. According to Wijnand Ijsselsteijn et al. (2008), it reliably distinguishes between the seven different dimensions of player experience, hence its usefulness for our study.

iGEQ has been used in the following research work

5.5 iGEQ with children

The iGEQ consists of 14 items divided in 7 game experience dimensions (W. Ijsselsteijn et al., 2008). This questionnaire was adapted to a child friendly format for use in this research; the layout and wordings were modified.

The player experience was measured with all the seven scales from the iGEQ – GEQ-competence, GEQ-challenge, GEQ-immersion, GEQ-flow, GEQ-tension, GEQ-positive affect and GEQ-negative affect.

The wordings of some of the items in the iGEQ were modified with the assistance of experts in the field of Child-Computer Interaction. The aim of the modifications was to make it more understandable for children between the ages of seven and eleven. It was hypothesized (and this is tested further on in this thesis) that these modifications would not change the meaning of the items. The iGEQ was originally developed for older children and adults.

Constructs	**Items**
Competence	I felt successful
	I felt skilful
Sensory and Imaginative Immersion	I was interested in the game's story

	I found it impressive
Flow	I forgot everything around me
	I felt completely absorbed
Tension	I felt frustrated
	I felt irritable
Challenge	I felt challenged
	I felt stimulated
Negative affect	I felt bored
	I found it tiresome
Positive affect	I felt content
	I felt good

Table 4 - A table showing the dimensions in the ORIGINAL iGEQ and the corresponding questions

The items contained in the questionnaire were reworded to make it child-friendly. Below is a summary of the modification with regards to the wordings.

Original version	Modified version
I found it impressive	I found it exciting
I found it irritable	It made me easily annoyed
I felt stimulated	I felt encouraged
I found it tiresome	I felt tired
I felt content	I felt satisfied
I felt frustrated	I felt angry
I felt I was completely absorbed	I felt I was in the game

Table 5 – Summary of modifications (wording) made to questionnaire

CHAPTER 6

FIRST STUDY: EMPIRICAL STUDY INVESTIGATING THE EFFECT OF GUIDANCE FADING ON PLAYER EXPERIENCE AND LEARNING OUTCOME

6.1 Introduction

Chapter 6 describes the first empirical study. The chapter is organized into the following sections – Statement of Aim; Statement of research questions; Statement of hypotheses; Research design; Data collection; and Reliability.

6.2 Statement of aim

The aim of this study was to investigate the effectiveness of gradually reducing the number of demonstrated steps (gradual removal) as opposed to abruptly removing these demonstration steps (all-or-nothing) in a gaming context – in this case a serious game context. The results of the study are intended to reveal how effective a 'gradual removal of guidance' can be in relation to children's gameplay experience and learning outcome.

6.3 Statement of research questions

The study sought to answer the following research questions

RQ1: In comparison to the 'all-or-nothing guidance-fading' (independent variable) approach, does 'gradual removal of guidance' (independent variable) improve children's gameplay experience (dependent variable)?

RQ2: What dimensions of gameplay experience are impacted and to what extent are they impacted by the gradual removal of guidance during gameplay?

RQ3: Would ‘gradual removal of guidance’ during gameplay improve knowledge gain?

RQ4: What effect would inappropriate guidance-fading have on game-play?

6.4 Statement of Hypotheses

For Gameplay Experience – ‘Gameplay experience would not be better in the gradual removal of scaffolding mode than it is in the all-or-nothing mode’.

For Learning Outcome –‘Learning gain would not increase more in the gradual removal of scaffolding mode than it will in the all-or-nothing mode’.

6.4.1 Gameplay Experience

H_0: There is no difference in gameplay experience between the ‘gradual removal of scaffolding’ and the ‘all-or-nothing’ modes, on average.

H_a: The gameplay in the ‘gradual removal of scaffolding’ mode would be better than gameplay experience in the ‘all-or-nothing’ mode, on average.

6.4.2 Learning Outcome

H_0: There is no difference in learning gain between the ‘gradual removal of scaffolding’ and the ‘all-or-nothing’ modes, on average

H_a: Gameplay in the ‘gradual removal of scaffolding’ mode would increase learning gain more than gameplay in the ‘all-or-nothing’ mode would, on average.

6.5 Research Design

The experimental design upon which this study was based involved a random assignment of groups to one of the three experimental conditions. Treatment 1 were groups playing in the 'no scaffolding' mode, Treatment 2 were groups playing in the 'all-or-nothing' mode, and Treatment 3 were groups playing in the 'gradual removal of scaffolding' mode.

The participants (children) were assigned randomly to one of three groups. The order effects such as fatigue and practice were eliminated by ensuring that no child was assigned to more than one group.

The independent variables were the scaffolding modes –

- No scaffolding (control) – A
- All-or-Nothing – B
- Gradual Removal – C

The dependent variables were the gameplay experience dimensions –

- Competence
- Immersion
- Flow
- Tension
- Challenge
- Negative affect
- Positive affect

Each group was briefed the same; filled the same questionnaire and attempted a set of multiple choice questions related to the game.

IV = Scaffolding			
	1. No Scaffolding (Control group)	**2. All-Or-Nothing**	**3. Gradual Removal of Scaffolding**
	Group A (18 children) – different from B and C	**Group B (17 children) – different from A and C**	**Group C (17 children) different from A and B**
DV	**Gameplay Experience**	**Gameplay Experience**	**Gameplay Experience**
	Competence	***Competence***	***Competence***
	Immersion	***Immersion***	***Immersion***
	Flow	***Flow***	***Flow***
	Tension	***Tension***	***Tension***
	Challenge	***Challenge***	***Challenge***
	Negative affect	***Negative affect***	***Negative affect***
	Positive affect	***Positive affect***	***Positive affect***

Table 6 Research Design for Gameplay Experience Comparison

IV = Scaffolding			
	1. No Scaffolding (Control group)	**2. All-Or-Nothing**	**3. Gradual Removal group**
	Group A (18 children) – different from B and C	**Group B (17 children) – different from A and C**	**Group C (17 children) different from A and B**
DV	**Learning Outcome**	**Learning Outcome**	**Learning Outcome**

Table 7 Research Design for Learning Outcome Comparison

6.6 Environment and Setting

Six test sessions were conducted (each one of an approximate duration of twenty five minutes). The sessions were conducted in the school's computer lab. The school's computer lab had 18 personal computers running under Microsoft Windows 7 operating system with 17" LCD displays with 1024x768 pixels screen resolution. The game (Alien Chef) ran on the google chrome browser.

Figure 23 The computer lab where the first study was conducted

Each session had a five minutes briefing and consent signing phase; fifteen minutes gameplay; and ten minutes for filling questionnaires and attempting quizzes. This was over a two day period. Year four on the first day and year five on the second day – three sessions per class. In each session the children were either playing the game in the 'gradual removal', 'all-or-nothing' OR the 'no scaffolding' mode. The study was carried out from 10am on the first day and from 1pm on the second day.

6.7 Data Collection Techniques

As this was a quantitative research (see section), numerical data was collected and statistically analyzed (Aliaga & Gunderson, 2000). The study used primary data to address the research questions. Unlike secondary data, primary data provide raw evidence by being basic and original (Sapsford and Jupp, 2006).

6.7.1 Gameplay Experience Measure:

The primary data source for gameplay experience was the concise version of the Game Experience Questionnaire referred to as the In-Game Experience Questionnaire (iGEQ). In order to make the questionnaire child-friendly, there were modifications with regards to layout and wordings - See section 5.5.

The In-game Game Experience Questionnaire (iGEQ) (a set of closed-ended questions) was administered at the end of gameplay to capture the subjective measure of seven dimensions of gameplay experience. This is a self-report instrument developed to assess participants experience during game-play (W. Ijsselsteijn et al., 2008). Using this questionnaire, the children were asked questions aimed at ascertaining how the gameplay made them feel. The ratings were on 5-point Likert scales.

6.7.2 Learning Tests:

To measure learning outcome (the capacity to recall, recognize and understand the Alien dish preparation concepts being introduced) at the knowledge level, a learning test was conducted after the gameplay. The test included four multiple-choice questions (quizzes). Each quiz was expected to reveal how the children assigned meaning to the images they came across during gameplay.

Two of the quizzes consisted of images of two of the three Alien dishes they were expected to prepare as an Alien Chef in the game and four alternative sets of ingredients for each. Each participant was expected to pick the right set of ingredients in each case.

The other two quizzes required that the child identify the correct sequence of activity within the game – 'the sequence for the Alien dishes' activity.

6.8 Ethical Consideration

The data was kept confidential and was only used for this research. In addition, the analysis was run on anonymized data – the identities of the participants are anonymous. The participants were informed that their gameplay was being tracked. They were also informed they could stop playing and opt out at any point.

For a research involving humans – children, an approval from the University of Central Lancashire STEM ethics committee was needed. This was applied for and was granted (See Appendix VIII). The research did not pose any physical or mental risk to the participants (children). In addition, the participants were given the opportunity to opt out of the research at any point.

In addition to the approval from the STEM ethics committee, there were also approvals from the schools' Head teachers. Permissions were also granted by the class teachers/ director of the various classes used for the study. This was in addition to informed consents from the children's parents.

6.9 Apparatus

For this study we used the Alien Chef game. The game is about an Alien Chef in an Alien world preparing Alien dishes for his Alien guests. The game was designed with three modes – the gradual removal of scaffolding mode; the all-or-nothing mode; the no scaffolding mode.

Playing in the gradual removal of scaffolding mode would mean playing with partial scaffolding in three of four attempts i.e. playing with full scaffolding in the first attempt then there is a lessening of the scaffolding as attempts increase;

Playing in the all-or-nothing mode is playing without scaffolding in three of the four attempts;

Playing in the 'no scaffolding' mode is playing without scaffolding in all of the four attempts;

See section 3.6 for details

6.10 Participants

The participants comprised Year four and five children – this was a mixture of boys and girls. All the children had sufficient level of computer skills (computer education was part of the school curriculum). Two teachers and the researcher (experimenter) were involved in the study. The Alien Chef game was played by children (n=52) aged between eight and ten years. The children were randomly assigned to one of the three modes. One group (n=18) played in the gradual removal mode, another group (n=17) played in the all-or-nothing mode and a third group (n=17) played with no scaffolding (control group). The study was over a two day period.

Day One: The Alien Chef game was played by children (n=27) aged between eight and nine years. The gameplay was in the school's computer laboratory. One group (n=9) played in the gradual removal mode – first session, another group (n=10) played in the all-or-nothing mode – second session and a third group (n=8) played with no scaffolding (control group) – third session.

Day Two: The Alien Chef game was played by children (n=25) aged between nine and ten years. The gameplay was in the school's computer laboratory. One group (n=9) played in the gradual removal mode – fourth session, another group (n=7) played in the all-or-nothing mode – fifth session, and a third group (n=9) played with no scaffolding (control group) – sixth session.

6.11 Procedure

The participants were given numbers while still in their classroom. The numbers were given according to their sitting arrangement. The numbers given were one, two and three. Those in year four participated on the first day, while those in year five participated on the second day. **The procedure was same for both days with three sessions on each day.**

The study was carried out in the school's computer laboratory (with eighteen computers).

Upon arrival to the computer laboratory (within the school premises), the potential participants were briefed.

As part of the brief, the experimenter welcomed and introduced himself as a research student from the University of Central Lancashire in the United Kingdom. He then told them they would be playing a game for about fifteen minutes. They were also told they would be answering some questions after gameplay after which he described the game to them – The game is about an Alien Chef in an Alien world preparing Alien dishes for his Alien guests. They were told they could stop whenever they choose to. They were also told that they are encouraged to ask questions whenever and on whatever they do not understand.

The potential participants were then asked if they were willing to take part in the study. They were given consent forms which they all signed to affirm their willingness to take part in the study. Prior to this study, the class teacher had collected the consent forms their parents had signed.

The experimental task on day one involved each participant with the number one sat on a computer and playing the Alien Chef game in the gradual removal mode (first session). After which those with the number two sat and played the same game in the all-or-nothing mode (second session). Then those with number three sat and played the same game in the all-or-nothing mode (third session). The fourth, fifth and sixth sessions were on the second day (same procedure). Each group of participants played for a maximum of fifteen minutes.

Each participant filled the modified iGEQ to measure their gameplay experience. A learning test (with four multiple choice questions to measure the learning gained from gameplay) was also conducted.

Filling the modified iGEQ and attempting the quizzes took the participants about ten minutes on the average.

6.12 Data Analysis

Data analysis which is the systematic interpretation of data by statistical techniques (Creswell, 2014), was applied to the collected data. There has been several debates on how Likert-scale data should be analysed (Subedi, 2016), leading to confusion and incorrect analyses of these data. To understand how Likert-scale data should be analysed, there is need to understand what Likert-scale data are. Firstly the underlying confusion in thinking Likert-scale data is no different from Likert-type data should be diffused.

6.12.1 Difference between Likert-scale data and Likert-type data

Likert-scale data are obtained from Likert scales composed of multiple Likert-type items. Likert-type data (from Likert-type items) on its own is ordinal. A combination of Likert-type items to make up a variable is referred to as a Likert-scale. This data is regarded as interval data (J. D. Brown, 2011).

6.12.2 iGEQ and Analysis

Firstly, the iGEQ, has various variables composed of Likert-type items, it should be regarded as a Likert-scale and the data treated as interval data.

Secondly, the measure of central tendency recommended by the authors of this instrument is the mean. Thus means and standard deviations should be used to describe the scale.

Thirdly, there is no need for a normality test as the sample size is greater than thirty. This is in line with the Central Limit Theorem.

Based on the aforementioned points, a parametric analysis of the iGEQ data is justifiable. The Analysis of Variance (ANOVA) is thus the appropriate inferential statistics for this study.

In addition to the ANOVA, there will also be post hoc testing where there is significant difference. This is because ANOVA is unable to determine specific means that are different from one another (Gravetter & Wallnau, 2013). To determine the specific significant mean differences, a Tukey's Honestly Significant Difference (HSD) is used (Gravetter & Wallnau, 2003). This analysis would seek to provide answers to RQ1 and RQ2 and even RQ4

6.12.3 The multiple-choice questions and Analysis

The multiple-choice questions are scored for the various participants. Since the numbers (for scores) indicate order and reflect meaningful distance between points, it is regarded as interval scale data. Just like the iGEQ, the measure of central tendency to be used with this data is the mean. The inferential statistics would involve running parametric tests which would include ANOVA to test for significance in learning outcome between the scaffolding modes being investigated, and Pearson correlation to investigate the relationship between learning outcomes and various gameplay experience dimensions. This analysis would seek to provide answers to RQ3.

6.13 Summary

The study details from the purpose of study right through to the procedure was described in this chapter. The data collection techniques for both gameplay experience and learning outcomes were also described. Also included in this chapter are the data analysis considerations and what research questions would be answered through the analyses.

The results are reported in the next chapter.

CHAPTER 7

EXPERIMENTAL RESULTS FROM STUDY ONE

7.1 Introduction

This chapter presents the statistical analysis of the results of the experiment. The implications are not presented in this chapter. The implications including interpretation and practical significance of the relationships will be discussed in Chapter 8.

The statistical methods used are presented. This is followed by the tests of the hypotheses. This will include the gameplay experience variables and learning outcome.

The data that was statistically analysed for gameplay experience and learning outcome was gathered from the iGEQ and a set of multiple choice questions respectively. The independent variables were the scaffolding modes – gradual removal, all-or-nothing and the no scaffolding modes. The dependent variables were the gameplay experience dimensions and learning outcomes.

7.2 Statistical Methods

The major statistical method used to analyse the data was analysis of variance (ANOVA) section 6.12.2 for details on why ANOVA was used). This was performed to determine if there was a difference in the means of the three groups. Follow-up analyses were also performed. The statistical method used for the follow-up analysis was a Tukey post hoc test. A Pearson correlation was also conducted to ascertain the relationship between each gameplay experience dimension and learning gain.

For this study, the SPSS statistical package was used to analyse the statistical data.

7.3 Statistical Results and Tests of the Hypotheses

The discussion of the results of the analysis is grouped into two areas based on the dependent variables.

1. Gameplay experience variables – Competence, immersion, flow, tension, challenge, negative affect and positive affect
2. Learning outcome

The results are presented in terms of support or non-support of the hypotheses stated in section 4.11.1. It was expected that manipulating in-game scaffolding would have a significant impact on the gameplay experiences and learning gain with gradually removing scaffolding expected to improve gameplay experience and increase learning outcome.

7.4 The Questionnaire – iGEQ

The iGEQ used to measure gameplay experience in this study, is a short self-report scale for exploration of player experience while playing a digital game (Ijsselsteijn et al. 2008) cited in (Drachen et al., 2010). "It contains 14-items, all rated on a Likert-type scale scored from 0-4, distributed in pairs between seven dimensions of player experience" (Drachen, Nacke, Yannakakis, & Pedersen, 2010 p.2) which are the dependent variables - Competence, Immersion, flow, challenge, tension, negative affect and positive affect. iGEQ is the concise version of the GEQ. The GEQ has previously been validated by the creators (Ijsselsteijn et al., 2008) and subsequently validated with psychophysiological methods (see L. E. Nacke & Lindley, 2010).

Considering the iGEQ was not designed for children there was a need to make some modifications to this questionnaire, with the aim of making it child friendly. There was also a pilot study to test the modified iGEQ questionnaire with children. Five children took part in this study. They played the Alien Chef game and indicated how the gameplay made them fill using the iGEQ. All five children said they found the questionnaire easy to use and understood every questions.

Though this study was carried out and the questionnaire seemed appropriate, a reliability test after the main study revealed inconsistencies (some low reliabilities) with some sub scales, though the overall scale had a high reliability. See table below.

7.5 Reliability Statistics

Scale	Cronbach's Alpha	Cronbach's alpha based on standardized items	N of items
Competence	0.627	0.627	2
Immersion	0.728	0.731	2
Flow	0.259	0.259	2
Tension	0.653	0.653	2
Challenge	0.471	0.473	2
Negative Affect	0.300	0.300	2
Positive Affect	0.789	0.803	2

Table 8 Showing the Cronbach's alpha for each subscale

Scale	Cronbach’s Alpha	Cronbach’s alpha based on standardized items	N of items
Overall Scale	0.880	0.889	14

Table 9 Showing the Cronbach's Alpha for the overall scale

Cronbach’s alpha was calculated for each subscale, as well as the overall scale. Considering the subscales had less than ten items, the reliability level of 0.6 would be considered acceptable as suggested by Loewenthal (1996) (Hassad, 2011)

The competence, immersion, tension and positive affect subscales of the iGEQ all had acceptable levels of reliability, alpha > 0.6. Immersion and positive affect both had high reliabilities, alpha > 0.7 However, flow, challenge and negative affect had unacceptable levels of reliability, alpha < 0.6.

Though the iGEQ is a Likert scale –i.e. consisting of subscales, Cronbach’s alpha was also calculated for the iGEQ as Likert type item – i.e. assuming no subscales. In this case, Cronbach’s alpha was highly reliable, alpha =0.880

7.6 Gameplay Experience Results

7.6.1 Competence

Competence measures included two items ‘I felt successful’ and ‘I felt skilful’. Since it is hypothesized that gameplay in the ‘gradual removal of scaffolding’ mode would be better than gameplay in the ‘all-or-nothing’ mode, it is expected that gameplay in the ‘gradual removal of scaffolding’ mode would lead to a higher level of competence, than gameplay in the ‘all-or-nothing’ mode will. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on competence in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For ‘no scaffolding’ mode (M=2.56, SD=1.46), ‘all or nothing’ (M=3.15, SD=1.06), ‘gradual removal’ (M=3.58, SD=0.55); $F\ (2,\ 49) = 3.966$, $p = 0.025$. This reveal a significant effect of scaffolding on competence at the $p < 0.05$ level for the three modes.

(I) group (control)	N	Mean	Std. Deviation	Std. Error	95% confidence interval lower bound	upper bound
No scaffolding	17	2.559	1.4565	0.3532	1.810	3.308
All-or-Nothing	17	3.147	1.0572	0.2564	2.604	3.691
Gradual Removal	18	3.583	0.5491	0.1294	3.310	3.856
Total	52	3.106	1.1390	0.1580	2.789	3.423

Table 10 Dependent variable: Competence Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.220	2	4.610	3.966	.025
Within Groups	56.949	49	1.162		
Total	66.168	51			

Table 11 Dependent variable: Competence ANOVA

Post-hoc comparisons showed that gameplay in the ‘gradual removal’ mode, significantly increased competence when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.019). In contrast, gameplay in the ‘all-or-nothing’ mode did not significantly increase competence when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.259). There was also no significant difference in competence between gameplay in the ‘gradual removal’ mode and gameplay in the ‘all-or-nothing’ mode (HSD-post-hoc test, p = 0.461).

(I) group	(J) group	mean difference (J-I)	std. error	sig.
Gradual removal	All-or-nothing	0.4363	0.3646	0.461
Gradual removal	No scaffolding	1.0245	0.3646	0.019
All-or-nothing	Gradual removal	-0.4363	0.3698	0.461

(I) group	(J) group	mean difference (J-I)	std. error	sig.
All-or-nothing	No scaffolding	0.5882	0.3698	0.259
No scaffolding	Gradual removal	-1.0245	0.3646	0.019
No scaffolding	All-or-nothing	-0.5882	0.3698	0.305

The mean difference is significant at the 0.05 level

Table 12 Dependent variable: Competence Tukey HSD.

There was a significant linear trend, F (1, 49) = 7.876, p = 0.007, indicating that as the removal of scaffolding became more gradual, competence increased proportionately. See table in Appendix II

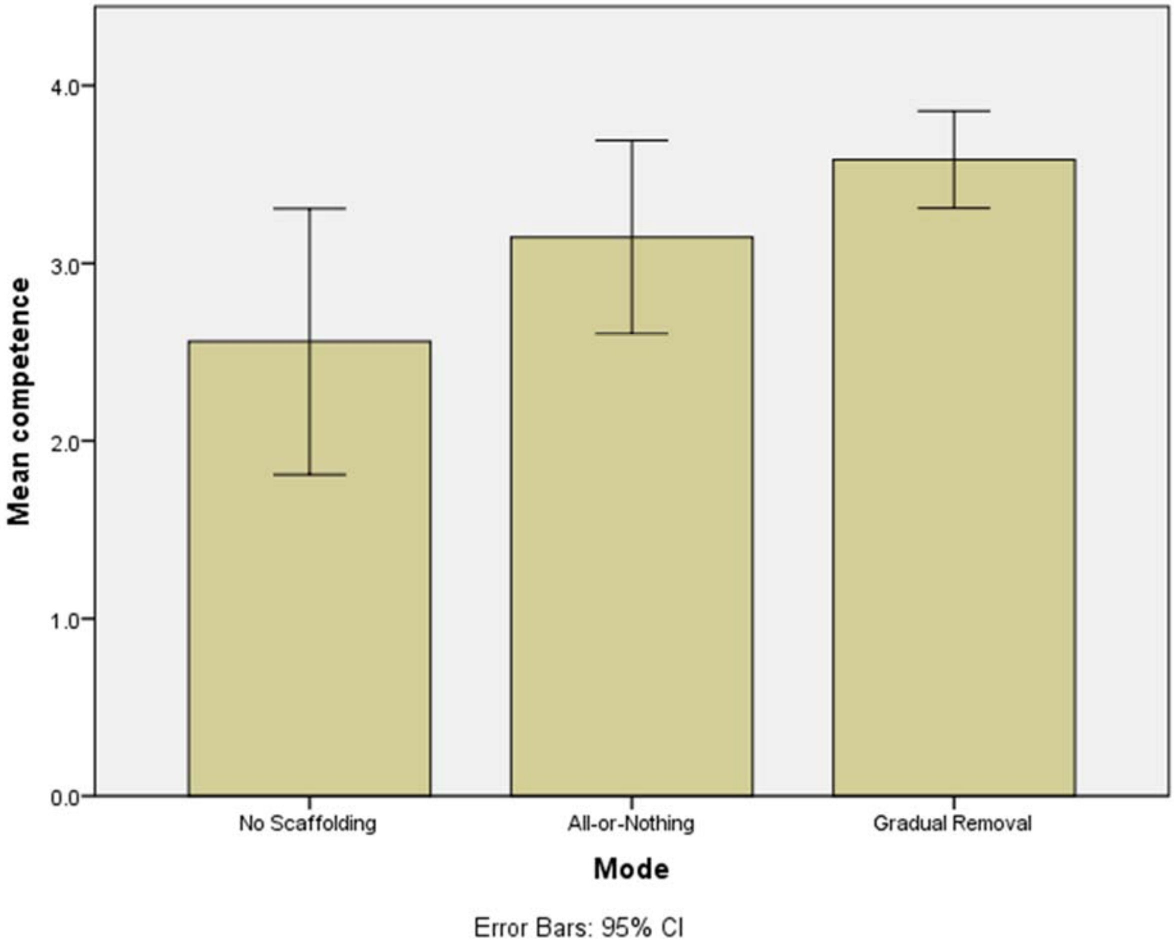

Figure 24 Error bars for Competence

7.6.2 Immersion

Immersion measures included two items 'I was interested in the game story' and 'I found it exciting'. Since it is hypothesized that gameplay in the 'gradual removal of scaffolding' mode would be better than gameplay in the 'all-or-nothing' mode, it is expected that gameplay in the 'gradual removal of scaffolding' mode would lead to a higher level of immersion, than gameplay in the 'all-or-nothing' mode will. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on immersion in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For ‘no scaffolding’ mode (M=2.62, SD=1.46), ‘all or nothing’ (M=3.38, SD=1.01), ‘gradual removal’ (M=3.69, SD=0.39); F (2, 49) = 4.912, p = 0.011.

(I) group (control)	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% confidence interval**	
					lower bound	**upper bound**
No scaffolding	17	2.618	1.4634	0.3549	1.865	3.370
All-or-Nothing	17	3.382	1.0082	0.2445	2.864	3.901
Gradual Removal	18	3.694	0.3888	0.0916	3.501	3.888
Total	52	3.240	1.1180	0.1550	2.929	3.552

Table 13 Dependent variable: Immersion Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.646	2	5.323	4.912	.011
Within Groups	53.099	49	1.084		
Total	63.745	51			

Table 14 Dependent variable: Immersion Descriptive statistics

Post-hoc comparisons showed that gameplay in the ‘gradual removal’ mode, significantly increased immersion when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.010). In contrast, gameplay in the ‘all-or-nothing’ mode did not significantly increase immersion when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.092). There was also no significant difference in immersion between gameplay in the ‘gradual removal’ mode and gameplay in the ‘all-or-nothing’ mode (HSD-post-hoc test, p = 0.651).

(I) group	**(J) group**	**mean difference (J-I)**	**std. error**	**sig.**
Gradual removal	All-or-nothing	0.3121	0.3521	0.651
Gradual removal	No scaffolding	1.0768	0.3521	0.010
All-or-nothing	Gradual removal	-0.3121	0.3521	0.651
All-or-nothing	No scaffolding	0.7647	0.3571	0.092

(I) group	(J) group	mean difference (J-I)	std. error	sig.
No scaffolding	Gradual removal	-1.0768	0.3521	0.010
No scaffolding	All-or-nothing	-0.7647	0.3571	0.092

The mean difference is significant at the 0.05 level

Table 15 Dependent variable: Immersion Tukey HSD.

There was a significant linear trend, F (1, 49) = 9.284, p = 0.004, indicating that as the removal of scaffolding became more gradual, immersion increased proportionately. See table in Appendix II

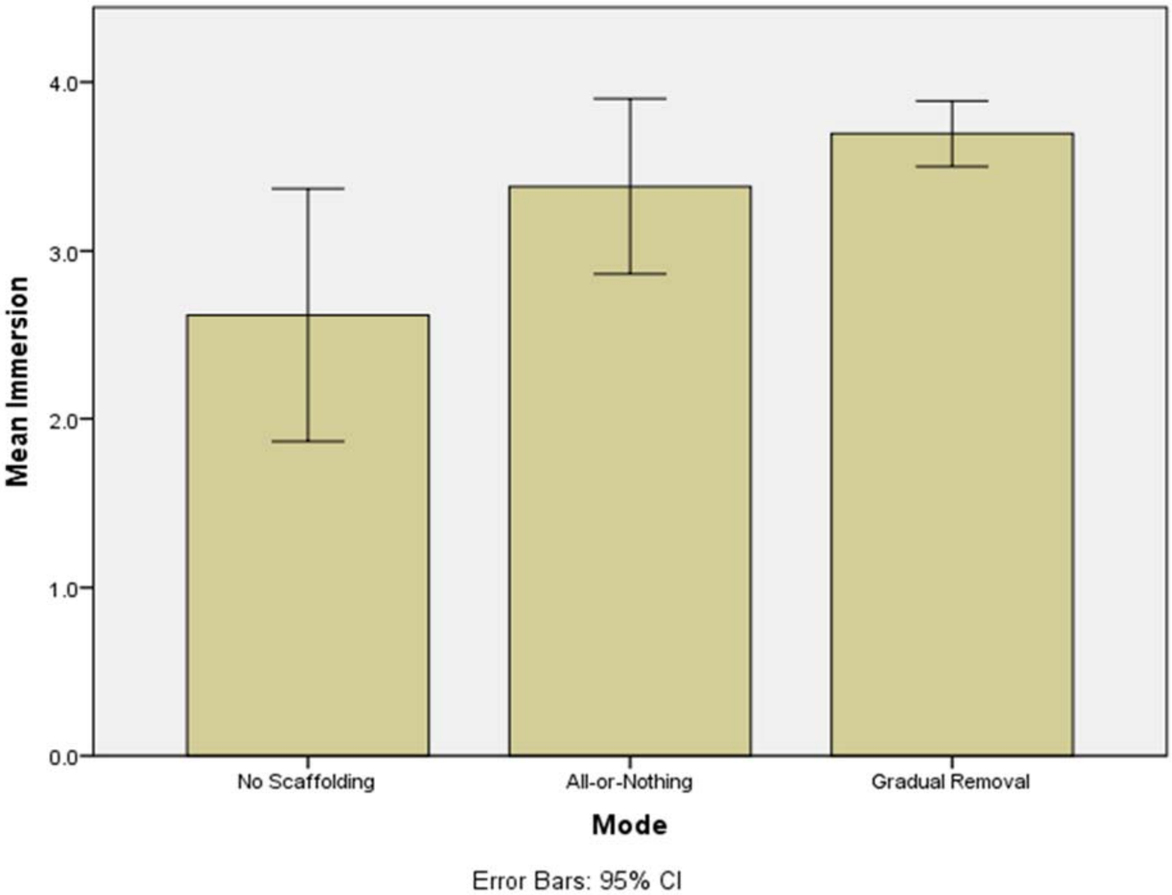

Figure 25 Error bars for Immersion

7.6.3 Flow

Flow measures included two items 'I forgot everything around me' and 'I felt completely absorbed'. Since it is hypothesized that gameplay in the 'gradual removal of scaffolding' mode would be better than gameplay in the 'all-or-nothing' mode, it is expected that gameplay in the 'gradual removal of scaffolding' mode would increase flow, than gameplay in the 'all-or-nothing' mode will. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on flow in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For 'no scaffolding' mode (M = 1.79, SD = 1.25), 'all or nothing' (M = 2.18, SD = 1.12), 'gradual removal' (M = 2.78, SD = 1.09); F (2, 49) = 3.249, p = 0.047.

					95% confidence interval	
(I) group (control)	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**lower bound**	**upper bound**
No scaffolding	17	1.794	1.2507	0.3033	1.151	2.437
All-or-Nothing	17	2.176	1.1172	0.2710	1.602	2.751
Gradual Removal	18	2.778	1.0877	0.2564	2.237	3.319
Total	52	2.260	1.2025	0.1668	1.925	2.594

Table 16 Dependent variable: Flow Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.634	2	4.317	3.249	.047
Within Groups	65.111	49	1.329		
Total	73.745	51			

Table 17 Dependent variable: Flow ANOVA

Post-hoc comparisons showed that gameplay in the 'gradual removal' mode, significantly increased flow when compared to gameplay in the 'no scaffolding' mode (HSD-post-hoc test, p = 0.039). In contrast, gameplay in the 'all-or-nothing' mode did not significantly increase flow when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.601). There was also no significant difference in flow between gameplay in the ‘gradual removal’ mode and gameplay in the ‘all-or-nothing’ mode (HSD-post-hoc test, p = 0.280).

(I) group	(J) group	mean difference (J-I)	std. error	sig.
Gradual removal	All-or-nothing	0.6013	0.3899	0.280
Gradual removal	No scaffolding	0.9837	0.3899	0.039
All-or-nothing	Gradual removal	-0.6013	0.3899	0.280
All-or-nothing	No scaffolding	0.3824	0.3954	0.601
No scaffolding	Gradual removal	-0.9837	0.3899	0.039
No scaffolding	All-or-nothing	-0.3824	0.3954	0.601

The mean difference is significant at the 0.05 level

Table 18 Dependent variable: Flow Tukey HSD.

There was a significant linear trend, F (1, 49) = 6.394, p = 0.015, indicating that as the removal of scaffolding became more gradual, flow increased proportionately. See table in Appendix II

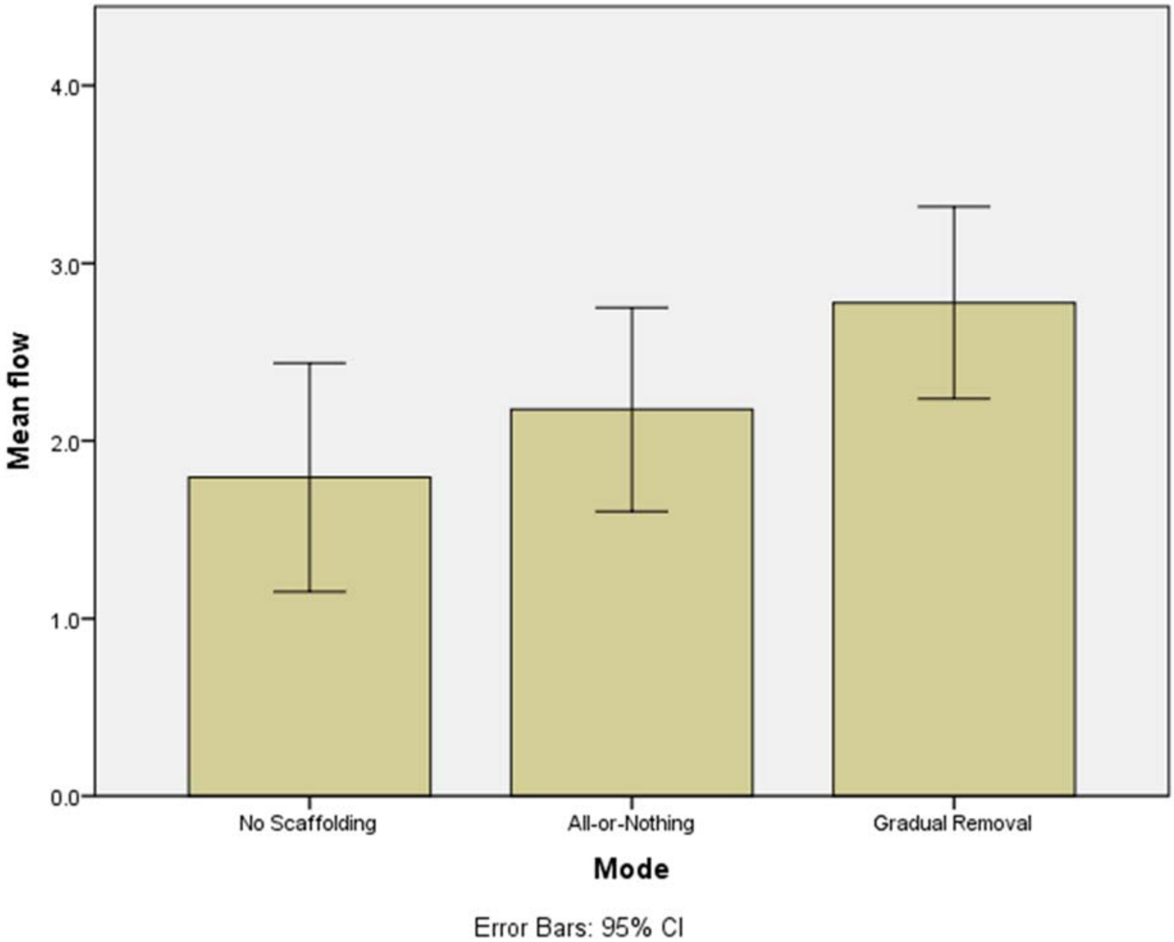

Figure 26 Error Bars for Flow

It is important to note that the reliability of this subscale was very low, alpha = 0.259 – an indication that the children might have found the composite Likert-type items confusing.

7.6.4 Tension

Tension measures included two items 'I felt frustrated' and 'It made me easily annoyed'. Since it is hypothesized that the gameplay experience in the 'gradual removal of scaffolding' mode would be better than the gameplay experience in the 'all-or-nothing' mode, it is expected that gameplay in the 'gradual removal of scaffolding' mode would reduce tension, than gameplay in the 'all-or-nothing' mode will. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on tension in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For 'no scaffolding' mode (M = 1.82, SD = 1.51), 'all or nothing' (M = 1.06, SD = 1.20), 'gradual removal' (M = 0.36, SD = 0.66); F (2, 49) = 6.857, p = 0.002.

(I) group (control)	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% confidence interval** lower bound	upper bound
No scaffolding	17	1.824	1.5098	0.3662	1.047	2.600
All-or-Nothing	17	1.059	1.1974	0.2904	0.443	1.674
Gradual Removal	18	0.361	1.6599	0.1555	0.033	0.689
Total	52	1.067	1.2949	0.1796	0.707	1.428

Table 19 Dependent variable: Tension Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.700	2	9.350	6.857	.002
Within Groups	66.815	49	1.364		
Total	85.514	51			

Table 20 Dependent variable: Tension ANOVA

Post-hoc comparisons showed that gameplay in the 'gradual removal' mode, significantly decreased tension when compared to gameplay in the 'no scaffolding' mode (HSD-post-hoc test, p = 0.002).In contrast, gameplay in the 'all-or-nothing' mode did not significantly decrease tension when compared to gameplay in the 'no scaffolding' mode (HSD-post-hoc test, p = 0.147). There was also no significant difference in tension between gameplay in the 'gradual removal' mode and gameplay in the 'all-or-nothing' mode (HSD-post-hoc test, p = 0.191).

(I) group	(J) group	mean difference (J-I)	std. error	sig.
Gradual removal	All-or-nothing	-0.6977	0.3949	0.191
Gradual removal	No scaffolding	1.4624	0.3949	0.002
All-or-nothing	Gradual removal	0.6977	0.3949	0.191
All-or-nothing	No scaffolding	-0.7647	0.4005	0.147
No scaffolding	Gradual removal	1.4624	0.3949	0.082
No scaffolding	All-or-nothing	0.7647	0.4005	0.525

The mean difference is significant at the 0.05 level

Table 21 Dependent variable: Tension Tukey HSD.

There was a significant linear trend, F (1, 49) = 13.705, p = 0.001, indicating that as the removal of scaffolding became more gradual, tension decreased proportionately. See table in Appendix II

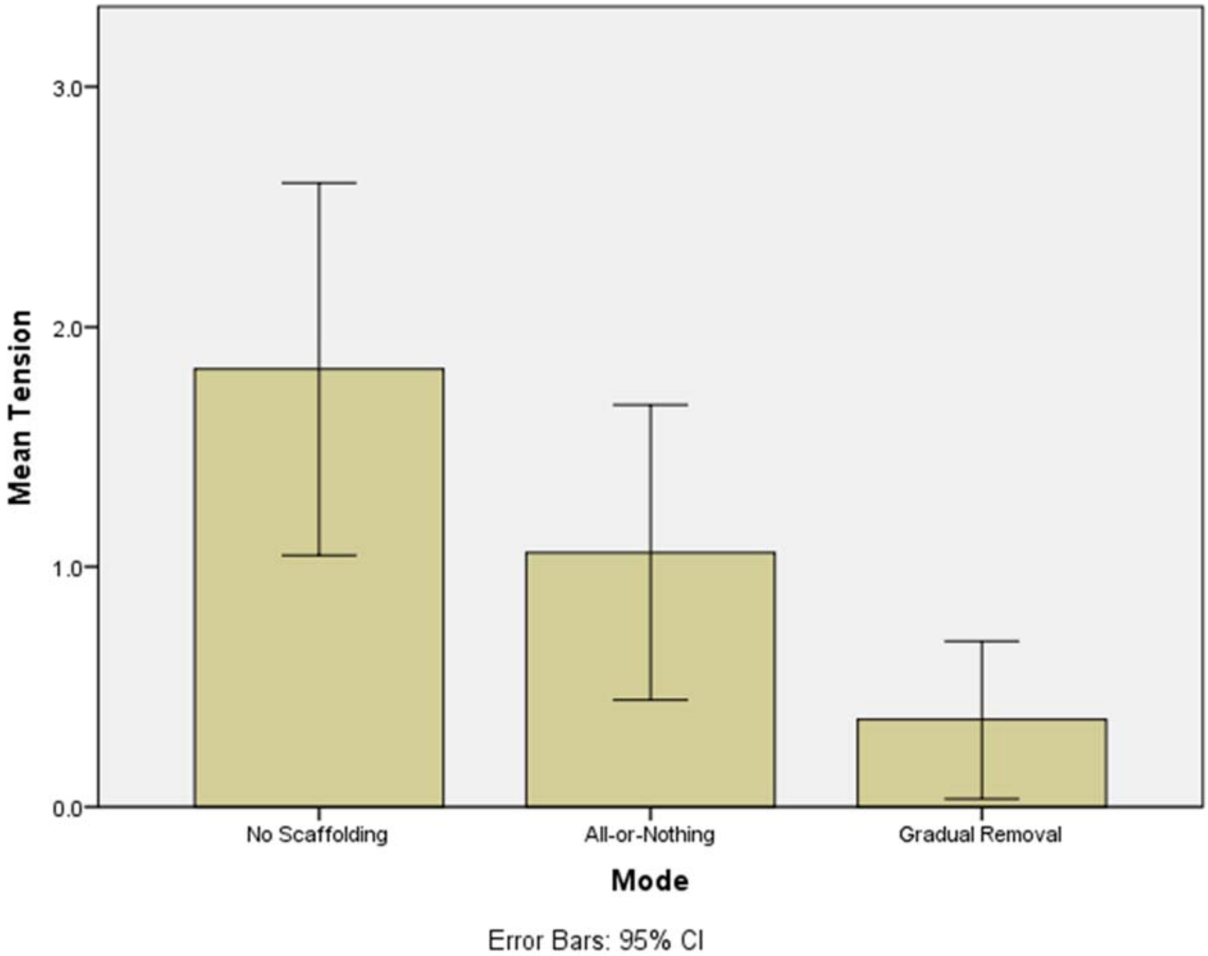

Figure 27 Error Bars for Tension

7.6.5 Challenge

Challenge measures included two items 'I felt challenged' and 'I felt encouraged'. Since it is hypothesized that the gameplay experience in the 'gradual removal of scaffolding' mode would be better than gameplay experience in the 'all-or-nothing' mode, it is expected that gameplay in the 'gradual removal of scaffolding' mode would improve challenge, than gameplay in the 'all-or-nothing' mode will. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on challenge in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For 'no scaffolding' mode (M = 2.68, SD = 1.31), 'all or nothing' (M = 2.24, SD = 1.19), 'gradual removal' (M = 3.11, SD = 1.04); $F(2, 49) = 2.406$, $p = 0.101$.

(I) group (control)	N	Mean	Std. Deviation	Std. Error	95% confidence interval lower bound	upper bound
No scaffolding	17	2.676	1.3103	0.3178	2.003	3.350
All-or-Nothing	17	2.235	1.1874	0.2880	1.625	2.846
Gradual Removal	18	3.111	1.0369	0.2444	2.595	3.627
Total	52	2.683	1.2128	0.1682	2.345	3.020

Table 22 Dependent variable: Challenge Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.707	2	3.354	2.406	.101
Within Groups	68.307	49	1.394		
Total	75.014	51			

Table 23 Dependent variable: Challenge ANOVA

There was NO significant linear trend, $F(1, 49) = 1.253$, $p = 0.268$. See table in Appendix II

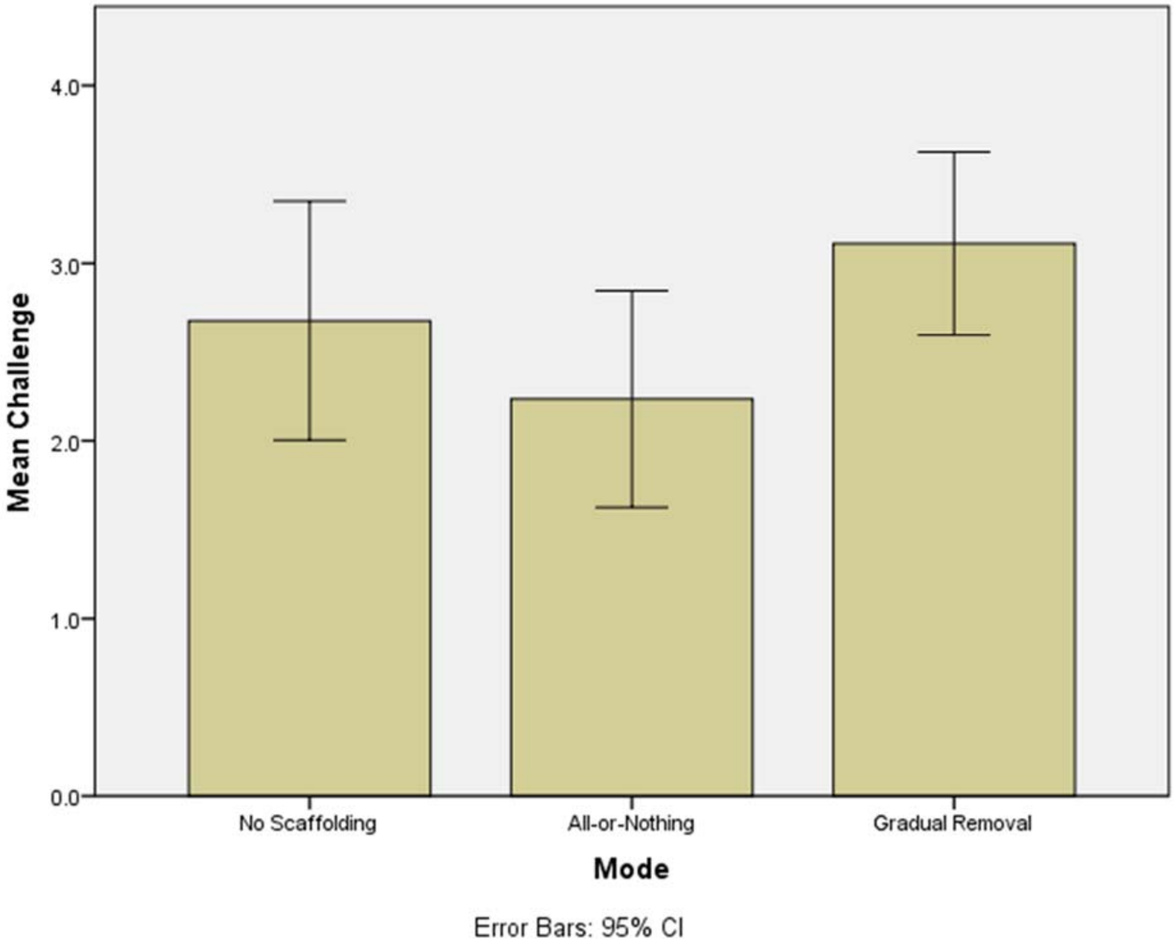

Figure 28 Error Bars for Challenge

It is important to note that the reliability of this subscale was low, alpha = 0.473 – an indication that the children might have found the composite Likert-type items confusing.

7.6.6 Negative Affect

Negative affect measures included two items 'I felt bored' and 'I felt tired'. Since it is hypothesized that the gameplay experience in the 'gradual removal of scaffolding' mode would be better than gameplay experience in the 'all-or-nothing' mode, it is expected that gameplay experience in the 'gradual removal of scaffolding' mode would reduce negative affect, than gameplay experience in the 'all-or-nothing' mode will. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on negative affect in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For 'no scaffolding' mode (M = 1.24, SD = 1.48), 'all or nothing' (M = 1.18, SD = 0.93), 'gradual removal' (M = 0.44, SD = 0.64); F (2, 49) = 3.000, p = 0.059.

(I) group (control)	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% confidence interval**	
					lower bound	**upper bound**
No scaffolding	17	1.235	1.4803	0.3590	0.474	1.996
All-or-Nothing	17	1.176	0.9344	0.2266	0.696	1.657
Gradual Removal	18	0.444	0.6391	0.1506	0.127	0.762
Total	52	0.942	1.1099	0.1539	0.633	1.251

Table 24 Dependent variable: Negative affects Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.853	2	3.427	3.000	.059
Within Groups	55.974	49	1.142		
Total	62.827	51			

Table 25 Dependent variable: Negative affects ANOVA

There was a significant linear trend, F (1, 49) = 4.865, p = 0.032, indicating that as the removal of scaffolding became more gradual, negative affect decreased proportionately. See table in Appendix II

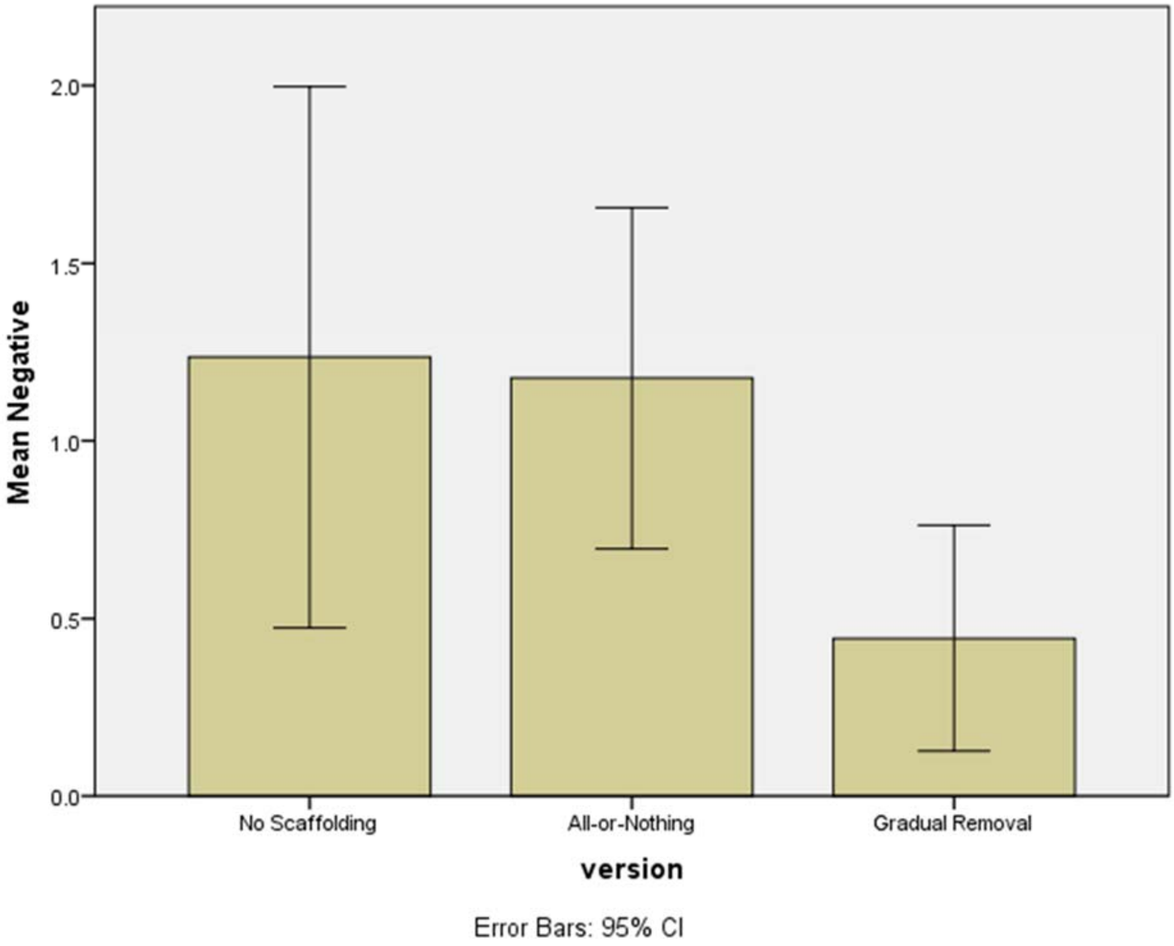

Figure 29 Error Bars for Negative Affect

It is important to note that the reliability of this subscale was very low, alpha = 0.300 – an indication that the children might have found the composite Likert-type items confusing.

7.6.7 Positive Affect

Positive affect measures included two items 'I felt satisfied' and 'I felt good'. Since it is hypothesized that the gameplay experience in the 'gradual removal of scaffolding' mode would be better than gameplay experience in the 'all-or-nothing' mode, it is expected that gameplay experience in the 'gradual removal of scaffolding' mode would increase positive affect, than gameplay experience in the 'all-or-nothing' mode would. A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on positive affect in gradual removal, all-or-nothing, and no scaffolding (control group) modes. For ‘no scaffolding’ mode (M = 2.62, SD = 1.53), ‘all or nothing’ (M = 3.32, SD = 1.32), ‘gradual removal’ (M = 3.64, SD = 0.51); F (2, 49) = 3.339, p = 0.044.

(I) group (control)	N	Mean	Std. Deviation	Std. Error	95% confidence interval lower bound	95% confidence interval upper bound
No scaffolding	17	2.618	1.5261	0.3701	1.833	3.402
All-or-Nothing	17	3.324	1.3222	0.3207	2.644	4.003
Gradual Removal	18	3.639	0.5089	0.1200	3.386	3.892
Total	52	3.202	1.2456	0.1727	2.855	3.549

Table 26 Dependent variable: Positive affects Descriptive statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.492	2	4.746	3.339	.044
Within Groups	69.638	49	1.421		
Total	79.130	51			

Table 27 Dependent variable: Positive affects ANOVA

Post-hoc comparisons showed that gameplay in the ‘gradual removal’ mode, significantly increased positive affect when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.038).In contrast, gameplay in the ‘all-or-nothing’ mode did not significantly increase positive affect when compared to gameplay in the ‘no scaffolding’ mode (HSD-post-hoc test, p = 0.206). There was also no significant difference in positive affect between gameplay in the ‘gradual removal’ mode and gameplay in the ‘all-or-nothing’ mode (HSD-post-hoc test, p = 0.716).

(I) group	(J) group	mean difference (J-I)	std. error	sig.
Gradual removal	All-or-nothing	0.3154	0.4032	0.716
Gradual removal	No scaffolding	1.0212	0.4032	0.038
All-or-nothing	Gradual removal	-0.3154	0.4032	0.716
All-or-nothing	No scaffolding	0.7059	0.4089	0.206
No scaffolding	Gradual removal	-1.0212	0.4032	0.038
No scaffolding	All-or-nothing	-0.7059	0.4089	0.206

The mean difference is significant at the 0.05 level

Table 28 Dependent variable: Positive Affects Tukey HSD.

There was a significant linear trend, F (1, 49) = 6.372, p = 0.015, indicating that as the removal of scaffolding became more gradual, positive affect increased proportionately. See table in Appendix II

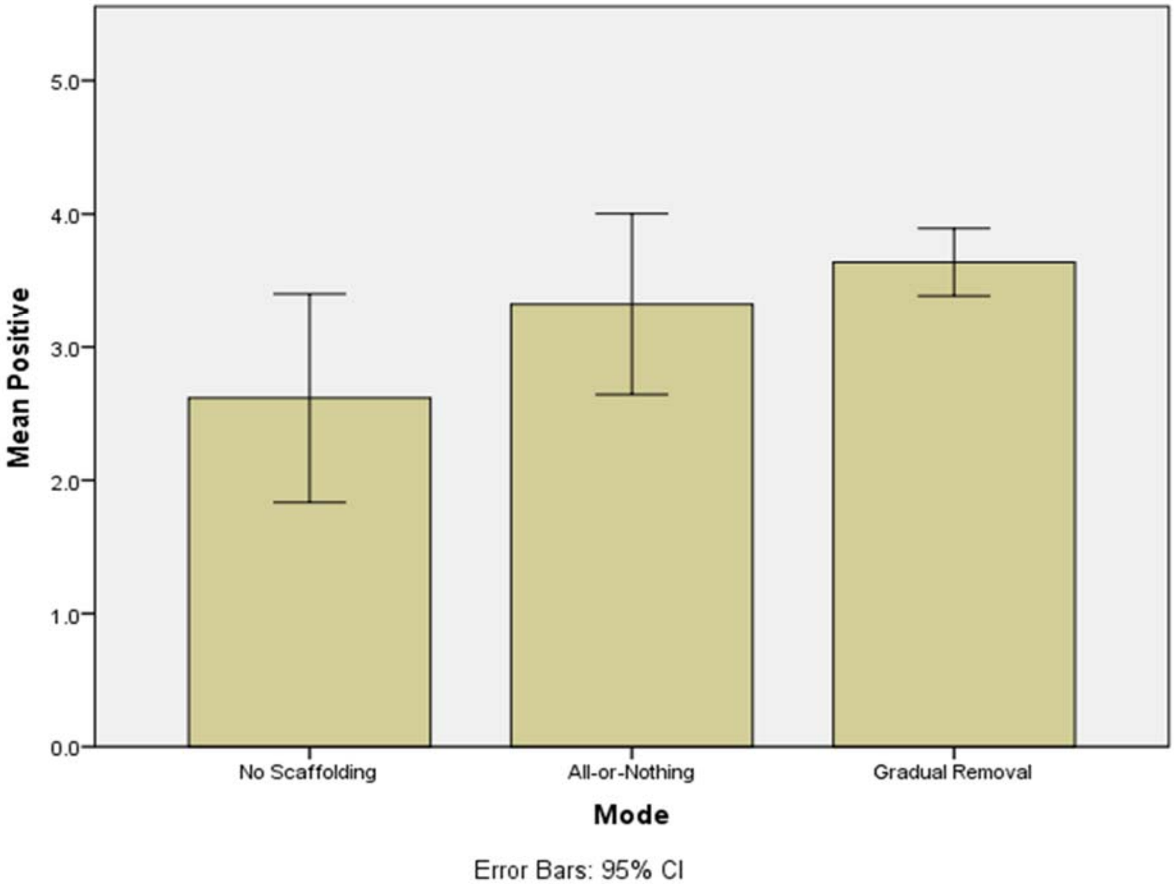

Figure 30 Error Bars for Positive Affect

It is important to note that the reliability of this subscale was very low, alpha = 0.259 – an indication that the children might have found the composite Likert-like items confusing.

7.7 Learning outcome Results

A one-way between subjects ANOVA was conducted to compare the effect of scaffolding on overall learning outcome in gradual removal, all-or-nothing, and no scaffolding (control group) modes. There was significant effect of scaffolding on the overall learning outcome at the $p < 0.001$ level for the three modes $F(2, 49) = 12.209$, $p = 0.000$.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.600	2	9.300	12.209	.000
Within Groups	37.324	49	.762		
Total	55.923	51			

Table 29 One-way Analysis of overall learning outcome

Post hoc comparisons using the Tukey HSD test indicated that the mean score for the gradual removal mode (M = 3.50, SD = 0.79) was significantly different from the no scaffolding mode (M = 2.12, SD = 0.99). The mean score for the all-or-nothing mode (M = 3.24, SD = 0.83) was also significantly different from the no scaffolding mode.

(I) group	**(J) group**	**mean difference (J-I)**	**std. error**	**sig.**
Gradual removal	All-or-nothing	0.256	0.295	0.645
Gradual removal	No scaffolding	1.382	0.295	0.000
All-or-nothing	Gradual removal	-0.265	0.295	0.645
All-or-nothing	No scaffolding	1.118	0.299	0.001
No scaffolding	Gradual removal	-1.382	0.295	0.000
No scaffolding	All-or-nothing	-1.118	0.299	0.001

The mean difference is significant at the 0.05 level

Table 30 Dependent variable: 'Learning outcome' Tukey HSD.

7.8 Correlation

A Pearson correlation (as both overall learning outcome and GEQ data are parametric) was conducted to determine if there was a relationship between overall learning outcome and any of the game experience dimensions.

	Competence	Immersion	Flow	Tension	Challenge	Negative Affect	Positive Affect
Learning outcome	**0.42**	**0.44**	0.07	**-0.56**	0.23	**-0.53**	*0.28*

Table 31 Correlations between learning outcome and the game experience dimensions

7.8.1 The Correlations between learning outcome and the game experience dimensions.

Statistically significant relationships are in boldface; marginally significant relationships are in italics As can be seen in Table 5 five correlations were statistically significant, four at the 0.01 level. However, one of the correlations was very weak (r=0.28) indicating little relationship between overall learning outcome and positive affect. The results suggest a very strong negative relationship between overall learning outcome and tension and also overall learning outcome and negative affect (r= -0.56 and r= -0.53). Overall Learning outcome also correlates strongly with competence and immersion (r=0.42 and r=0.44).

7.9 Summary

This chapter has presented the result of the statistical tests. The results for gameplay experience are summarized thus:

1. Gameplay experience dimensions significantly affected by the 'gradual removal of scaffolding' mode when compared to the 'no scaffolding' mode. (GR/NS) – Competence, immersion, flow, tension and positive affect. But the flow subscale has low reliability.
2. Gameplay experience dimensions significantly affected by the 'all-or-nothing' mode when compared to the 'no scaffolding' mode. (AN/NS) - none
3. Gameplay experience dimensions significantly affected by the 'gradual removal' mode when compared to the 'all-or-nothing' mode. (GR/AN) – none

This is presented in the table below

GR/NS (5)	AN/NS (0)	GR/AN (0)
Competence Immersion Flow (low reliability) Tension Positive affect		

Table 32 showing the various comparisons and the dimensions impacted

Since the results show no significant difference in the effect of a gradual removal of scaffolding on gameplay experience when compared to an abrupt removal of scaffolding (all-or-nothing), the hypothesis that a gradual removal of scaffolding would significantly improve gameplay when compared to an abrupt removal (all-or-nothing) is not supported.

For the learning outcome, the results are summarized as follows

1. There is significant difference in the learning outcome from gameplay in the ‘gradual removal of scaffolding’ mode when compared to the learning outcome from gameplay in the ‘no scaffolding’ mode.
2. There is significant difference in the learning outcome from gameplay in the ‘all-or-nothing’ mode when compared to the learning outcome from gameplay in the ‘no scaffolding’ mode.
3. There is NO significant difference in the learning outcome from gameplay in the ‘gradual removal of scaffolding’ mode when compared to the learning outcome from gameplay in the ‘all-or-nothing’ mode.

Results also reveal that learning outcome correlates with five dimensions of gameplay experience. They include competence, immersion, tension, negative affect and positive affect. The result reveal a weak correlation between learning outcome and positive affect. Flow and challenge did not correlate with learning outcome.

The implications of these findings are discussed in Chapter 9.

CHAPTER 8

THE ANALYTICS: SECOND STUDY

8.1 Introduction

8.1.1 Game Analytics

In contrast to the traditional methods of data collection which is limited to studying users in usability labs, studying surveys or a combination of both, a more detailed insight with a more effective tracking and location of problems is possible with visualization which is associated with game analytics.

Continual Analysis and understudying of players' gameplay behaviours under ecological conditions is currently an important research direction aimed at helping designers, trainers and teachers (in industry and academia) analyse, design, validate, and also adapt and personalize the games (Bouvier, Lavoue, Sehaba, & George, 2013)(Bouvier, Sehaba, Lavoue, & George, 2013)(Gagne, Seif El-Nasr, & Shaw, 2011). The collection and organization of user activity traces – actions performed towards learning games (Bouvier, Sehaba, et al., 2013), give insights into how the game could be improved including the effect of certain features in the game.

8.1.2 Objective

The purpose of the chapter is to compare the effect of a gradual removal of scaffolding to the effect of an abrupt removal of scaffolding on player behaviour. Player activity traces were gathered in the course of gameplay. These were then analysed for insights on player behaviour. Thus the player behaviour in the gradual removal was compared with the player behaviour in the all-or-nothing.

The findings are basically for the purpose of substantiating the claims from the controlled experiment in chapter 6.

8.1.3 Scope

In chapter 6, the gameplay experience and knowledge gain in the scaffolding modes under investigation (gradual removal and the all-or-nothing modes) were compared. The gradual removal had a significant effect on competence, immersion, flow, tension and positive affect – five of the seven gameplay dimensions measured with iGEQ. There was also a significant increase in conceptual knowledge as a result of a gradual removal of scaffolding. Here in Chapter 7, the gameplay metrics analysis is reported so the effect of the scaffolding modes under investigation on player behaviour is investigated by tracking player gameplay activities. The findings from this study substantiates the claims from the controlled experiment.

8.2 User Activity Traces/ Telemetry Collection and Analysis

(Shoukry, Gobel, & Steinmetz, 2014), (Serrano-Laguna, Torrente, Moreno-Ger, & Fernandez-Manjon, 2014) described three types of traces – generic, phase and input traces. Generic traces, they referred to as traces which can be extracted from learning games for learning analytics (Serrano-Laguna et al., 2014). This they state include starting, quitting and ending a game (Serrano-Laguna et al., 2014). Phase traces, they referred to as "meaningful variable traces" (Serrano-Laguna et al., 2014). These they state include starting and ending of phases in the game. They described the input traces as clicks and keypresses (Serrano-Laguna et al., 2014)(Shoukry et al., 2014).

The game start traces contain information such as the time the game started; user identification information; context and demography (Shoukry et al., 2014)

- The game end traces record when and how the game was finished. Of the various endings the game has, which one was reached (Shoukry et al., 2014).
- If the game was quit before it ended the quit game traces capture the context of interruption (Shoukry et al., 2014).

Phase traces include phase start and phase end traces. These would respectively describe the start and end of the sub games – whether it was completed successfully or not (Shoukry et al., 2014)

The remote measurement and collection of user activity traces is referred to as telemetry (WindowsAppsTeam, 2014). This is used in various industries. (Seif El-Nasr, Drachen, & Canossa, 2013) defined game telemetry as any source of data associated with game research and development obtained over distance.

> Game telemetry data are the raw units of data that are derived from - an installed game client. Code embedded in the game client transmits data to a collection server about how a player interacts with the game; or alternatively telemetry data are collected from game servers
>
> (Drachen, Seif El-Nasr, et al., 2013)

It is highlighted by Drachen, Seif El-Nasr, et al. (2013) that raw telemetry data stored in various database formats are ordered in such a way that they are both transformable and interpretable e.g. "average completion time as a function of individual game levels…number of daily active users" (Drachen, Seif El-Nasr, & Canossa, 2013 p.17-18) – these are called gameplay metrics (Drachen, Seif El-Nasr, et al., 2013). Suffice it to say "gameplay metrics are measures of player behaviour" (Drachen, Seif El-Nasr, et al., 2013). (Drachen, Seif El-Nasr, et al., 2013) described gameplay metrics as the most important form of gameplay telemetry for the purpose of user and design evaluations, useful where ever the actual behaviour of the users is of interest - this would include design, user research, and quality assurance. Canossa (2009) pointed out that gameplay metrics are not game heuristics – the latter they referred to as design principles for game development and the former (gameplay metrics) described as "instrumentation data derived from game engines" (Canossa, 2009 p.165).

> An analysis of gameplay metrics provide the opportunity to address key questions, including whether any game world areas are over – or underused, if players utilize game features as intended, or whether there are any barriers hindering player progression
>
> (Drachen, Seif El-Nasr, et al., 2013)

The core limitation of gameplay metrics is that it is unable to point out the reason why the user has taken a particular action or exhibiting a particular behaviour although inferences could be made (Drachen, Canossa, & Sorensen, 2013). Other challenges faced by researchers as highlighted by (Seif El-Nasr, Desurvire, Aghabeigi, & Drachen, 2013), include

- not fully understanding the behaviours to collect
- limited knowledge on how the data could be visualized for designers
- the challenge of presenting the information quick enough to enable decision-making

Most games are currently instrumented by either implementing customized tracing/ logging API or registering with a third-party analytics provider – these are telemetry tracking systems.

(Drachen & Schubert, 2013) highlighted four types of information that could be logged when player does or is exposed to something during gameplay. They include

- What is happening?
- At what time is it happening?
- To whom is it happening?
- Where is it happening

Simon & Mackie (2013) highlighted some initial metrics that can be easily extracted and analysed.

They include:

1 Frequency: This is basically "how often a particular event is occurring" (Simon & Mackie, 2013 p.174). It is required that specific events (the events of interest) be recorded (Simon & Mackie, 2013).

2 Correlation: With the use of time and sequence, events that occur together are recorded. This reveals events that co-occur (Simon & Mackie, 2013).

Simon & Mackie (2013) stated that events can be broken down temporally into Instantaneous and Duration-based events

Instantaneous events they described as events that are recorded with a specific time while Duration-based events span a period of time (Simon & Mackie, 2013)

Considering the huge amount data that could be captured from gameplay, there is need for the filtering of partially irrelevant data for detailed exploration and efficient analysis (Shoukry et al., 2014). In addition, analytics could be tailored to specific game features and evaluation requirements (Shoukry et al., 2014)

> All major game mechanics in an “analytics-efficient” design are chosen in such a way as to directly reflect a learner’s skill or behaviour interesting in terms of evaluation (Shoukry et al., 2014)

Drachen & Canossa (2009), highlights the importance of gameplay metrics. They are as follows

- The player behaviour data is quantitative and highly detailed
- Play session data can be objectively visualized and analysed
- Detailed insights relevant to game design and mechanics are revealed
- Appropriately supplements existing methods of user experience testing and bug tracking
- For effective tracking and location of game problems
- More detailed layers analysis

8.3 The Game Analytics Process

It is stated by (Drachen, Seif El-Nasr, et al., 2013) that “game analytics follows the standard process for knowledge discovery in data which is widely used in data-driven analytics to discover useful knowledge from data” (Drachen, Seif El-Nasr, et al., 2013). The phases include ‘attribute definition’, ‘data acquisition’, ‘data pre-processing’, ‘metrics development’, ‘analysis and evaluation’, ‘visualization’, ‘reporting’ and ‘knowledge deployment. The game analytics process is a knowledge discovery process which include these phases in a cyclic nature (Drachen, Seif El-Nasr, et al., 2013)

Figure 31 game analytics process as a knowledge discovery process (Drachen, Seif El-Nasr, et al., 2013)

8.3.1 Attribute definition:

the first phase in the process involving defining objectives and requirements (Drachen, Seif El-Nasr, et al., 2013). The user attributes to track are selected at this point. The tracking strategy is also decided (Drachen, Seif El-Nasr, et al., 2013)

8.3.2 Data acquisition:

A telemetry system is required at this point. The defined attributes are implemented in this telemetry system (Drachen, Seif El-Nasr, et al., 2013).

8.3.3 Data pre-processing:

The in-coming telemetry data are loaded onto a database where they are easily accessed and prepared for analysis (Drachen, Seif El-Nasr, et al., 2013).

8.3.4 Metrics development:

At this point the data are transformed into “variables/ features and metrics” (Drachen, Seif El-Nasr, et al., 2013).

8.3.5 Analysis and evaluation:

Features and cases are selected as required for analysis during this phase. The analysis is run and the results evaluated (Drachen, Seif El-Nasr, et al., 2013).

8.3.6 Visualization:

The results are then visualized so the stakeholders can make sense of them (Drachen, Seif El-Nasr, et al., 2013).

8.3.7 Reporting:

The discovered knowledge is then presented to relevant stakeholders. It is presented in such a way that the stakeholders are able to understand, interpret and act on the result (Drachen, Seif El-Nasr, et al., 2013).

8.3.8 Knowledge deployment:

This is the phase where the knowledge is deployed and would often initiate a new discovery cycle (Drachen, Seif El-Nasr, et al., 2013).

The whole process involves defining variables for the game's systems, measuring this variables and transforming them into metrics data, then the extraction and selection of features (the interpretation of the measured player action) with the aim of generating models of player behaviour and thus revealing the game's potential (Canossa, 2013).

8.4 The second study

> "Instrumentation data from users form an important contribution to not only user research and testing during the development phases of game production, but also in monitoring and evaluating user (player) behaviour during the extended usage, i.e. during the live periods of games, where given the right tools, data can be obtained directly from the users operating within their natural environments – at home in internet cafes, LAN-parties etc. This is particularly useful for academic purposes, e.g. where the aim is to examine how people play games in their own environments" (Canossa, 2009)

The effect of a gradual removal of scaffolding on gameplay experience is investigated. The study is carried out to support and explain the findings from the empirical study (centred on the hypotheses).

The study was carried out in a primary school in Nigeria. The gradual removal of scaffolding mode and an all-or-nothing scaffolding mode are compared. The children played in one of the two modes. By having them participate in one mode only, the order effects (e.g. fatigue and practice) are avoided (McLeod, 2007).

8.4.1 Environment and Setting

Two sessions were conducted (each one of an approximate duration of twenty minutes). The sessions were conducted in the school's computer lab. The school's computer lab had 15 personal computers running under Microsoft Windows 7 operating system with 17” LCD displays with 1024x768 pixels screen resolution. The game (Alien Chef) ran on the google chrome browser.

Figure 32 Computer Lab where the second study was conducted

In each session, there was five minutes for briefing and signing of consent forms AND fifteen minutes for gameplay. In each session the children were either playing the game in the ‘gradual removal’ OR ‘all-or-nothing’. The study was carried out from 1pm.

8.4.2 Data Collection Techniques

8.4.2.1 Analytics and Telemetry Collection

Flurry Analytics was used to track useful data expected to give an insight into how and where people are playing the game. "Analytics is the process of gathering and finding patterns within a set of data. This data can be any quantifiable action, such as a mouse click, and its related elements, such as what was clicked" (Elliot, 2013). “While it is possible to track anything and everything, it is generally better to focus on things that are most relevant to the user experience" (Elliot, 2013)

A unique session id was recorded for each event. "Flurry session length is defined as the length of time between the start of application event and the end application event" (Ilmjarv, 2015, p.4). Due to a limitation in the telemetry collection system (flurry), data was collected in a per session basis, not per player (it is impossible to know if two sessions are linked to one player). Thus the collected data are associated with sessions.

The data used for this study is test data (that is data from representatives of the target audience – children aged between nine and eleven).

A game session typically consists of the following collected telemetry (They are all instantaneous events)

Attempt (level) information:

- Transition from one attempt to another
- Time up on a particular attempt
- Order1 on table (with the attempt information)
- Order2 on table (with the attempt information)
- Wrong item dropped in pot (reset)
- Loss of life on an attempt

Life information

- Loss of life while preparing order 1
- Loss of life while preparing order 2

Time Information:

- Time of transition from one attempt to another
- Time when order1 was dropped on table
- Time when order2 was dropped on table

- Time of reset (when wrong item was dropped in pot)

The dataset used for this study was retrieved from flurry analytics. The figure below is the snapshot

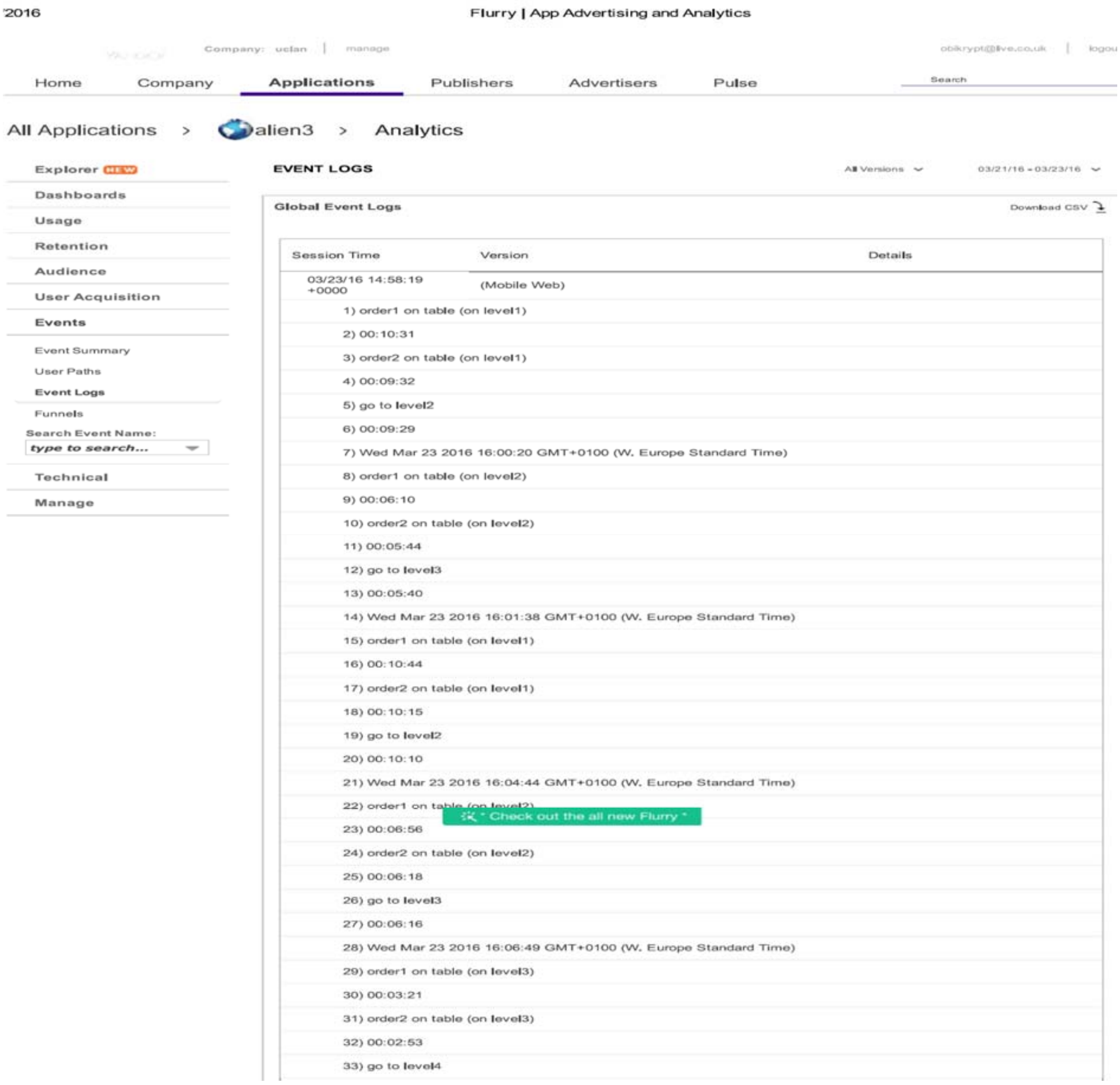

Figure 33 Raw data as presented on flurry

8.4.3 Ethical Consideration

Same as section 6.8

8.4.4 The Study

8.4.4.1 Aim: *To examine the effect of a gradual removal of scaffolding on gameplay experience with the aim of supporting the empirical study*

8.4.4.2 *Apparatus:*

1. *The Game:* For this study we used the Alien Chef game. The game is about an Alien Chef in an Alien world preparing Alien dishes for his Alien guests. The game is designed with three modes – the gradual removal of scaffolding mode; the all-or-nothing mode; the no scaffolding mode.

   Playing in the gradual removal of scaffolding mode would mean playing with partial scaffolding in three of four attempts i.e. playing with full scaffolding in the first attempt then there is a lessening of the scaffolding as attempts increase;

   Playing in the all-or-nothing mode is playing without scaffolding in three of the four attempts; See section 3.6 for details
2. *Setting up Flurry Analytics*

   Account set up: An account was set up with the free service - http://www.flurry.com/

   Application key: Logging into the service, the application link on the menu was selected and an application created -'Web-based applications or mobile websites' for the platform was selected. An application key is presented at this point.

The application key was copied and pasted in the flurry object API key property. This is done after adding the flurry object to the construct2 Alien Chef game project.

8.4.4.3 Design

The experimental design upon which this study was based involved a random assignment of groups to one of the two conditions – 'gradual removal of scaffolding' and 'all-or-nothing'. Treatment one were groups playing in the 'gradual removal of scaffolding' mode AND Treatment Two were groups playing in the 'all-or-nothing' mode.

The participants were assigned randomly to these groups.

8.4.4.4 Participants

The participants comprised Year five and six children. All the children had sufficient level of computer skills (computer education was part of the school curriculum). A teacher and the researcher (experimenter) were involved in the study. The Alien Chef game was played by children (n=23) aged between nine and eleven years. The children were randomly assigned to one of two modes. One group (n=12) played in the gradual removal mode – first session, another group (n=11) played in the all-or-nothing mode – second session. There were two sessions.

8.4.4.5 Procedure

The participants were given numbers while still in their classroom. The numbers were given according to their sitting arrangement. The numbers given were one and two. The numbers were given across both classes. Those with number one participated in the first session, playing the game in the 'gradual removal' mode WHILE those with number two participated in the second session, playing the game in the 'all-or-nothing mode. **The procedure was the same in all sessions.**

The study was carried out in the school's computer laboratory (with about fifteen personal computers).

Upon arrival to the computer laboratory (within the school premises), the potential participants were briefed.

As part of the brief, the experimenter welcomed and introduced himself as a research student from the University of Central Lancashire in the United Kingdom. He then told them they would be playing a game for about fifteen minutes and their gameplay would be tracked. The game was subsequently described to them – The game is about Alien Chef in an Alien world preparing Alien dishes for his Alien guests. They were told they could stop whenever they choose to.

The potential participants were then asked if they were willing to take part in the study. They were given consent forms which they all signed to affirm their willingness to take part in the study. Prior to this study, the class teacher had collected the consent forms which their parents had signed.

The experimental task for the first session involved each participant with the number one sat on a computer and playing the Alien Chef game in the gradual removal mode. As they played, their in-game behaviour was logged via telemetry (flurry). They played until their gameplay time was up. For session two which was immediately after session one, those with number two played the same game in the all-or-nothing mode. Their in-game behavior was also logged via telemetry (flurry). They also played until their gameplay time was up.

8.5 The Event Logging System – Flurry

The data is synthesized from a small sample size of twenty three children and the various gameplay metrics captured via flurry.

Flurry logs and analyses gameplay metrics data over time. Data stored can be downloaded in an excel format. Flurry also allows for the turning on and off of metrics so specific (required) metrics can be collected. This is in addition to the 'metrics-into-game code' functionality which works with the game engine (construct 2).

Only instantaneous events were implemented in the event logging system – Flurry. The duration-based events required (in this case time spent on attempt 2) was calculated as a feature using start and end events.

The features selected for study include completed attempts, playing time on each attempt, incomplete attempts due to time (time ups).

8.6 Results and Analysis

The information required was manually extracted from the database and analysed using excel. The aim of the analysis was is to compare player behaviour in the gradual removal mode and in the all-or-nothing mode

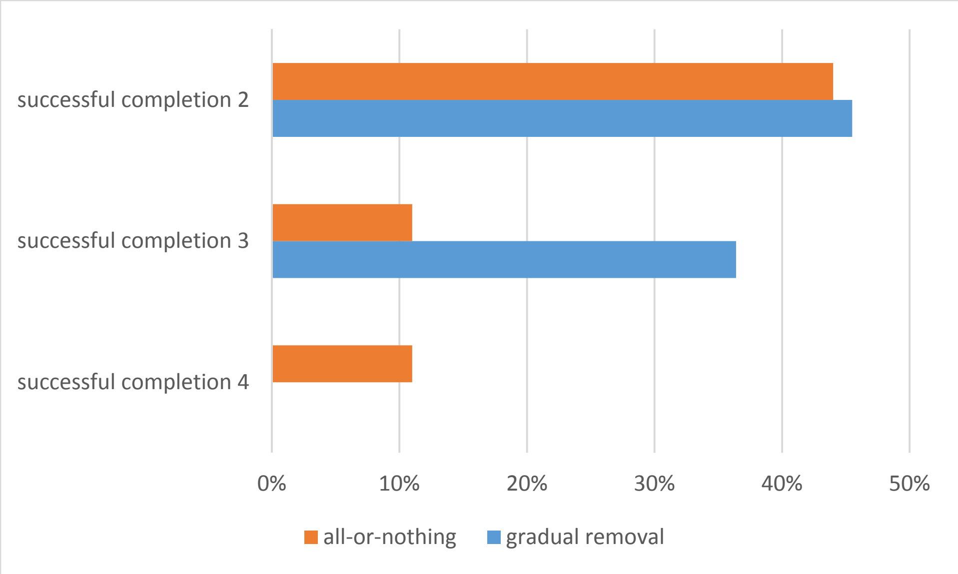

Figure 34 The percentage completion relative to all-or-nothing and gradual removal modes across three attempts – attempts 2, 3 and 4

A greater percentage successfully completed attempts 2 and 3 in the gradual removal mode. The same percentage successfully completed attempts 3 and 4 in the all-or-nothing mode. None successfully completed attempt 4 in the gradual removal mode.

The same percentage successfully completed attempts 3 and 4 in the all-or-nothing mode - The player would be playing with no scaffolding for the second time on attempt 3 (already played with no scaffolding on attempt 2). Thus it could be established that if a player successfully completes two consecutive attempts (in this case attempts 2 and 3) without scaffolding they are regarded as experts as they do not require the scaffolding.

It could also be inferred that those playing in the gradual removal mode found it difficult playing with no scaffolding though they were only required to play with no scaffolding on the fourth attempt – none were able to successfully complete on this attempt (playing in the gradual removal mode).

Only completed attempts were included

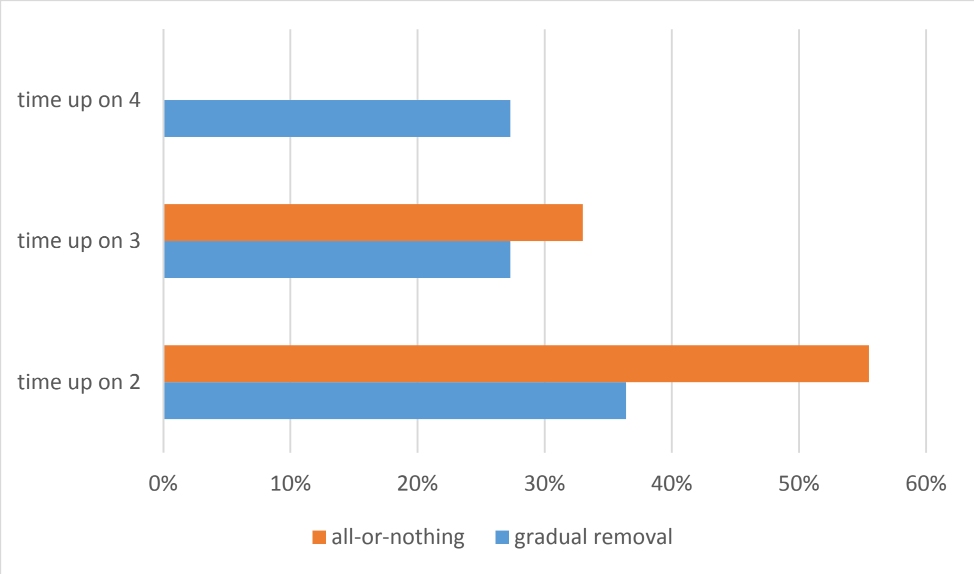

Figure 35 The percentage time up relative to all-or-nothing and gradual removal modes across three attempts – attempts 2, 3 and 4

A greater percentage ran out of time on attempts 2 and 3 while playing in the all-or-nothing. No one ran out of time playing on attempt 4.

The data reveal that a great percentage ran out of time on attempt 2 while playing with no scaffolding, implying that the abrupt switch from full scaffolding to no scaffolding would likely require more effort and time which in most cases could lead to frustration.

While 11% of participants made it to attempt 4 in the all-or-nothing mode, 27% made it to attempt 4 in the gradual removal mode. The 11% in the all-or-nothing mode successfully completed attempt 4 (as seen in chart1), while the 27% who made it to attempt 4 in the gradual removal mode ran out of time.

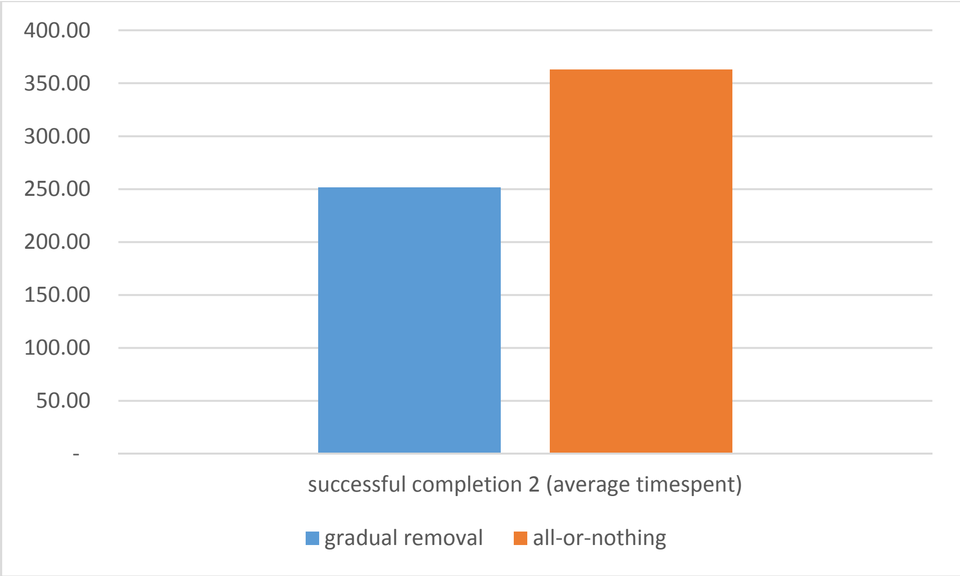

Figure 36 The average completion time (in seconds) per successful attempt on attempt 2, relative to all-or-nothing and gradual removal mode

Compared to the gradual removal mode, much more time was required to complete attempt 2 in the all-or-nothing mode.

This is an important indication that children were more confident playing with partial rather than no scaffolding on attempt 2. Because they were not yet familiar with the gameplay at this point, no scaffolding would make for an inappropriate level of difficulty.

Only completed attempts were included.

CHAPTER 9

DISCUSSION AND CONCLUSION

9.1 Introduction

The effectiveness of gradually reducing the number of demonstrated steps (gradual removal) as opposed to abruptly removing these demonstration steps (all-or-nothing) has been affirmed in non-gaming contexts including learning technologies (Renkl, Freiburg, Atkinson, & Maier, 1999), (Renkl et al., 2002), (Schworm & Renkl, 2006). The effectiveness in a gaming context would mean high quality gameplay experience and beneficial learning outcome. The goal of the present study was to determine how effective a 'gradual removal of scaffolding' mode would be when compared to an 'all-or-nothing' mode in a serious game context.

This study was designed to determine if the 'gradual removal' of scaffolding mode, compared to an 'all-or-nothing' mode, or a 'no scaffolding' mode, would improve the quality of gameplay and learning experience. This chapter discusses the implications of the statistical findings presented in chapter 7. The statistical results and their implications will be described in terms of significant results and non-significant results. The findings are also explained by the user activities traces captured in the second study.

The possible limitations to the research are also highlighted and discussed in this chapter

9.2 Discussion and Interpretation of the Research Findings

This section will discuss and interpret the research findings. The results associated with gameplay experience will be presented first, followed by the results associated with Learning.

9.3 Gameplay Experience Results

9.3.1 Competence:

In the first study, gameplay in the 'gradual removal' mode, when compared to gameplay in the 'no scaffolding' mode significantly improved competence. In contrast, gameplay in the all-or-nothing' mode, when compared to gameplay in the 'no scaffolding' mode did not significantly improve competence.

No significant result was found in terms of comparing gameplay in the 'gradual removal' mode with 'all-or-nothing' mode (with regards to competence). Thus the finding, as it relates to the competence dimension of gameplay experience, does not support the hypothesis – gameplay experience in the 'gradual removal' of scaffolding mode is significantly better than gameplay experience in the 'all-or-nothing' mode.

In interpreting these results it is reassuring to note that though the gameplay in the 'gradual removal' mode was not significantly better than the gameplay in the 'all-or-nothing' mode (with regards to competence), the 'gradual removal' mode led to a significantly better gameplay experience (with regards to competence) when compared to the 'no scaffolding'. This is unlike the 'all-or-nothing' mode which was not significantly better than the 'no scaffolding' mode.

It is also important to note that the competence scale showed an acceptable level of reliability, alpha = 0.627

9.3.2 Immersion:

In the first study gameplay in the 'gradual removal' mode, when compared to gameplay in the 'no scaffolding' mode significantly improved immersion. In contrast, gameplay in the all-or-nothing' mode, when compared to gameplay in the 'no scaffolding' mode did not significantly improve immersion.

No significant result was found in terms of comparing gameplay in the 'gradual removal' mode with 'all-or-nothing' mode (with regards to immersion). Thus the finding, as it relates to the Immersion dimension of gameplay experience, does not support the hypothesis – gameplay experience in the 'gradual removal' of scaffolding mode is significantly better than gameplay experience in the 'all-or-nothing' mode.

In interpreting these results it is reassuring to note that though the gameplay in the 'gradual removal' mode was not significantly better than the gameplay in the 'all-or-nothing' mode (with regards to immersion), the 'gradual removal' mode led to a significantly better gameplay experience (with regards to immersion) when compared to the 'no scaffolding'. This is unlike the 'all-or-nothing' mode which was not significantly better than the 'no scaffolding' mode.

It is also important to note that the Immersion scale showed an acceptable level of reliability, alpha = 0.728

9.3.3 Flow:

In the first study gameplay in the 'gradual removal' mode, when compared to gameplay in the 'no scaffolding' mode improved flow. In contrast, gameplay in the all-or-nothing' mode, when compared to gameplay in the 'no scaffolding' mode did not improve flow.

No significant result was found in terms of comparing gameplay in the 'gradual removal' mode with 'all-or-nothing' mode (with regards to flow). Thus the finding, as it relates to the Flow dimension of gameplay experience, does not support the hypothesis – gameplay experience in the 'gradual removal' of scaffolding mode is significantly better than gameplay experience in the 'all-or-nothing' mode.

In interpreting these results it is reassuring to note that though the gameplay in the 'gradual removal' mode was not significantly better than the gameplay in the 'all-or-nothing' mode (with regards to flow), the 'gradual removal' mode (unlike the all-or-nothing mode) led to a significantly better gameplay experience (with regards to flow) when compared to the 'no scaffolding' mode.

It is also important to note that the Flow scale did not show an acceptable level of reliability, alpha = 0.259, indicating this finding cannot be reliable.

9.3.4 Tension:

In the first study gameplay in the 'gradual removal' mode, when compared to gameplay in the 'no scaffolding' mode significantly decreased tension. In contrast, gameplay in the all-or-nothing' mode, when compared to gameplay in the 'no scaffolding' mode did not significantly decrease tension.

No significant result was found in terms of comparing gameplay in the 'gradual removal' mode with 'all-or-nothing' mode (with regards to tension). Thus the finding, as it relates to the tension dimension of gameplay experience, does not support the hypothesis – gameplay experience in the 'gradual removal' of scaffolding mode is significantly better than gameplay experience in the 'all-or-nothing' mode.

In interpreting these results it is reassuring to note that though the gameplay in the 'gradual removal' mode was not significantly better than the gameplay in the 'all-or-nothing' mode (with regards to tension), the 'gradual removal' mode (unlike the all-or-nothing mode) led to a significantly better gameplay experience (with regards to tension) when compared to the 'no scaffolding' mode.

It is also important to note that the Tension scale showed an acceptable level of reliability, alpha = 0.653, indicating this finding could be reliable.

9.3.5 Challenge:

In the first study, neither gameplay in the ‘gradual removal’ mode or gameplay in the ‘all-or-nothing mode, when compared to gameplay in the ‘no scaffolding’ mode had a significant impact on challenge.

There was also no significant result in terms of comparing gameplay in the ‘gradual removal’ mode with gameplay in the ‘all-or-nothing’ mode (with regards to challenge). Thus the finding, as it relates to the challenge dimension of gameplay experience, does not support the hypothesis – gameplay experience in the ‘gradual removal’ of scaffolding mode is significantly better than gameplay experience in the ‘all-or-nothing’ mode.

It is also important to note that the Challenge scale did NOT show an acceptable level of reliability, alpha = 0.473, indicating this finding cannot be reliable.

9.3.6 Negative affect:

In the first study, neither gameplay in the ‘gradual removal’ mode or gameplay in the ‘all-or-nothing mode, when compared to gameplay in the ‘no scaffolding’ mode had a significant impact on negative affect.

There was also no significant result in terms of comparing gameplay in the ‘gradual removal’ mode with gameplay in the ‘all-or-nothing’ mode (with regards to negative affect). Thus the finding, as it relates to the negative affect dimension of gameplay experience, does not support the hypothesis – gameplay experience in the ‘gradual removal’ of scaffolding mode is significantly better than gameplay experience in the ‘all-or-nothing’ mode.

It is also important to note that the Negative affect scale did NOT show an acceptable level of reliability, alpha = 0.300, indicating this finding cannot be reliable.

9.3.7 Positive Affect:

In the first study gameplay in the 'gradual removal' mode, when compared to gameplay in the 'no scaffolding' mode significantly increased positive affect. In contrast, gameplay in the all-or-nothing' mode, when compared to gameplay in the 'no scaffolding' mode did not significantly increase positive affect.

No significant result was found in terms of comparing gameplay in the 'gradual removal' mode with 'all-or-nothing' mode (with regards to positive affect). Thus the finding, as it relates to the positive affect dimension of gameplay experience, does not support the hypothesis – gameplay experience in the 'gradual removal' of scaffolding mode is significantly better than gameplay experience in the 'all-or-nothing' mode.

In interpreting these results it is reassuring to note that though the gameplay in the 'gradual removal' mode was not significantly better than the gameplay in the 'all-or-nothing' mode (with regards to positive affect), the 'gradual removal' mode (unlike the all-or-nothing mode) led to a significantly better gameplay experience (with regards to positive affect) when compared to the 'no scaffolding' mode.

It is also important to note that the positive affect scale showed an acceptable level of reliability, alpha = 0.789, indicating this finding could be reliable.

9.4 Learning Outcome Results

The results with regards to learning outcome suggest that both gradual removal of scaffolding and the all-or-nothing have a significant effect on learning outcome. Thus, just like there is a significant increase in learning outcome with the gradual removal of scaffolding, there is also a significant increase in learning outcome with the abrupt removal of scaffolding (all-or-nothing). However, it should be noted that in the absence of scaffolding (no scaffolding mode), there would be no significant increase in learning outcome.

9.5 Correlation Results

From table (see chapter 7), it is evident that the learning outcomes are correlated with multiple dimensions of the iGEQ. The results thus imply the learning outcome to be related to more than one gameplay experience dimension.

The results suggest a very strong negative relationship between learning outcome and tension and also learning outcome and negative affect (r= -0.56 and r= -0.53)

A decrease in learning outcome is indicative of an increase in frustration, with the feeling of anger and annoyance (items for tension dimension). It also suggests that a decrease in learning outcome is indicative of an increase boredom and tiredness (items for the negative affect dimension). Learning outcome also correlates strongly with competence and immersion (r=0.42 and r=0.44). This suggests an increase in learning outcome is indicative of an increase in the feeling of success and skilfulness (items for competence). It also suggests an increase in immersion is indicative of an increase in learning outcome.

9.6 Triangulation: Converging the Controlled Experiment and the Game Analytics

While 27% of those who played in the 'gradual removal' of scaffolding mode made it to the final attempt, only 11% made it to the final (fourth) attempt playing in the 'all-or-nothing' mode. This could mean that the level of difficulty was more appropriate with a 'gradual removal of scaffolding than it was with an 'all-or-nothing'. It could also mean that the competence level was higher in the gradual removal mode than in the all-or-nothing mode. An increase in competence level is often associated with an increase in confidence, thus saying those playing in the gradual removal mode were more confident could be true. An appropriate level of difficulty could also mean less frustration, thus the finding from the controlled experiment indicating that tension (described as frustration in the iGEQ) in the gradual removal mode is significantly reduced when compared to the 'no scaffolding' mode. This is in contrast to tension in the ‘all-or-nothing’ mode compared to the ‘no scaffolding’ mode. In addition, Immersion and flow can only be attained at an appropriate level of difficulty.

Though there was no significant difference in competence, immersion, flow, tension, or positive affect in the ‘gradual removal of scaffolding’ relative to the ‘all-or-nothing’, there was a significant difference in the ‘gradual removal of scaffolding’ relative to the ‘no scaffolding’ which is in contrast to the ‘all-or-nothing’ relative to the ‘no scaffolding’ with no significant difference also. This, in addition to having 27% making it to the final attempt in the gradual removal of scaffolding mode as opposed to 11% making it to the final attempt in the all-or-nothing mode, could be an indication that the appropriateness of the level of difficulty could be enhanced by gradually removing the scaffolding in a serious game context as affirmed (from literature) in the non-gaming context.

In the introduction of this thesis, the main research objective this thesis aimed to achieve and the four research questions the thesis aimed to answer were identified. The rest of the thesis summarizes how this objective has been achieved by answering the research questions. The research questions include

RQ1: In comparison to the all-or-nothing (switch) guidance-fading approach, does gradual removal of guidance (in micro-scaffolding) improve children’s gameplay experience?

RQ2: What dimensions of gameplay experience are impacted and to what extent are they impacted by the gradual removal of guidance (in micro-scaffolding) during gameplay?

RQ3: Would gradual removal of scaffolding during gameplay improve competence (learning)?

RQ4: What effect would inappropriate guidance-fading have on game-play?

9.7 Conclusions RQ1:

When compared with the all-or-nothing (switch) guidance-fading approach, does gradual removal of guidance (in micro-scaffolding) improve children’s gameplay experience?

To answer this, an empirical study was conducted to measure and compare the gameplay experience in these modes – gradual removal and the all-or-nothing mode. The gameplay experience was measured subjectively using the concise Game Experience Questionnaire (iGEQ) (see Appendix I). In addition to this study, another study where user activity traces were extracted from gameplay in each of these modes was conducted. The user activity traces were collected and measured remotely - telemetry.

Upon statistically analysing the data gathered with the iGEQ, it was discovered that children who played in the 'gradual removal' mode, did not have a significantly better gameplay experience when compared with those who played in the 'all-or-nothing' mode. But children who played in the gradual removal mode had a significantly better gameplay experience (with regards to competence, immersion, flow, tension and positive affect) than those who played in the 'no scaffolding' mode (the result for flow is questionable because the subscale has a low reliability). This is in contrast to those who played in the all-or-nothing mode; the gameplay experience in the all-or-nothing mode was not significantly better than the gameplay experience in the 'no scaffolding' mode.

An analysis of the gameplay metrics from the user activity traces collected suggests children played more confidently in the gradual removal mode than in the all-or-nothing mode – completing more attempts. This could suggest that children who played in the gradual removal mode were more competent. There are also indications from the gameplay metrics analysis that the attempts are made more manageable and achievable in the gradual removal mode than in the all-or-nothing mode – for instance, those who completed attempt 2 in the gradual removal mode, completed it in far less time than those who completed the same attempt in the all-or-nothing mode.

There is also an indication that frustration is reduced in the gradual removal mode –the findings from the gameplay metrics analysis indicate a greater percentage of players made it to attempt 4 in the gradual removal mode than in the all-or-nothing mode. In addition, the controlled experiment showed that unlike the 'all-or-nothing' mode, tension (associated with frustration) reduced significantly in the gradual removal mode when compared to the 'no scaffolding' mode.

9.8 Conclusions RQ2:

What dimensions of gameplay experience are impacted and to what extent are they impacted by the gradual removal of guidance (in micro-scaffolding) during gameplay?

The answer to this question can be found in the empirical study measuring and comparing gameplay experience in the ‘gradual removal’, ‘all-or-nothing’ and ‘no scaffolding’ modes. The instrument used – the iGEQ, has the capability of subjectively measuring seven dimensions of gameplay experience. These dimensions include competence, immersion, flow, challenge, tension, negative affect and positive affect. It is evident from the study with this instrument (iGEQ) that all of the gameplay experience dimensions measured except for challenge and negative affect improved significantly in the gradual removal mode when compared to the ‘no scaffolding’. None of the gameplay experience dimensions improved significantly in the ‘all-or-nothing’ mode when compared to the ‘no scaffolding’ mode. There was also no significant difference in any of the dimensions, when gameplay experience in the ‘gradual removal of scaffolding’ mode was compared with gameplay experience in the ‘all-or-nothing’ mode.

The more immersed a player is, the more likely they are interested in the game. Though the interest level (associated with immersion) did not significantly improve in the ‘gradual removal’ mode when compared to the ‘all-or-nothing’ mode; but when compared to gameplay in the ‘no scaffolding’ mode, the gameplay experience in the gradual removal of scaffolding mode significantly increased immersion, suggesting the children who played in the ‘gradual removal’ mode were more interested in the game when compared to those playing in the ‘no scaffolding’ mode. With the ‘all-or-nothing’ mode the interest level (associated with immersion) when compared to the interest level in the ‘no scaffolding’ did not significantly improve. This goes to show that if children were not interested in the game while playing without scaffolding, they would most likely not be interested in the game while playing in the all-or-nothing mode. In contrast, children are more likely to develop an interest in the game when played in the gradual removal mode, even though an interest could not be developed while playing in the ‘no scaffolding’ mode.

Furthermore, the study with the iGEQ revealed that if competence do not increase in the ‘no scaffolding’ it would most likely not increase in the ‘all-or-nothing’ mode (no significant difference between the two groups). In contrast, competence would most likely increase in the ‘gradual removal’ of scaffolding mode even if it does not increase in the ‘no scaffolding’ mode (significant difference between the two groups). Also, if competence do not increase in the ‘all-or-nothing’ it would likely not increase in the ‘gradual removal’ mode as there is no significant difference in gameplay experience between the two groups.

Gameplay in the ‘gradual removal’ mode would not reduce frustration (associated with tension) significantly more than gameplay in the ‘all-or-nothing’ mode will. Furthermore, there would not be a significant decrease in frustration while playing in the ‘all-or-nothing’ compared to the level of frustration experienced in the ‘no scaffolding’ mode. The significant decrease in frustration is only noticed, when gameplay in the ‘gradual removal’ mode is compared to gameplay in the ‘no scaffolding’ mode.

None of the modes under investigation significantly impacted challenge and negative affect.

9.9 Conclusions RQ3:

Would gradual removal of scaffolding during gameplay improve competence (learning)?

The result from the controlled experiment with the iGEQ, show that competence is not significantly improved by gameplay in the ‘gradual removal’ mode when compared to gameplay in the all-or-nothing. No significant improvement in competence is also seen when gameplay in the ‘all-or-nothing’ mode is compared to gameplay in the ‘no scaffolding’ mode. Gameplay is only significantly improved when gameplay in the ‘gradual removal’ mode is compared to gameplay in the ‘no scaffolding’ mode. With items such as ‘I felt skilful’ and ‘I felt successful’, as depicted in the iGEQ, competence is simply the feeling of self-confidence associated with learning. But to answer the question as it relates to learning itself, the learning outcome as a result of gameplay in the three modes under investigation is compared. Comparing the learning outcome from gameplay in the 'no scaffolding' mode, the learning outcome in both the all-or-nothing mode and the 'gradual removal' mode increased significantly. But comparing the learning outcome from gameplay in the 'all-or-nothing' and the 'gradual removal' mode, the learning outcome did not increase significantly.

9.10 Conclusions RQ4:

What effect would inappropriate guidance-fading have on game-play?

If the guidance-fading is inappropriate, the gameplay experience would not be better than the gameplay experience without guidance (scaffolding). Therefore gameplay experience with inappropriate guidance fading would be as bad as gameplay experience without guidance. The result from the controlled experiment with the iGEQ, revealed that gameplay experience from gameplay in the all-or-nothing mode was not significantly better than gameplay experience from gameplay in the 'no scaffolding' mode in any of the gameplay experience dimensions investigated. This is unlike the gameplay experience from gameplay in the 'gradual removal' of scaffolding mode, which significantly improved competence, increased immersion, reduced tension, improved flow and enhanced the positive affect, in comparison to gameplay experience from gameplay in the 'no scaffolding' mode.

Inappropriate guidance fading could also mean an inappropriate level of difficulty. The analytics show that only 11% of those playing in the all-or-nothing mode made it to the final attempt, while 27% of those playing in the gradual-removal mode made it to the final attempt. With just a tenth of those playing in the 'all-or-nothing' mode making it to the final attempt, the level of difficulty could be higher than it should for children. Furthermore, children are known to have a lower working memory capacity than adults do (Holmes et al., 2009a), (Gathercole & Alloway, 2007), (Gathercole & Alloway, 2007). As a result with inappropriate guidance-fading, the gameplay would be more difficult - this is also seen in the game metrics analysis indicating that a lot more time was required to complete attempt 2 in the all-or-nothing mode.

In summary poor quality gameplay experience and inappropriate level of difficulty are core effects of inappropriate guidance fading.

9.11 Hypotheses Results

9.11.1 Learning Outcome

H_0: There is no difference in learning gain between the 'gradual removal of scaffolding' and the 'all-or-nothing' modes, on average

H_a: Gameplay in the 'gradual removal of scaffolding' mode would increase learning gain more than gameplay in the 'all-or-nothing' mode would, on average.

The result from the controlled experiment, show that when compared to the 'all-or-nothing' mode, the learning outcome did not improve significantly in the 'gradual removal' of scaffolding mode. Thus, we fail to reject the null hypothesis, and cannot accept the alternative hypothesis.

9.11.2 Gameplay Experience

H_0: There is no difference in gameplay experience between the 'gradual removal of scaffolding' and the 'all-or-nothing' modes, on average.

H_a: The gameplay in the ‘gradual removal of scaffolding’ mode would be better than gameplay experience in the ‘all-or-nothing’ mode, on average.

The result from the controlled experiment, show that when compared to the ‘all-or-nothing’ mode, the gameplay experience did not improve significantly in the ‘gradual removal’ of scaffolding mode for any of the seven dimensions of gameplay experience investigated using the iGEQ. Thus, we fail to reject the null hypothesis, and cannot accept the alternative hypothesis.

9.12 Limitations of the Research

9.12.1 Reliability

The iGEQ used for this study had some reliability issues – some of the subscales had low reliabilities. While competence, immersion, tension and positive affect subscales had acceptable levels of reliability, flow, challenge and negative affect had low reliabilities. The overall scale had high reliability.

A closer look at the scale revealed three questions that should be modified to improve the questionnaire. The values in the column labelled ‘Alpha if item is deleted’ showed three questions that if removed would increase the reliability of the overall scale.

Items	Cronbach’s Alpha if Item Deleted

I was interested in the game's story	0.866
I felt successful	0.868
I felt bored	0.864
I found it exciting	0.865
I forgot everything around me	0.901
I felt angry	0.875
I felt tired	0.889
It made me easily annoyed	0.869
I felt skilful	0.864
I felt I was into the game	0.866
I felt satisfied	0.867
I felt challenged	0.882
I felt encouraged	0.868
I felt good	0.859

The questions include 'I forgot everything around me', 'I felt tired' and 'I felt challenged'. In the iGEQ, these questions were associated with flow, negative affect and challenge respectively. These were the subscales with the low reliabilities. Though children in the pilot study conducted claimed to understand the questionnaire, what they thought the question meant could be different from what the question actually means. There could have been a level of confusion as to what the question meant. In future study, these questions should be modified. Seven questions from the original iGEQ were modified for this study with children. There is need now to modify two more questions ('I forgot everything around me' and 'I felt tired') in addition to remodifying the question 'I felt tired' which was originally 'I found it tiresome'.

Considering the fact the original version of the iGEQ was not in English, there could also be some translation issues here.

It is however important to note that the original version of this questionnaire was not designed with children in mind.

9.12.2 Measure: iGEQ and flurry

The reliance on children recalling their gameplay experience (subjective) cannot be as accurate as the reliance on information presented by an appropriate monitoring device (objective). The children could also be biased in their responses.

The use of monitoring devices would mean carrying out the study in a lab instead of in schools – this would rob the study of its ecological validity. In addition the subjective measure is cheaper and less demanding than the objective measure.

Flurry used to log the gameplay metrics data in the study two is not robust enough, as there is a limit to the number of events it can handle. There is the also the issue of delayed logging of the gameplay metrics data with this analytics tool.

9.12.3 Generalization

Considering students in this study were from one school, it would be difficult to generalize the finding. Furthermore, since only one game was used for this study, it would also be difficult to generalize in this regard.

9.13 Future work and Recommendation

As pointed out in the limitation section of this thesis, the effort to make the iGEQ child-friendly was not sufficient, hence the low reliability with some of the subscales. It is expected that the iGEQ be made sufficiently child-friendly if it must be used in future studies involving children. It is also expected that a better metrics data logging tool be developed if bigger games with more events to log is used.

The fading approach investigated in this research is the static fading, where the guidance is faded as the number of attempts increases (Reisslein et al., 2006). Future work should seek to compare this fading approach to the adaptive fading approach, where the guidance is faded as the number of SUCCESSFUL attempts increases.

9.14 Contribution to knowledge

With previous studies showing the effectiveness of gradually removing scaffolding (guidance) in the non-gaming context, this research aimed at implementing and testing the effectiveness of this approach of scaffolding in a gaming context.

The major contribution to the body of knowledge is implementing a gradual removal of scaffolding – (which up until now has only been implemented in a non-gaming context) approach (fading) to scaffolding, in a serious game context. Fading has been proven to be advantageous to children's learning experience as it prevents the overload of the relatively limited working memory they are known to possess.

The research also highlight the problems associated with inappropriate guidance fading – poor quality gameplay experience and inappropriate level of difficulty. The analytics showing 27% of participants playing in the 'gradual removal' of scaffolding making it to the fourth attempt as opposed to only 11% making it to the fourth attempt in the 'all-or-nothing' mode would suggest a relatively inappropriate level of difficulty in the 'all-or-nothing'. Secondly, compared to gameplay experience in the 'no scaffolding' mode which is considered inappropriate, the gameplay experience in the 'all-or-nothing' mode did not significantly improve. This is in contrast to gameplay experience in the 'gradual removal' mode which revealed significant improvement in competence, immersion, flow (questionable because of low reliability), tension and positive affect, when compared to gameplay experience in the 'no scaffolding' mode. If relative to the 'no scaffolding' mode gameplay experience is not significantly improved then the scaffolding approach could be deemed inappropriate, suggesting the ‘all-or-nothing’ could be deemed inappropriate.

This research also revealed a significant correlation between learning and some gameplay experience dimensions – competence, immersion, tension and negative affect (negative affect is questionable as it has a low reliability).

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APPENDICES

Appendix I - iGEQ (Reworded version)

Version__________ **Participant No__________**

1 I was interested in the game's story

a lot a little bit not bothered not much not at all

2 I felt successful

a lot a little bit not bothered not much not at all

3 I felt bored

a lot a little bit not bothered not much not at all

4 I found it exciting

a lot a little bit not bothered not much not at all

5 **I forgot everything around me**

a lot | a little bit | not bothered | not much | not at all

6 **I felt angry**

a lot | a little bit | not bothered | not much | not at all

7 **I felt tired**

a lot | a little bit | not bothered | not much | not at all

8 **It made me easily annoyed**

a lot | a little bit | not bothered | not much | not at all

9 **I felt skilful**

a lot | a little bit | not bothered | not much | not at all

10 I felt I was into the game

a lot | a little bit | not bothered | not much | not at all

11 I felt satisfied

a lot | a little bit | not bothered | not much | not at all

12 I felt challenged

a lot | a little bit | not bothered | not much | not at all

13 I felt encouraged

a lot | a little bit | not bothered | not much | not at all

14 I felt good

a lot | a little bit | not bothered | not much | not at all

Appendix II – Tables of Result

ANOVA

				Sum of Squares	df	Mean Square	F	Sig.
competence	Between Groups	(Combined)		9.220	2	4.610	3.966	.025
		Linear Term	Unweighted	9.177	1	9.177	7.896	.007
			Weighted	9.154	1	9.154	7.876	.007
			Deviation	.066	1	.066	.057	.813
		Quadratic Term	Unweighted	.066	1	.066	.057	.813
			Weighted	.066	1	.066	.057	.813
	Within Groups			56.949	49	1.162		
	Total			66.168	51			
Immersion	Between Groups	(Combined)		10.646	2	5.323	4.912	.011
		Linear Term	Unweighted	10.137	1	10.137	9.355	.004
			Weighted	10.060	1	10.060	9.284	.004
			Deviation	.586	1	.586	.541	.466
		Quadratic Term	Unweighted	.586	1	.586	.541	.466
			Weighted	.586	1	.586	.541	.466
	Within Groups			53.099	49	1.084		
	Total			63.745	51			
flow	Between Groups	(Combined)		8.634	2	4.317	3.249	.047
		Linear Term	Unweighted	8.459	1	8.459	6.366	.015
			Weighted	8.497	1	8.497	6.394	.015
			Deviation	.137	1	.137	.103	.749
		Quadratic Term	Unweighted	.137	1	.137	.103	.749
			Weighted	.137	1	.137	.103	.749
	Within Groups			65.111	49	1.329		
	Total			73.745	51			
Tension	Between Groups	(Combined)		18.700	2	9.350	6.857	.002
		Linear Term	Unweighted	18.698	1	18.698	13.713	.001
			Weighted	18.687	1	18.687	13.705	.001
			Deviation	.013	1	.013	.009	.923
		Quadratic Term	Unweighted	.013	1	.013	.009	.923
			Weighted	.013	1	.013	.009	.923
	Within Groups			66.815	49	1.364		
	Total			85.514	51			
Challenge	Between Groups	(Combined)		6.707	2	3.354	2.406	.101
		Linear Term	Unweighted	1.652	1	1.652	1.185	.282
			Weighted	1.747	1	1.747	1.253	.268
			Deviation	4.960	1	4.960	3.558	.065
		Quadratic Term	Unweighted	4.960	1	4.960	3.558	.065
			Weighted	4.960	1	4.960	3.558	.065
	Within Groups			68.307	49	1.394		
	Total			75.014	51			
Negative	Between Groups	(Combined)		6.853	2	3.427	3.000	.059
		Linear Term	Unweighted	5.468	1	5.468	4.787	.033
			Weighted	5.557	1	5.557	4.865	.032
			Deviation	1.296	1	1.296	1.135	.292
		Quadratic Term	Unweighted	1.296	1	1.296	1.135	.292
			Weighted	1.296	1	1.296	1.135	.292
	Within Groups			55.974	49	1.142		
	Total			62.827	51			
Positive	Between Groups	(Combined)		9.492	2	4.746	3.339	.044
		Linear Term	Unweighted	9.118	1	9.118	6.416	.015
			Weighted	9.056	1	9.056	6.372	.015
			Deviation	.436	1	.436	.307	.582
		Quadratic Term	Unweighted	.436	1	.436	.307	.582
			Weighted	.436	1	.436	.307	.582
	Within Groups			69.638	49	1.421		
	Total			79.130	51			

Table 33 Showing ANOVA and Linear Trend

Tukey HSD

Dependent Variable	(I) version	(J) version	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
competence	1	2	.4363	.3646	.461	-.445	1.317
		3	1.0245*	.3646	.019	.143	1.906
	2	1	-.4363	.3646	.461	-1.317	.445
		3	.5882	.3698	.259	-.305	1.482
	3	1	-1.0245*	.3646	.019	-1.906	-.143
		2	-.5882	.3698	.259	-1.482	.305
Immersion	1	2	.3121	.3521	.651	-.539	1.163
		3	1.0768*	.3521	.010	.226	1.928
	2	1	-.3121	.3521	.651	-1.163	.539
		3	.7647	.3571	.092	-.098	1.628
	3	1	-1.0768*	.3521	.010	-1.928	-.226
		2	-.7647	.3571	.092	-1.628	.098
flow	1	2	.6013	.3899	.280	-.341	1.544
		3	.9837*	.3899	.039	.041	1.926
	2	1	-.6013	.3899	.280	-1.544	.341
		3	.3824	.3954	.601	-.573	1.338
	3	1	-.9837*	.3899	.039	-1.926	-.041
		2	-.3824	.3954	.601	-1.338	.573
Tension	1	2	-.6977	.3949	.191	-1.652	.257
		3	-1.4624*	.3949	.002	-2.417	-.508
	2	1	.6977	.3949	.191	-.257	1.652
		3	-.7647	.4005	.147	-1.733	.203
	3	1	1.4624*	.3949	.002	.508	2.417
		2	.7647	.4005	.147	-.203	1.733
Challenge	1	2	.8758	.3993	.082	-.089	1.841
		3	.4346	.3993	.526	-.530	1.400
	2	1	-.8758	.3993	.082	-1.841	.089
		3	-.4412	.4050	.525	-1.420	.538
	3	1	-.4346	.3993	.526	-1.400	.530
		2	.4412	.4050	.525	-.538	1.420
Negative	1	2	-.7320	.3615	.117	-1.606	.142
		3	-.7908	.3615	.083	-1.664	.083

	2	1	.7320	.3615	.117	-.142	1.606
		3	-.0588	.3666	.986	-.945	.827
	3	1	.7908	.3615	.083	-.083	1.664
		2	.0588	.3666	.986	-.827	.945
Positive	1	2	.3154	.4032	.716	-.659	1.290
		3	1.0212*	.4032	.038	.047	1.996
	2	1	-.3154	.4032	.716	-1.290	.659
		3	.7059	.4089	.206	-.282	1.694
	3	1	-1.0212*	.4032	.038	-1.996	-.047
		2	-.7059	.4089	.206	-1.694	.282

*. The mean difference is significant at the 0.05 level.

		Sum of Squares	df	Mean Square	F	Sig.
competence	Between Groups	9.220	2	4.610	3.966	.025
	Within Groups	56.949	49	1.162		
	Total	66.168	51			
Immersion	Between Groups	10.646	2	5.323	4.912	.011
	Within Groups	53.099	49	1.084		
	Total	63.745	51			
flow	Between Groups	8.634	2	4.317	3.249	.047
	Within Groups	65.111	49	1.329		
	Total	73.745	51			
Tension	Between Groups	18.700	2	9.350	6.857	.002
	Within Groups	66.815	49	1.364		
	Total	85.514	51			
Challenge	Between Groups	6.707	2	3.354	2.406	.101
	Within Groups	68.307	49	1.394		
	Total	75.014	51			
Negative	Between Groups	6.853	2	3.427	3.000	.059
	Within Groups	55.974	49	1.142		
	Total	62.827	51			
Positive	Between Groups	9.492	2	4.746	3.339	.044
	Within Groups	69.638	49	1.421		
	Total	79.130	51			

Table 34 One-Way Analysis of the gameplay experience

Table 35 Table 7 One-Way Analysis of the gameplay experience - Multiple Comparison

1 = gradual removal

2 = all-or-nothing

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.600	2	9.300	12.209	.000
Within Groups	37.324	49	.762		
Total	55.923	51			

Table 36 One-way Analysis of overall learning outcome

Dependent Variable: Ltotal
Tukey HSD

(I) version	(J) version	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	.265	.295	.645	-.45	.98
	3	1.382*	.295	.000	.67	2.10
2	1	-.265	.295	.645	-.98	.45
	3	1.118*	.299	.001	.39	1.84
3	1	-1.382*	.295	.000	-2.10	-.67
	2	-1.118*	.299	.001	-1.84	-.39

*. The mean difference is significant at the 0.05 level.

Ltotal = overall learning outcome

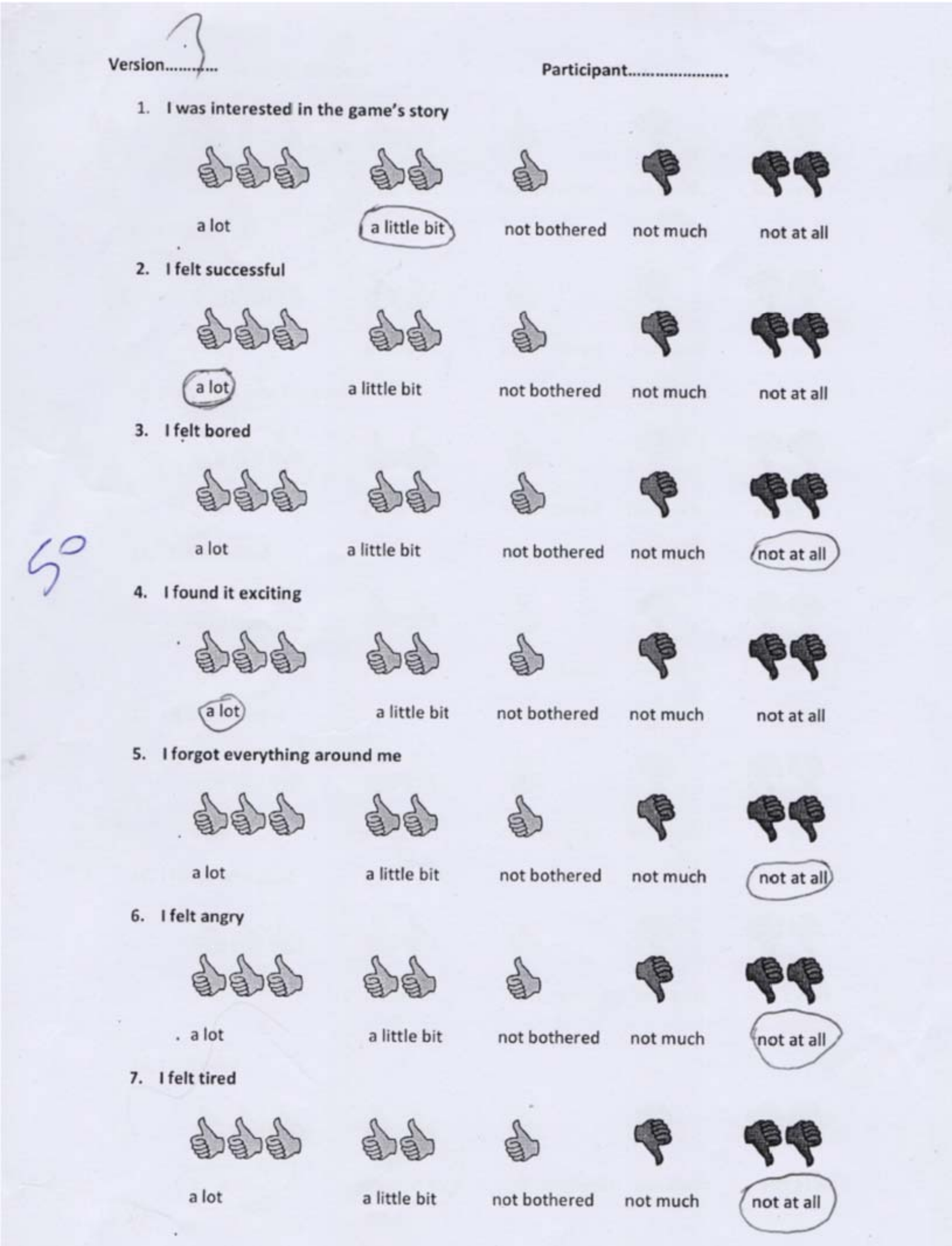
Table 37 One-way Analysis of overall learning outcome - Multiple Comparisons

1 = gradual removal

2 = all-or-nothing

3 = no scaffolding

Appendix III – A sample of the iGEQ completed by one of the participants AND A sample of a completed Multiple Choice Question (MCQ)



Version.....3...   Participant.....................

1. I was interested in the game's story

a lot	a little bit	not bothered	not much	not at all

2. I felt successful

a lot	a little bit	not bothered	not much	not at all

3. I felt bored

a lot	a little bit	not bothered	not much	not at all

50

4. I found it exciting

a lot	a little bit	not bothered	not much	not at all

5. I forgot everything around me

a lot	a little bit	not bothered	not much	not at all

6. I felt angry

a lot	a little bit	not bothered	not much	not at all

7. I felt tired

a lot	a little bit	not bothered	not much	not at all

8. **It made me easily annoyed**

a lot	a little bit	not bothered	not much	not at all

9. **I felt skilful**

a lot	a little bit	not bothered	not much	not at all

10. **I felt I was into the game**

a lot	a little bit	not bothered	not much	not at all

11. **I felt satisfied**

a lot	a little bit	not bothered	not much	not at all

12. **I felt challenged**

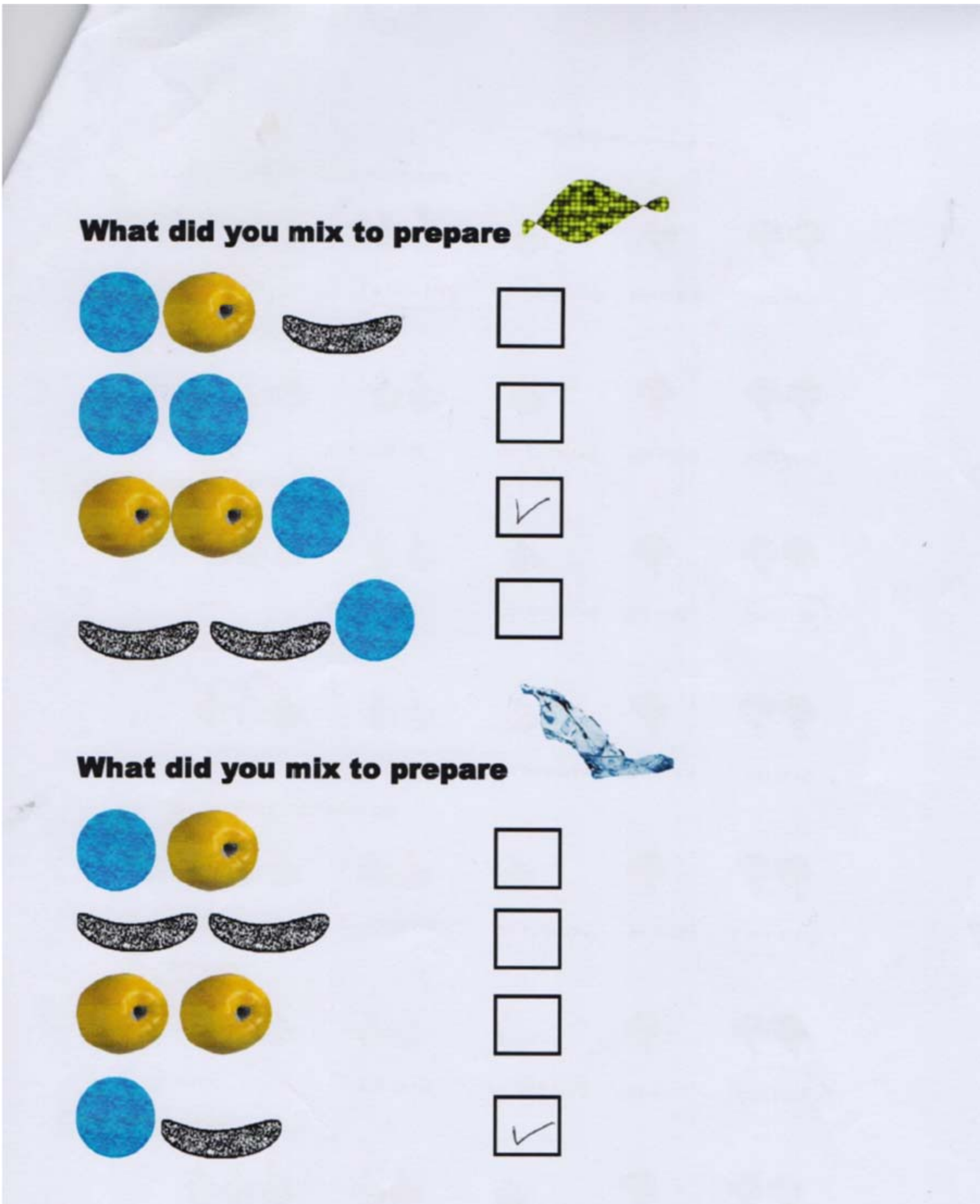
a lot	a little bit	not bothered	not much	not at all

13. **I felt encouraged**

a lot	a little bit	not bothered	not much	not at all

14. **I felt good**

a. a lot	a little bit	not bothered	not much	not at all



What did you mix to prepare

What did you mix to prepare

Where did you take the food to after preparing it?

To the guests ☑

To the garden ☐

To a pot ☐

Where did you get the fruits used in preparing the food?

From the guests ☐

From the garden ☑

From the kitchen ☐

Appendix V - Correlation between the different gameplay experience dimensions and overall knowledge gain

Correlations

		competence	Immersion	flow	Tension	Challenge	Negative	Positive	Ltotal
competence	Pearson Correlation	1	.838**	.348*	-.573**	.493**	-.596**	.748**	.423**
	Sig. (2-tailed)		.000	.011	.000	.000	.000	.000	.002
	N	52	52	52	52	52	52	52	52
Immersion	Pearson Correlation	.838**	1	.274*	-.529**	.589**	-.506**	.792**	.435**
	Sig. (2-tailed)	.000		.050	.000	.000	.000	.000	.001
	N	52	52	52	52	52	52	52	52
flow	Pearson Correlation	.348*	.274*	1	-.348*	.306*	-.124	.478**	.070
	Sig. (2-tailed)	.011	.050		.011	.027	.379	.000	.620
	N	52	52	52	52	52	52	52	52
Tension	Pearson Correlation	-.573**	-.529**	-.348*	1	-.289*	.613**	-.501**	-.562**
	Sig. (2-tailed)	.000	.000	.011		.038	.000	.000	.000
	N	52	52	52	52	52	52	52	52
Challenge	Pearson Correlation	.493**	.589**	.306*	-.289*	1	-.425**	.653**	.230
	Sig. (2-tailed)	.000	.000	.027	.038		.002	.000	.102
	N	52	52	52	52	52	52	52	52
Negative	Pearson Correlation	-.596**	-.506**	-.124	.613**	-.425**	1	-.420**	-.533**
	Sig. (2-tailed)	.000	.000	.379	.000	.002		.002	.000
	N	52	52	52	52	52	52	52	52
Positive	Pearson Correlation	.748**	.792**	.478**	-.501**	.653**	-.420**	1	.277*
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.002		.047
	N	52	52	52	52	52	52	52	52
Ltotal	Pearson Correlation	.423**	.435**	.070	-.562**	.230	-.533**	.277*	1
	Sig. (2-tailed)	.002	.001	.620	.000	.102	.000	.047	
	N	52	52	52	52	52	52	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 38 Correlation between the different gameplay experience dimensions and overall knowledge gain

Ltotal = overall learning outcome

Appendix VI Research Information and Consent sheets

Research Information sheet

Researcher: Chinedu Obikwelu

University of Central Lancashire, (UCLan) United Kingdom, PR1 2HE

This study aims at deriving guidelines for better instructional design in serious games. Serious games always have a learning objective attached to the game objective. The study will involve children playing a serious game with aspects of the game including the type and location of feedback together with its presentation manipulated at different points. Post-game data expected to reveal the child's overall gameplay experience would be captured. This would include the level of engagement. Some in-game data would also be captured - this would include Game performance based upon in-game scores, such as time and avoidable mistakes.

It is expected that every participating child would be engaged for about thirty minutes.

Consent Sheets

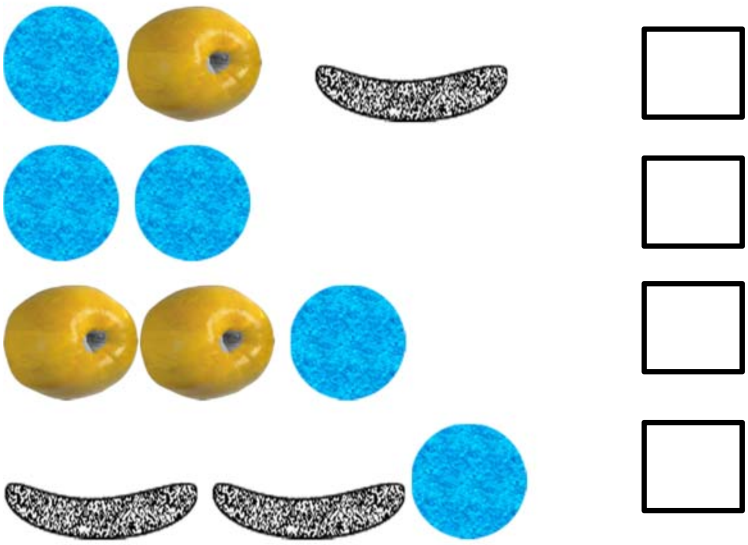
Having read the information sheet I am happy for my child ………………………………to participate in the research study described. I understand that my child will also be asked to consent and should he/she choose to withdraw consent then his/her decision will override this consent

Name………………………………………………………………………

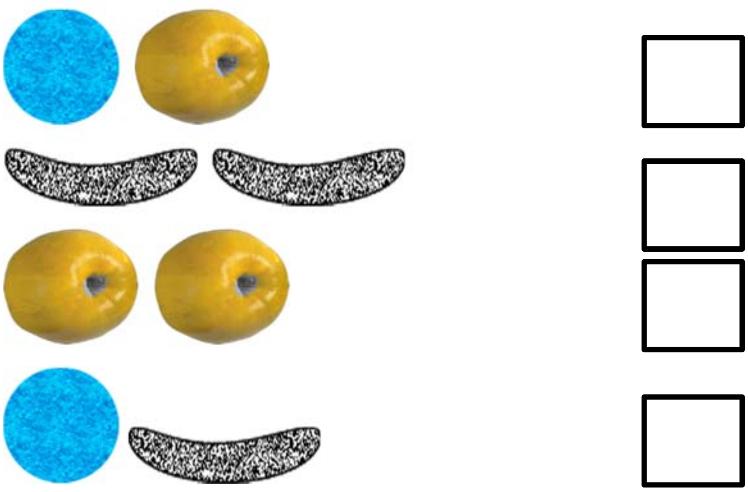
Signature…………………………………………..

Appendix VII Post-Game Test

What did you mix to prepare 



What did you mix to prepare 



Where did you take the food to after preparing it?

To the guests ☐

To the garden ☐

To a pot ☐

Where did you get the fruits used in preparing the food?

From the guests ☐

From the garden ☐

From the kitchen ☐

Appendix VIII Ethical Approval

Dear Janet / Chinedu

Re: STEM Ethics Committee Application
Unique Reference Number: STEMH 097_amendment

The STEMH Ethics Committee has approved your proposed amendment - participant group will include 6-11 years - to your application **'The Serious Game Approach to Problem-Based Learning for the Dependent Learner'**.

Yours sincerely

Kevin Butt
Vice-Chair
STEMH Ethics Committee

uclan
University of Central Lancashire

6 January 2014

Janet Read / Chinedu Obikwelu
School of Computing, Engineering and Physical Sciences
University of Central Lancashire

Dear Janet / Chinedu

Re: STEM Ethics Committee Application
Unique Reference Number: **STEM 097_PhD stage**

The STEM ethics committee has granted approval of your proposal application '**The Serious Game Approach to Problem-Based Learning for the Dependent Learner**'.

Please note that approval is granted up to the end of project date or for 5 years, whichever is the longer. This is on the assumption that the project does not significantly change, in which case, you should check whether further ethical clearance is required.

We shall e-mail you a copy of the end-of-project report form to complete within a month of the anticipated date of project completion you specified on your application form. This should be completed, within 3 months, to complete the ethics governance procedures or, alternatively, an amended end-of-project date forwarded to roffice@uclan.ac.uk quoting your unique reference number.

Yours sincerely

Kevin Butt
Vice Chair
STEM Ethics Committee

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals as a result of gained.

version	L1	L2	L3	L4	Ltotal	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14		competenc	Immersion	flow	Tension	Challenge	Negative	Positive
1 C		1	0	1	1	3	4	4	0	3	0	0	0	0	3	4	4	4	3	4	3.5	3.5	2	0	3.5	0	4
2 C		1	0	1	0	2	3	4	0	4	0	0	0	0	4	4	4	4	0	4	4	3.5	2	0	2	0	4
3 C		0	1	0	0	1	0	2	4	4	3	1	4	4	2	3	4	3	4	3	2	2	3	2.5	3.5	4	3.5
4 C		1	0	0	0	1	0	0	4	0	0	1	4	4	0	0	0	0	0	0	0	0	0	2.5	0	4	0
5 C		0	0	0	0	0	3	1	4	0	1	4	4	4	0	0	0	0	0	0	0.5	1.5	0.5	4	0	4	0
6 C		1	0	1	1	3	0	0	4	0	0	4	0	4	0	0	0	4	0	0	0	0	0	4	2	2	0
7 C		0	1	0	0	1	4	3	1	4	1	3	1	3	4	0	3	4	4	4	3.5	4	0.5	3	4	1	3.5
8 C		0	1	0	1	2	0	3	3	4	0	3	0	0	0	0	0	2	1	3	1.5	2	0	1.5	1.5	1.5	1.5
9 B		1	1	0	1	3	4	4	0	4	1	0	3	4	2	4	4	0	4	4	3	4	2.5	2	2	1.5	4
10 B		1	1	1	1	4	1	4	3	3	3	1	1	4	0	0	0	0	0	0	2	2	1.5	2.5	0	2	0
11 B		0	0	1	1	2	3	3	1	4	4	3	4	0	4	4	4	4	1	4	3.5	3.5	4	1.5	2.5	2.5	4
12 B		1	1	1	1	4	4	4	0	4	0	0	0	0	4	4	4	4	4	4	4	4	2	0	4	0	4
13 B		1	1	1	1	4	3	3	0	4	0	0	0	0	3	3	4	0	4	4	3	3.5	1.5	0	2	0	4
14 B		1	1	1	1	4	3	4	0	4	1	0	1	0	3	4	4	3	4	4	3.5	3.5	2.5	0	3.5	0.5	4
15 B		1	1	1	1	4	4	4	3	3	0	0	0	0	4	4	3	0	2	3	4	3.5	2	0	1	1.5	3
16 B		1	1	0	0	2	0	0	4	0	3	4	0	4	0	0	0	0	0	0	0	0	1.5	4	0	2	0
17 B		0	1	1	1	3	4	1	1	4	3	0	4	0	4	4	4	4	0	3	2.5	4	3.5	0	2	2.5	3.5
18 B		0	1	1	0	2	4	4	3	3	4	0	1	3	4	3	4	0	3	4	4	3.5	3.5	1.5	1.5	2	4
19 A		1	1	1	1	4	3	4	1	3	4	1	0	1	0	4	3	4	3	3	2	3	4	1	3.5	0.5	3
20 A		1	1	1	1	4	3	4	0	3	3	0	0	0	4	0	3	0	0	4	4	3	1.5	0	0	0	3.5
21 A		0	0	1	1	2	4	4	0	4	3	0	3	0	4	3	4	0	4	4	4	4	3	0	2	1.5	4
22 A		0	1	1	1	3	4	3	0	3	4	0	3	0	3	3	4	4	3	4	3	3.5	3.5	0	3.5	1.5	4
23 A		1	1	1	1	4	3	4	2	4	3	0	0	0	3	3	4	4	2	3	3.5	3.5	3	0	3	1	3.5
24 A		1	1	1	1	4	4	4	0	4	3	0	0	0	4	4	4	3	3	4	4	4	3.5	0	3	0	4
25 A		1	1	1	1	4	4	4	0	3	2	0	0	0	3	4	4	2	3	4	3.5	3.5	3	0	2.5	0	4
26 A		1	1	1	1	4	4	4	0	4	3	0	1	0	4	4	3	4	4	4	4	4	3.5	0	4	0.5	3.5
27 A		1	1	1	1	4	4	3	0	4	0	3	0	1	4	0	1	1	3	3	3.5	4	0	2	2	0	2
28 A		1	1	1	1	4	4	3	0	4	3	1	3	0	4	4	4	3	4	3	3.5	4	3.5	0.5	3.5	1.5	3.5
29 A		1	1	1	1	4	4	4	0	4	0	0	0	0	2	2	3	4	4	4	3	4	1	0	4	0	3.5
30 A		1	0	1	1	3	4	3	0	4	3	0	0	0	3	4	4	3	4	4	3	4	3.5	0	3.5	0	4
31 A		0	0	1	1	2	3	3	0	4	3	0	0	0	4	3	4	4	4	4	3.5	3.5	3	0	4	0	4
32 A		1	1	1	1	4	4	4	0	4	0	0	0	0	4	4	4	4	4	4	4	4	2	0	4	0	4
33 A		1	1	1	1	4	4	4	0	3	0	3	3	0	4	4	4	4	4	4	4	3.5	2	1.5	4	1.5	4
34 A		1	1	1	1	4	4	4	0	4	4	0	0	0	4	4	4	4	4	4	4	4	4	0	4	0	4
35 A		1	1	0	0	2	4	4	0	4	3	0	0	3	4	4	3	3	2	4	4	4	3.5	1.5	2.5	0	3.5
36 A		1	0	1	1	3	3	4	0	3	1	0	0	0	4	4	3	2	4	4	4	3	2.5	0	3	0	3.5
37 B		1	0	1	1	3	4	4	0	3	0	0	0	0	4	3	1	0	3	4	4	3.5	1.5	0	1.5	0	2.5
38 B		0	0	1	1	2	3	1	0	3	0	3	4	1	3	4	4	3	4	4	2	3	2	2	3.5	2	4
39 B		1	1	1	1	4	4	3	2	4	0	1	0	1	4	1	3	3	3	4	3.5	4	0.5	1	3	1	3.5
40 B		1	1	1	1	4	4	4	0	4	0	0	0	0	4	4	4	3	4	4	4	4	2	0	3.5	0	4
41 B		1	1	1	1	4	4	4	0	4	0	3	2	0	3	0	4	3	3	4	3.5	4	0	1.5	3	1	4
42 B		1	0	1	1	3	4	4	3	3	4	2	0	2	4	4	4	1	3	4	4	3.5	4	2	2	1.5	4
43 B		1	0	1	1	3	4	4	0	4	1	0	0	0	2	4	4	3	3	4	3	4	2.5	0	3	0	4
44 C		1	1	0	0	2	0	0	0	0	4	0	0	0	3	4	0	1	2	3	1.5	0	4	0	1.5	0	1.5
45 C		0	1	0	1	2	4	3	0	3	0	3	0	3	4	4	3	4	3	4	3.5	3.5	2	3	3.5	0	3.5
46 C		1	0	1	1	3	3	0	2	3	1	4	1	1	3	4	4	3	2	4	1.5	3	2.5	2.5	2.5	1.5	4
47 C		1	0	0	1	2	3	4	3	4	4	3	0	3	4	4	3	4	4	4	4	3.5	4	3	4	1.5	3.5
48 C		0	0	1	1	2	4	3	0	4	0	3	1	1	4	4	4	4	4	4	3.5	4	2	2	4	0.5	4
49 C		1	0	1	0	2	1	3	0	4	1	3	2	3	4	3	4	4	3	3	3.5	2.5	2	3	3.5	1	3.5
50 C		1	1	1	1	4	3	4	0	4	0	0	0	0	4	4	0	3	3	4	4	3.5	2	0	3	0	2
51 C		1	1	1	0	3	4	4	0	4	0	0	0	0	4	4	4	3	4	4	4	4	2	0	3.5	0	4
52 C		1	0	1	1	3	4	3	0	4	0	0	0	0	3	4	0	3	4	4	3	4	2	0	3.5	0	2

Appendix X Data from SECOND study

Timestamp	Session Ind	Event	Description	Version	Platform	Device	User ID	Params
3/23/2016	1	order1 on table (on level1)			Mobile Web			{}
3/23/2016	2	00:10:31			Mobile Web			{}
3/23/2016	3	order2 on table (on level1)			Mobile Web			{}
3/23/2016	4	00:09:32			Mobile Web			{}
3/23/2016	5	go to level2			Mobile Web			{}
3/23/2016	6	00:09:29			Mobile Web			{}
3/23/2016	7	Wed Mar 23 2016 16:00:20 GMT+			Mobile Web			{}
3/23/2016	8	order1 on table (on level2)			Mobile Web			{}
3/23/2016	9	00:06:10			Mobile Web			{}
3/23/2016	10	order2 on table (on level2)			Mobile Web			{}
3/23/2016	11	00:05:44			Mobile Web			{}
3/23/2016	12	go to level3			Mobile Web			{}
3/23/2016	13	00:05:40			Mobile Web			{}
3/23/2016	14	Wed Mar 23 2016 16:01:38 GMT+			Mobile Web			{}
3/23/2016	15	order1 on table (on level1)			Mobile Web			{}
3/23/2016	16	00:10:44			Mobile Web			{}
3/23/2016	17	order2 on table (on level1)			Mobile Web			{}
3/23/2016	18	00:10:15			Mobile Web			{}
3/23/2016	19	go to level2			Mobile Web			{}
3/23/2016	20	00:10:10			Mobile Web			{}
3/23/2016	21	Wed Mar 23 2016 16:04:44 GMT+			Mobile Web			{}
3/23/2016	22	order1 on table (on level2)			Mobile Web			{}
3/23/2016	23	00:06:56			Mobile Web			{}
3/23/2016	24	order2 on table (on level2)			Mobile Web			{}
3/23/2016	25	00:06:18			Mobile Web			{}
3/23/2016	26	go to level3			Mobile Web			{}
3/23/2016	27	00:06:16			Mobile Web			{}
3/23/2016	28	Wed Mar 23 2016 16:06:49 GMT+			Mobile Web			{}
3/23/2016	29	order1 on table (on level3)			Mobile Web			{}
3/23/2016	30	00:03:21			Mobile Web			{}
3/23/2016	31	order2 on table (on level3)			Mobile Web			{}
3/23/2016	32	00:02:53			Mobile Web			{}
3/23/2016	33	go to level4			Mobile Web			{}
3/23/2016	34	00:02:51			Mobile Web			{}
3/23/2016	35	Wed Mar 23 2016 16:08:10 GMT+			Mobile Web			{}
3/23/2016	36	order1 on table (on level4)			Mobile Web			{}
3/23/2016	37	00:00:51			Mobile Web			{}
3/23/2016	38	MISTAKE reset for order2 (on leve			Mobile Web			{}
3/23/2016	39	00:00:28			Mobile Web			{}
3/23/2016	40	lose a life on order2 (on level4)			Mobile Web			{}
3/23/2016	41	00:00:28			Mobile Web			{}
3/23/2016	42	time up on level4			Mobile Web			{}
3/23/2016	43	time up on level4			Mobile Web			{}
3/23/2016	44	time up on level4			Mobile Web			{}
3/23/2016	45	time up on level4			Mobile Web			{}
3/23/2016	46	time up on level4			Mobile Web			{}
3/23/2016	47	time up on level4			Mobile Web			{}
3/23/2016	48	time up on level4			Mobile Web			{}
3/23/2016	49	time up on level4			Mobile Web			{}

3/23/2016	1	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	2	00:08:46	Mobile Web	{}
3/23/2016	3	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	4	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	5	00:06:39	Mobile Web	{}
3/23/2016	6	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	7	order1 on table (on level1)	Mobile Web	{}
3/23/2016	8	00:04:25	Mobile Web	{}
3/23/2016	9	order2 on table (on level1)	Mobile Web	{}
3/23/2016	10	00:03:20	Mobile Web	{}
3/23/2016	11	go to level2	Mobile Web	{}
3/23/2016	12	00:03:11	Mobile Web	{}
3/23/2016	13	Wed Mar 23 2016 15:36:06 GMT+	Mobile Web	{}
3/23/2016	1	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	2	00:11:04	Mobile Web	{}
3/23/2016	3	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	4	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	5	00:09:48	Mobile Web	{}
3/23/2016	6	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	7	order1 on table (on level1)	Mobile Web	{}
3/23/2016	8	00:08:48	Mobile Web	{}
3/23/2016	9	MISTAKE reset for order2 (on leve	Mobile Web	{}
3/23/2016	10	00:08:30	Mobile Web	{}
3/23/2016	11	lose a life on order2 (on level1)	Mobile Web	{}
3/23/2016	12	order2 on table (on level1)	Mobile Web	{}
3/23/2016	13	00:07:58	Mobile Web	{}
3/23/2016	14	go to level2	Mobile Web	{}
3/23/2016	15	00:07:55	Mobile Web	{}
3/23/2016	16	Wed Mar 23 2016 15:11:59 GMT+	Mobile Web	{}

3/23/2016	17	order1 on table (on level2)	Mobile Web	{}
3/23/2016	18	00:03:07	Mobile Web	{}
3/23/2016	19	order2 on table (on level2)	Mobile Web	{}
3/23/2016	20	00:02:51	Mobile Web	{}
3/23/2016	21	go to level3	Mobile Web	{}
3/23/2016	22	00:02:48	Mobile Web	{}
3/23/2016	23	Wed Mar 23 2016 15:13:00 GMT+	Mobile Web	{}
3/23/2016	24	order1 on table (on level3)	Mobile Web	{}
3/23/2016	25	00:01:10	Mobile Web	{}
3/23/2016	26	order2 on table (on level3)	Mobile Web	{}
3/23/2016	27	00:00:40	Mobile Web	{}
3/23/2016	28	go to level4	Mobile Web	{}
3/23/2016	29	00:00:38	Mobile Web	{}
3/23/2016	30	Wed Mar 23 2016 15:14:10 GMT+	Mobile Web	{}
3/23/2016	1	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	2	00:10:45	Mobile Web	{}
3/23/2016	3	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	4	order1 on table (on level1)	Mobile Web	{}
3/23/2016	5	00:09:31	Mobile Web	{}
3/23/2016	6	order2 on table (on level1)	Mobile Web	{}
3/23/2016	7	00:08:46	Mobile Web	{}
3/23/2016	8	go to level2	Mobile Web	{}
3/23/2016	9	00:08:40	Mobile Web	{}
3/23/2016	10	Wed Mar 23 2016 14:48:02 GMT+	Mobile Web	{}
3/23/2016	11	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	12	00:04:05	Mobile Web	{}
3/23/2016	13	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	14	00:04:05	Mobile Web	{}
3/23/2016	15	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	16	00:02:55	Mobile Web	{}
3/23/2016	17	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	18	00:02:55	Mobile Web	{}
3/23/2016	19	order1 on table (on level2)	Mobile Web	{}
3/23/2016	20	00:01:16	Mobile Web	{}
3/23/2016	21	order2 on table (on level2)	Mobile Web	{}
3/23/2016	22	00:00:50	Mobile Web	{}
3/23/2016	23	order1 on table (on level1)	Mobile Web	{}
3/23/2016	24	00:10:34	Mobile Web	{}
3/23/2016	25	order2 on table (on level1)	Mobile Web	{}
3/23/2016	26	00:09:35	Mobile Web	{}
3/23/2016	27	go to level2	Mobile Web	{}
3/23/2016	28	00:08:50	Mobile Web	{}
3/23/2016	29	Wed Mar 23 2016 14:57:54 GMT+	Mobile Web	{}
3/23/2016	30	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	31	00:04:59	Mobile Web	{}
3/23/2016	32	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	33	00:04:59	Mobile Web	{}
3/23/2016	34	order1 on table (on level2)	Mobile Web	{}
3/23/2016	35	00:04:29	Mobile Web	{}
3/23/2016	36	order2 on table (on level2)	Mobile Web	{}

3/23/2016	37 00:03:57	Mobile Web	{}
3/23/2016	38 go to level3	Mobile Web	{}
3/23/2016	39 00:03:50	Mobile Web	{}
3/23/2016	40 Wed Mar 23 2016 14:59:46 GMT+	Mobile Web	{}
3/23/2016	41 order1 on table (on level3)	Mobile Web	{}
3/23/2016	42 00:01:19	Mobile Web	{}
3/23/2016	43 order2 on table (on level3)	Mobile Web	{}
3/23/2016	44 00:00:49	Mobile Web	{}
3/23/2016	45 go to level4	Mobile Web	{}
3/23/2016	46 00:00:47	Mobile Web	{}
3/23/2016	47 Wed Mar 23 2016 15:00:57 GMT+	Mobile Web	{}
3/23/2016	1 order1 on table (on level1)	Mobile Web	{}
3/23/2016	2 00:10:38	Mobile Web	{}
3/23/2016	3 order2 on table (on level1)	Mobile Web	{}
3/23/2016	4 00:09:52	Mobile Web	{}
3/23/2016	5 go to level2	Mobile Web	{}
3/23/2016	6 00:09:48	Mobile Web	{}
3/23/2016	7 Wed Mar 23 2016 14:26:12 GMT+	Mobile Web	{}
3/23/2016	8 MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	9 00:07:21	Mobile Web	{}
3/23/2016	10 lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	11 00:07:21	Mobile Web	{}
3/23/2016	12 MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	13 00:07:00	Mobile Web	{}
3/23/2016	14 lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	15 00:07:00	Mobile Web	{}
3/23/2016	16 MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	17 00:06:47	Mobile Web	{}
3/23/2016	18 lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	19 00:06:47	Mobile Web	{}
3/23/2016	20 MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	21 00:06:01	Mobile Web	{}
3/23/2016	22 lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	23 00:06:01	Mobile Web	{}
3/23/2016	24 MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	25 00:05:23	Mobile Web	{}
3/23/2016	26 lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	27 00:05:23	Mobile Web	{}
3/23/2016	28 gameover on level2	Mobile Web	{}
3/23/2016	29 00:05:23	Mobile Web	{}
3/23/2016	30 go to level3	Mobile Web	{}
3/23/2016	31 00:05:23	Mobile Web	{}
3/23/2016	32 Wed Mar 23 2016 14:28:31 GMT+	Mobile Web	{}
3/23/2016	33 order1 on table (on level3)	Mobile Web	{}
3/23/2016	34 00:02:34	Mobile Web	{}
3/23/2016	35 MISTAKE reset for order2 (on leve	Mobile Web	{}
3/23/2016	36 00:02:09	Mobile Web	{}
3/23/2016	37 lose a life on order2 (on level3)	Mobile Web	{}
3/23/2016	38 00:02:09	Mobile Web	{}
3/23/2016	39 MISTAKE reset for order2 (on leve	Mobile Web	{}

3/23/2016	40	00:01:57	Mobile Web	{}
3/23/2016	41	lose a life on order2 (on level3)	Mobile Web	{}
3/23/2016	42	00:01:57	Mobile Web	{}
3/23/2016	1	order1 on table (on level1)	Mobile Web	{}
3/23/2016	2	00:10:33	Mobile Web	{}
3/23/2016	3	order2 on table (on level1)	Mobile Web	{}
3/23/2016	4	00:10:01	Mobile Web	{}
3/23/2016	5	go to level2	Mobile Web	{}
3/23/2016	6	00:09:52	Mobile Web	{}
3/23/2016	7	Wed Mar 23 2016 13:46:15 GMT+	Mobile Web	{}
3/23/2016	8	order1 on table (on level2)	Mobile Web	{}
3/23/2016	9	00:06:51	Mobile Web	{}
3/23/2016	10	order2 on table (on level2)	Mobile Web	{}
3/23/2016	11	00:06:27	Mobile Web	{}
3/23/2016	12	go to level3	Mobile Web	{}
3/23/2016	13	00:06:21	Mobile Web	{}
3/23/2016	14	Wed Mar 23 2016 13:47:39 GMT+	Mobile Web	{}
3/23/2016	15	order1 on table (on level3)	Mobile Web	{}
3/23/2016	16	00:04:06	Mobile Web	{}
3/23/2016	17	order2 on table (on level3)	Mobile Web	{}
3/23/2016	18	00:03:38	Mobile Web	{}
3/23/2016	19	go to level4	Mobile Web	{}
3/23/2016	20	00:03:26	Mobile Web	{}
3/23/2016	21	Wed Mar 23 2016 13:49:11 GMT+	Mobile Web	{}
3/23/2016	22	order1 on table (on level4)	Mobile Web	{}
3/23/2016	23	00:01:16	Mobile Web	{}
3/23/2016	1	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	2	00:09:55	Mobile Web	{}
3/23/2016	3	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	4	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	5	00:08:53	Mobile Web	{}
3/23/2016	6	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	7	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	8	00:08:13	Mobile Web	{}
3/23/2016	9	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	10	order1 on table (on level1)	Mobile Web	{}
3/23/2016	11	00:07:30	Mobile Web	{}
3/23/2016	12	MISTAKE reset for order2 (on leve	Mobile Web	{}
3/23/2016	13	00:06:59	Mobile Web	{}
3/23/2016	14	lose a life on order2 (on level1)	Mobile Web	{}
3/23/2016	15	order2 on table (on level1)	Mobile Web	{}
3/23/2016	16	00:06:00	Mobile Web	{}
3/23/2016	17	go to level2	Mobile Web	{}
3/23/2016	18	00:05:56	Mobile Web	{}
3/23/2016	19	Wed Mar 23 2016 13:23:14 GMT+	Mobile Web	{}
3/23/2016	1	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	2	00:09:29	Mobile Web	{}
3/23/2016	3	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	4	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	5	00:08:51	Mobile Web	{}

3/23/2016	6	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	7	order1 on table (on level1)	Mobile Web	{}
3/23/2016	8	00:06:57	Mobile Web	{}
3/23/2016	9	go to level2	Mobile Web	{}
3/23/2016	10	00:06:26	Mobile Web	{}
3/23/2016	11	Wed Mar 23 2016 10:52:06 GMT+	Mobile Web	{}
3/23/2016	12	time up on level2	Mobile Web	{}
3/23/2016	13	time up on level2	Mobile Web	{}
3/23/2016	14	time up on level2	Mobile Web	{}
3/23/2016	15	time up on level2	Mobile Web	{}
3/23/2016	16	time up on level2	Mobile Web	{}
3/23/2016	17	time up on level2	Mobile Web	{}
3/23/2016	18	time up on level2	Mobile Web	{}
3/23/2016	19	time up on level2	Mobile Web	{}
3/23/2016	20	time up on level2	Mobile Web	{}
3/23/2016	21	time up on level2	Mobile Web	{}
3/23/2016	22	time up on level2	Mobile Web	{}
3/23/2016	23	time up on level2	Mobile Web	{}
3/23/2016	24	time up on level2	Mobile Web	{}
3/23/2016	25	time up on level2	Mobile Web	{}
3/23/2016	26	time up on level2	Mobile Web	{}
3/23/2016	27	time up on level2	Mobile Web	{}
3/23/2016	28	time up on level2	Mobile Web	{}
3/23/2016	29	time up on level2	Mobile Web	{}
3/23/2016	30	time up on level2	Mobile Web	{}
3/23/2016	31	time up on level2	Mobile Web	{}
3/23/2016	32	time up on level2	Mobile Web	{}
3/23/2016	33	time up on level2	Mobile Web	{}
3/23/2016	34	time up on level2	Mobile Web	{}
3/23/2016	35	time up on level2	Mobile Web	{}
3/23/2016	36	time up on level2	Mobile Web	{}
3/23/2016	37	time up on level2	Mobile Web	{}
3/23/2016	38	time up on level2	Mobile Web	{}
3/23/2016	39	time up on level2	Mobile Web	{}
3/23/2016	40	time up on level2	Mobile Web	{}
3/23/2016	41	time up on level2	Mobile Web	{}
3/23/2016	42	time up on level2	Mobile Web	{}
3/23/2016	43	time up on level2	Mobile Web	{}
3/23/2016	44	time up on level2	Mobile Web	{}
3/23/2016	45	time up on level2	Mobile Web	{}
3/23/2016	46	time up on level2	Mobile Web	{}
3/23/2016	47	time up on level2	Mobile Web	{}
3/23/2016	48	time up on level2	Mobile Web	{}
3/23/2016	49	time up on level2	Mobile Web	{}
3/23/2016	50	time up on level2	Mobile Web	{}
3/23/2016	51	time up on level2	Mobile Web	{}
3/23/2016	52	time up on level2	Mobile Web	{}
3/23/2016	53	time up on level2	Mobile Web	{}
3/23/2016	54	time up on level2	Mobile Web	{}
3/23/2016	55	time up on level2	Mobile Web	{}

3/23/2016	1148	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	1149	00:10:06	Mobile Web	{}
3/23/2016	1150	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	1151	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	1152	00:09:11	Mobile Web	{}
3/23/2016	1153	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	1154	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	1155	00:08:10	Mobile Web	{}
3/23/2016	1156	lose a life on order1 (on level1)	Mobile Web	{}
3/23/2016	1157	order1 on table (on level1)	Mobile Web	{}
3/23/2016	1158	00:07:23	Mobile Web	{}
3/23/2016	1159	order2 on table (on level1)	Mobile Web	{}
3/23/2016	1160	00:06:33	Mobile Web	{}
3/23/2016	1161	go to level2	Mobile Web	{}
3/23/2016	1162	00:06:29	Mobile Web	{}
3/23/2016	1163	Wed Mar 23 2016 11:00:50 GMT+	Mobile Web	{}
3/23/2016	1164	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	1165	00:00:12	Mobile Web	{}
3/23/2016	1166	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	1167	00:00:12	Mobile Web	{}
3/23/2016	1168	time up on level2	Mobile Web	{}
3/23/2016	1169	time up on level2	Mobile Web	{}
3/23/2016	1170	time up on level2	Mobile Web	{}

3/23/2016	1	order1 on table (on level1)	Mobile Web	{}
3/23/2016	2	00:10:19	Mobile Web	{}
3/23/2016	3	order2 on table (on level1)	Mobile Web	{}
3/23/2016	4	00:09:33	Mobile Web	{}
3/23/2016	5	go to level2	Mobile Web	{}
3/23/2016	6	00:09:27	Mobile Web	{}
3/23/2016	7	Wed Mar 23 2016 10:35:34 GMT+	Mobile Web	{}
3/23/2016	8	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	9	00:06:02	Mobile Web	{}
3/23/2016	10	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	11	00:06:02	Mobile Web	{}
3/23/2016	12	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	13	00:05:48	Mobile Web	{}
3/23/2016	14	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	15	00:05:48	Mobile Web	{}
3/23/2016	16	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	17	00:05:48	Mobile Web	{}
3/23/2016	18	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	19	00:05:48	Mobile Web	{}
3/23/2016	20	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	21	00:05:05	Mobile Web	{}
3/23/2016	22	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	23	00:05:05	Mobile Web	{}
3/23/2016	24	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	25	00:04:08	Mobile Web	{}
3/23/2016	26	lose a life on order1 (on level2)	Mobile Web	{}
3/23/2016	27	00:04:08	Mobile Web	{}
3/23/2016	28	gameover on level2	Mobile Web	{}
3/23/2016	29	00:04:08	Mobile Web	{}
3/23/2016	30	go to level3	Mobile Web	{}
3/23/2016	31	00:04:08	Mobile Web	{}
3/23/2016	32	Wed Mar 23 2016 10:38:30 GMT+	Mobile Web	{}
3/23/2016	33	MISTAKE reset for order1 (on leve	Mobile Web	{}
3/23/2016	34	00:00:10	Mobile Web	{}
3/23/2016	35	lose a life on order1 (on level3)	Mobile Web	{}
3/23/2016	36	00:00:10	Mobile Web	{}

3/23/2016	37 time up on level3	Mobile Web	{}
3/23/2016	38 time up on level3	Mobile Web	{}
3/23/2016	39 time up on level3	Mobile Web	{}
3/23/2016	40 time up on level3	Mobile Web	{}
3/23/2016	41 time up on level3	Mobile Web	{}
3/23/2016	42 time up on level3	Mobile Web	{}
3/23/2016	43 time up on level3	Mobile Web	{}
3/23/2016	44 time up on level3	Mobile Web	{}
3/23/2016	45 time up on level3	Mobile Web	{}
3/23/2016	46 time up on level3	Mobile Web	{}
3/23/2016	47 time up on level3	Mobile Web	{}
3/23/2016	48 time up on level3	Mobile Web	{}
3/23/2016	49 time up on level3	Mobile Web	{}
3/23/2016	50 time up on level3	Mobile Web	{}
3/23/2016	51 time up on level3	Mobile Web	{}
3/23/2016	52 time up on level3	Mobile Web	{}
3/23/2016	53 time up on level3	Mobile Web	{}
3/23/2016	54 time up on level3	Mobile Web	{}
3/23/2016	55 time up on level3	Mobile Web	{}
3/23/2016	56 time up on level3	Mobile Web	{}
3/23/2016	57 time up on level3	Mobile Web	{}
3/23/2016	58 time up on level3	Mobile Web	{}
3/23/2016	59 time up on level3	Mobile Web	{}
3/23/2016	60 time up on level3	Mobile Web	{}
3/23/2016	61 time up on level3	Mobile Web	{}
3/23/2016	62 time up on level3	Mobile Web	{}
3/23/2016	63 time up on level3	Mobile Web	{}
3/23/2016	64 time up on level3	Mobile Web	{}
3/23/2016	65 time up on level3	Mobile Web	{}
3/23/2016	66 time up on level3	Mobile Web	{}
3/23/2016	67 time up on level3	Mobile Web	{}
3/23/2016	68 time up on level3	Mobile Web	{}
3/23/2016	69 time up on level3	Mobile Web	{}
3/23/2016	70 time up on level3	Mobile Web	{}
3/23/2016	71 time up on level3	Mobile Web	{}
3/23/2016	72 time up on level3	Mobile Web	{}
3/23/2016	73 time up on level3	Mobile Web	{}
3/23/2016	74 time up on level3	Mobile Web	{}
3/23/2016	75 time up on level3	Mobile Web	{}
3/23/2016	76 time up on level3	Mobile Web	{}
3/23/2016	77 time up on level3	Mobile Web	{}
3/23/2016	78 time up on level3	Mobile Web	{}
3/23/2016	79 time up on level3	Mobile Web	{}
3/23/2016	80 time up on level3	Mobile Web	{}
3/23/2016	81 time up on level3	Mobile Web	{}
3/23/2016	82 time up on level3	Mobile Web	{}
3/23/2016	83 time up on level3	Mobile Web	{}
3/23/2016	84 time up on level3	Mobile Web	{}
3/23/2016	85 time up on level3	Mobile Web	{}
3/23/2016	86 time up on level3	Mobile Web	{}

Timestamp	Session Ind	Event	Descriptior	Version	Platform	Device	User ID	Params
########	1	go to level2			Mobile Web			{}
########	2	00:11:29			Mobile Web			{}
########	3	order1 on table (on level1)			Mobile Web			{}
########	4	00:10:57			Mobile Web			{}
########	5	order2 on table (on level1)			Mobile Web			{}
########	6	00:10:33			Mobile Web			{}
########	7	go to level2			Mobile Web			{}
########	8	00:10:30			Mobile Web			{}
########	9	go to level2			Mobile Web			{}
########	10	00:10:30			Mobile Web			{}
########	11	go to level2			Mobile Web			{}
########	12	00:10:29			Mobile Web			{}
########	13	go to level2			Mobile Web			{}
########	14	00:10:29			Mobile Web			{}
########	15	go to level2			Mobile Web			{}
########	16	00:10:29			Mobile Web			{}
########	17	go to level2			Mobile Web			{}
########	18	00:10:29			Mobile Web			{}
########	19	go to level2			Mobile Web			{}
########	20	00:10:29			Mobile Web			{}
########	21	go to level2			Mobile Web			{}
########	22	00:10:28			Mobile Web			{}
########	23	go to level2			Mobile Web			{}
########	24	00:10:25			Mobile Web			{}
########	25	go to level2			Mobile Web			{}
########	26	00:10:24			Mobile Web			{}
########	27	go to level2			Mobile Web			{}
########	28	00:10:22			Mobile Web			{}
########	29	go to level2			Mobile Web			{}
########	30	00:10:22			Mobile Web			{}
########	31	go to level2			Mobile Web			{}
########	32	00:10:20			Mobile Web			{}
########	33	go to level2			Mobile Web			{}
########	34	00:10:17			Mobile Web			{}
########	35	go to level2			Mobile Web			{}
########	36	00:10:16			Mobile Web			{}
########	37	go to level2			Mobile Web			{}
########	38	00:10:16			Mobile Web			{}
########	39	go to level2			Mobile Web			{}
########	40	00:10:10			Mobile Web			{}
########	41	go to level2			Mobile Web			{}
########	42	00:10:10			Mobile Web			{}
########	43	go to level2			Mobile Web			{}
########	44	00:09:45			Mobile Web			{}
########	45	go to level2			Mobile Web			{}
########	46	00:09:44			Mobile Web			{}
########	47	go to level2			Mobile Web			{}
########	48	00:09:44			Mobile Web			{}
########	49	go to level2			Mobile Web			{}
########	50	00:09:44			Mobile Web			{}

########	51 go to level2	Mobile Web	{}
########	52 00:09:42	Mobile Web	{}
########	53 go to level2	Mobile Web	{}
########	54 00:09:42	Mobile Web	{}
########	55 go to level2	Mobile Web	{}
########	56 00:09:36	Mobile Web	{}
########	57 go to level2	Mobile Web	{}
########	58 00:09:36	Mobile Web	{}
########	59 go to level2	Mobile Web	{}
########	60 00:09:35	Mobile Web	{}
########	61 go to level2	Mobile Web	{}
########	62 00:09:35	Mobile Web	{}
########	63 go to level2	Mobile Web	{}
########	64 00:09:35	Mobile Web	{}
########	65 go to level2	Mobile Web	{}
########	66 00:09:34	Mobile Web	{}
########	67 go to level2	Mobile Web	{}
########	68 00:09:33	Mobile Web	{}
########	69 go to level2	Mobile Web	{}
########	70 00:09:13	Mobile Web	{}
########	71 go to level2	Mobile Web	{}
########	72 00:09:13	Mobile Web	{}
########	73 go to level2	Mobile Web	{}
########	74 00:09:13	Mobile Web	{}
########	75 go to level2	Mobile Web	{}
########	76 00:09:07	Mobile Web	{}
########	77 go to level2	Mobile Web	{}
########	78 00:09:07	Mobile Web	{}
########	79 go to level2	Mobile Web	{}
########	80 00:09:07	Mobile Web	{}
########	81 go to level2	Mobile Web	{}
########	82 00:09:06	Mobile Web	{}
########	1 MISTAKE reset for order1 (on leve	Mobile Web	{}
########	2 00:09:31	Mobile Web	{}
########	3 lose a life on order1 (on level1)	Mobile Web	{}
########	4 00:09:31	Mobile Web	{}
########	5 MISTAKE reset for order1 (on leve	Mobile Web	{}
########	6 00:08:54	Mobile Web	{}
########	7 lose a life on order1 (on level1)	Mobile Web	{}
########	8 00:08:54	Mobile Web	{}
########	9 MISTAKE reset for order1 (on leve	Mobile Web	{}
########	10 00:08:09	Mobile Web	{}
########	11 lose a life on order1 (on level1)	Mobile Web	{}
########	12 00:08:09	Mobile Web	{}
########	13 order1 on table (on level1)	Mobile Web	{}
########	14 00:06:54	Mobile Web	{}
########	15 order2 on table (on level1)	Mobile Web	{}
########	16 00:06:10	Mobile Web	{}
########	17 go to level2	Mobile Web	{}
########	18 00:06:06	Mobile Web	{}
########	19 Tue Mar 22 2016 12:00:43 GMT+(	Mobile Web	{}

########	20	time up on level2	Mobile Web	{}
########	1115	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	1116	00:09:34	Mobile Web	{}
########	1117	lose a life on order1 (on level1)	Mobile Web	{}
########	1118	00:09:34	Mobile Web	{}
########	1119	order1 on table (on level1)	Mobile Web	{}
########	1120	00:08:36	Mobile Web	{}
########	1121	order2 on table (on level1)	Mobile Web	{}
########	1122	00:07:57	Mobile Web	{}
########	1123	go to level2	Mobile Web	{}
########	1124	00:07:51	Mobile Web	{}
########	1125	Tue Mar 22 2016 12:08:56 GMT+(	Mobile Web	{}
########	1126	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	1127	00:02:45	Mobile Web	{}
########	1128	lose a life on order1 (on level2)	Mobile Web	{}
########	1129	00:02:45	Mobile Web	{}
########	1130	order1 on table (on level2)	Mobile Web	{}
########	1131	00:01:53	Mobile Web	{}
########	1132	MISTAKE reset for order2 (on leve	Mobile Web	{}
########	1133	00:01:35	Mobile Web	{}
########	1134	lose a life on order2 (on level2)	Mobile Web	{}
########	1135	00:01:35	Mobile Web	{}
########	1136	order2 on table (on level2)	Mobile Web	{}
########	1137	00:01:03	Mobile Web	{}
########	1138	go to level3	Mobile Web	{}
########	1139	00:01:00	Mobile Web	{}
########	1140	Tue Mar 22 2016 12:11:40 GMT+(	Mobile Web	{}
########	1141	order1 on table (on level3)	Mobile Web	{}
########	1142	0-1:0-3:0-19	Mobile Web	{}
########	1143	MISTAKE reset for order2 (on leve	Mobile Web	{}
########	1144	0-1:0-3:0-41	Mobile Web	{}
########	1145	lose a life on order2 (on level3)	Mobile Web	{}
########	1146	0-1:0-3:0-41	Mobile Web	{}
########	1147	order2 on table (on level3)	Mobile Web	{}
########	1148	0-1:0-4:0-15	Mobile Web	{}
########	1149	go to level4	Mobile Web	{}
########	1150	0-1:0-4:0-18	Mobile Web	{}
########	1151	Tue Mar 22 2016 12:13:16 GMT+(	Mobile Web	{}
########	1152	order1 on table (on level4)	Mobile Web	{}
########	1153	0-1:0-6:0-26	Mobile Web	{}
########	1154	order2 on table (on level4)	Mobile Web	{}
########	1155	final attempt completed	Mobile Web	{}
########	1156	0-1:0-6:0-47	Mobile Web	{}
########	1	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	2	00:04:40	Mobile Web	{}
########	3	lose a life on order1 (on level1)	Mobile Web	{}
########	4	00:04:40	Mobile Web	{}
########	5	lose a life on order2 (on level1)	Mobile Web	{}
########	6	00:02:22	Mobile Web	{}
########	7	order1 on table (on level1)	Mobile Web	{}
########	8	00:01:59	Mobile Web	{}

########	9	MISTAKE reset for order2 (on leve	Mobile Web	{}
########	10	00:01:15	Mobile Web	{}
########	11	lose a life on order2 (on level1)	Mobile Web	{}
########	12	00:01:15	Mobile Web	{}
########	13	MISTAKE reset for order2 (on leve	Mobile Web	{}
########	14	00:00:22	Mobile Web	{}
########	15	lose a life on order2 (on level1)	Mobile Web	{}
########	16	00:00:22	Mobile Web	{}
########	17	time up on level1	Mobile Web	{}
########	2331	order1 on table (on level1)	Mobile Web	{}
########	2332	00:08:38	Mobile Web	{}
########	2333	order2 on table (on level1)	Mobile Web	{}
########	2334	00:07:33	Mobile Web	{}
########	2335	go to level2	Mobile Web	{}
########	2336	00:07:27	Mobile Web	{}
########	2337	Tue Mar 22 2016 11:10:16 GMT+(	Mobile Web	{}
########	2338	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	2339	00:02:07	Mobile Web	{}
########	2340	lose a life on order1 (on level2)	Mobile Web	{}
########	2341	00:02:07	Mobile Web	{}
########	2342	order1 on table (on level2)	Mobile Web	{}
########	2343	00:00:25	Mobile Web	{}
########	2344	time up on level2	Mobile Web	{}
########	5415	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5416	00:09:24	Mobile Web	{}
########	5417	lose a life on order1 (on level1)	Mobile Web	{}
########	5418	00:09:24	Mobile Web	{}
########	5419	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5420	00:08:31	Mobile Web	{}
########	5421	lose a life on order1 (on level1)	Mobile Web	{}
########	5422	00:08:31	Mobile Web	{}
########	5423	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5424	00:08:14	Mobile Web	{}
########	5425	lose a life on order1 (on level1)	Mobile Web	{}
########	5426	00:08:14	Mobile Web	{}
########	5427	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5428	00:07:18	Mobile Web	{}
########	5429	lose a life on order1 (on level1)	Mobile Web	{}
########	5430	00:07:18	Mobile Web	{}
########	5431	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5432	00:06:40	Mobile Web	{}
########	5433	lose a life on order1 (on level1)	Mobile Web	{}
########	5434	00:06:40	Mobile Web	{}
########	5435	gameover on level1	Mobile Web	{}
########	5436	00:06:40	Mobile Web	{}
########	5437	go to level2	Mobile Web	{}
########	5438	00:06:40	Mobile Web	{}
########	5439	Tue Mar 22 2016 11:19:45 GMT+(	Mobile Web	{}
########	5440	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5441	00:00:42	Mobile Web	{}
########	5442	lose a life on order1 (on level2)	Mobile Web	{}

########	5443	00:00:42	Mobile Web	{}
########	5444	MISTAKE reset for order1 (on leve	Mobile Web	{}
########	5445	00:00:08	Mobile Web	{}
########	5446	lose a life on order1 (on level2)	Mobile Web	{}
########	5447	00:00:08	Mobile Web	{}
########	5448	time up on level2	Mobile Web	{}
########	1	lose a life on order2 (on level1)	Mobile Web	{}
########	2	00:09:59	Mobile Web	{}
########	3	lose a life on order2 (on level1)	Mobile Web	{}
########	4	00:09:58	Mobile Web	{}
########	5	lose a life on order2 (on level1)	Mobile Web	{}
########	6	00:09:58	Mobile Web	{}
########	7	lose a life on order2 (on level1)	Mobile Web	{}
########	8	00:09:58	Mobile Web	{}
########	9	lose a life on order2 (on level1)	Mobile Web	{}
########	10	00:09:58	Mobile Web	{}
########	11	gameover on level1	Mobile Web	{}
########	12	00:09:58	Mobile Web	{}
########	13	lose a life on order2 (on level1)	Mobile Web	{}
########	14	00:09:58	Mobile Web	{}
########	15	lose a life on order2 (on level1)	Mobile Web	{}
########	16	00:09:58	Mobile Web	{}
########	17	go to level2	Mobile Web	{}
########	18	00:09:58	Mobile Web	{}
########	19	go to level2	Mobile Web	{}
########	20	00:09:58	Mobile Web	{}
########	21	go to level2	Mobile Web	{}
########	22	00:09:58	Mobile Web	{}
########	23	go to level2	Mobile Web	{}
########	24	00:09:58	Mobile Web	{}
########	25	go to level2	Mobile Web	{}
########	26	00:09:58	Mobile Web	{}
########	27	go to level2	Mobile Web	{}
########	28	00:09:58	Mobile Web	{}
########	29	go to level2	Mobile Web	{}
########	30	00:09:58	Mobile Web	{}
########	31	go to level2	Mobile Web	{}
########	32	00:09:58	Mobile Web	{}
########	33	go to level2	Mobile Web	{}
########	34	00:09:58	Mobile Web	{}
########	35	go to level2	Mobile Web	{}
########	36	00:09:58	Mobile Web	{}
########	37	go to level2	Mobile Web	{}
########	38	00:09:58	Mobile Web	{}
########	39	go to level2	Mobile Web	{}
########	40	00:09:58	Mobile Web	{}
########	41	go to level2	Mobile Web	{}
########	42	00:09:58	Mobile Web	{}