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SCHOOL OF ECONOMIC & BUSINESS SCIENCES

Research Dissertation

Digital Game-Based Learning: Effects on Students' Perceptions and Achievements in a Business Process Management Course

For the Degree of MCom by Dissertation in the Field of Information Systems

Submitted by:

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DECLARATION

I declare that this dissertation is my own unassisted work, except only where acknowledgements and references have been made in the text. I have read and fully understood the school Senate Policy on Plagiarism. I am well aware that plagiarism constitutes presentation of others as one's own, and failure to give credit where it is due.

This dissertation has not been submitted before, to any other institution, for an award of any degree or examination.

Thomas D Grace

Date:

ABSTRACT

The study aimed to investigate the impact of the introduction of digital game-based learning (DGBL) and its effect on students' perceptions of competence, usefulness, and enjoyment, as well as their achievement. The context of the study was a third year Business Process Management (BPM) module, within an information systems course at the University of the Witwatersrand. Eight research questions were formulated and ten hypotheses were derived. The study was underpinned by Deci and Ryan (2002)'s self-determination theory (SDT) of human motivation, which included two of the sub-theories of SDT, cognitive evaluation theory (CIT) and organismic interaction theory (OIT), as well as Ryan et al. (2006)'s adaptation of the construct of presence into SDT.

The study adopted a single group natural experiment pre-post design and a longitudinal relational design. The study was conducted with a sample of 24 students. Three baseline surveys were used to measure students' levels of intrinsic motivation, perceived competence and perceived usefulness. This was done prior to the introduction of IBM's Innov8 2.0, which was the digital learning game used in the study. The baseline surveys were administered one week apart, prior to the introduction of the game. After the game was introduced, an endline survey was used to capture students' levels of intrinsic motivation, perceived competence, perceived usefulness and presence with the game. Learning achievement was measured through the use of three assessments conducted one week, one month and two months after the end of the BPM course.

Hypothesis testing was conducted using t-tests, correlation, and PLS regression techniques. Results confirmed significant effects of the digital game to decrease perceived competence, a positive relationship between intrinsic motivation and achievement, and a positive relationship between presence and intrinsic motivation.

As a result of the study, we now know that DGBL effects achievement through intrinsic motivation when in close proximity to the assessments. DGBL can appear to decrease perceived competence as it appears to be a feedback mechanism, which should be seen as a positive rather than negative effect. Certain DGBL characteristics such as presence increase intrinsic motivation perceptions.

Keywords: Digital Game Based Learning (DGBL), Competence, Motivation, Presence, Business Process Management (BPM)

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1 CHAPTER 1: INTRODUCTION

Digital game based learning (DGBL) can be defined as the use of computer games (or digital games) to support or supplement learning within an educational context[1] (Prensky, 2005). There is a growing interest in the application of DGBL in practice and numerous anecdotal accounts of their incorporation into primary, secondary, tertiary and even a workplace learning context. The use of and research surrounding DGBL has been growing considerably over the past decade. Recent reviews illustrate a growing interest in the study of DGBL from all over the world (Hwang and Wu, 2012; Ritzhaupt, Poling, Frey and Johnson, 2014).

The concept of using digital games to support learning activities is not novel as there have been studies found dating back more than 40 years. These early simulation games, along with many of the digital games available today, are considered to be powerful learning tools that are available to educators. In particular, DGBL is sometimes considered as a learning support tool that has potential effects on students' motivation, and learning achievement. A large number of studies make claims asserting digital games' potential to increase students' motivations to learn (Papastergiou, 2009; Connolly, Boyle, MacArthur, Hainey and Boyle, 2012).They also have been found to potentially increase students' learning achievement, or knowledge acquisition (Ariffin and Sulaiman, 2013).

However, despite these potential benefits claimed by various studies there is still a lack of empirical evidence available on DGBL. This gap becomes evident when examining studies contrasting DGBL with traditional teaching approaches. In these studies there are mixed results concerning the motivational benefits (Kebritchi, Hirumi and Bai, 2010), as well as the benefits associated with learning achievement (Girard, Ecalle and Magnan, 2013). Some studies claim that while a specific game might work in one context with one specific group of learners, the same game might be far less effective in another context, or with another group of learners (Kebritchi et al., 2010). The evidence base is further complicated because some studies fail to

[1] DGBL extends from the use of "Quest Atlantis" to teach basic scientific and ecological concepts in a primary school context (Filsecker and Hickey, 2014), through to the use of "Operation ARA" to teach scientific reasoning and critical thinking skills in a university context (Halpern, Millis, Graesser, Butler, Forsyth and Cai, 2012).

articulate the details of the digital game they use, while others tend to provide inadequate descriptions of their samples (Ritzhaupt et al., 2014).

Despite the inconclusive evidence on their effectiveness in some of the DGBL studies (Kebritchi et al., 2010; Lim, Nonis and Hedberg, 2006), there are still many supporters of DGBL (Papastergiou, 2009; Woo, 2014). These supporters claim that DGBL offers educators a potential tool that, in the right context, is capable of raising students' motivations as well as providing them with an opportunity to learn through experience (Connolly et al., 2012). Gee (2007) proposes that this is one of the most powerful ways to learn as it aligns to situated learning and deep learning principles. DGBL has the potential to positively affect students' motivations towards a subject domain, while also potentially boosting their perceived competence to a subject domain (Hung, Huang and Hwang, 2014). However, there has been a limited number of studies addressing this aspect of DGBL (Hung et al., 2014).

This study aimed to address the shortcomings of prior research on DGBL as a learning technology with high potential. Specifically, the aim of the study was to evaluate the effects of the inclusion of DGBL within an undergraduate university course on student motivation and learning achievement through a natural experiment pre/post-test design and longitudinal study design.

It contributed to the field of DGBL in two ways. First, it addressed the mixed empirical evidence on how DGBL effects motivation, and learning achievement. Specifically at whether the inclusion of a digital learning game has an effect on students' motivation in a course. Second, it addressed some of the more limited research associated with students' perceived competence in a particular subject domain. Specifically on how the inclusion of a digital learning game effects students' perceived competence in a course.

The remainder of the introduction outlines the purpose and limitations associated with the study. It also provides a diagram of the study design.

1.1 Purpose of the study

The current study sought to evaluate the effect of the inclusion of DGBL in an undergraduate course. Drawing on Deci and Ryan (2002)'s theory of motivation, the study was specifically concerned with measuring the effect of DGBL on students'

levels of, motivation and learning achievement, as well as students' perceived confidence felt towards a particular subject domain. The study was guided by the following research questions:

RQ1: To what extent does the inclusion of DGBL effect students' motivation in the course?

RQ2: To what extent does the inclusion of DGBL effect students' perceived competence in the course?

RQ3: To what extent does the inclusion of DGBL effect students' perceived usefulness towards DGBL?

RQ4: To what extent does perceived competence in the course effect students' motivation in the course?

RQ5: To what extent does students' presence in the game effect their motivation in the course?

RQ6: To what extent does students' perceived usefulness of the game effect their motivation in the course?

RQ7: To what extent does the inclusion of DGBL effect students' learning achievement through its effect on students' motivation and perceived competence in the course?

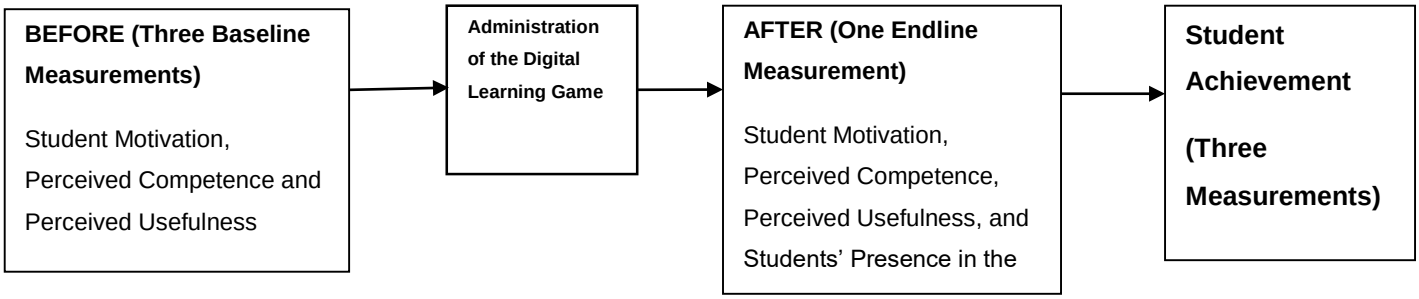
RQ8: To what extent does presence in the game and perceived usefulness towards the game effect their learning achievement?

1.2 Research Design Outline

The research design of the study involved the use of a natural experiment pre/post-test design and a longitudinal relational design. Three surveys, each a week apart, were administered before the use of a digital game (pre-test). This established a baseline measurement of students' motivation, perceived competence and perceived usefulness. A survey was then administered after the introduction of a digital game in order to measure endline scores of these same variables. Examination of the differences between the endline and the baseline scores allowed for an assessment of the impact of the digital game on those variables.

Furthermore, data on learner achievement were collected from three assessments. The assessments were conducted roughly one week, one month and two months after the introduction of DGBL. This allowed the study to also examine the interrelationships between students' motivation, perceived competence and perceived usefulness, as well as presence in the game, and their long-term impacts on the students' achievement. A graphical depiction of the research design can be seen below in figure 1.1 below.

Figure 1.1: Diagram of Study Design



1.3 Context of the Study

The study was conducted at the University of the Witwatersrand in South Africa. It was conducted in a third year information systems course in a module on business process management (BPM). The duration of the module was approximately three weeks and the sample consisted of third year information systems undergraduate students.

The digital game that was administered was a business simulation game called "Innov8 2.0". The game was created by IBM and is specifically designed to simulate the activities of business process management inside of an office context. The player is placed into a virtual office context and has to perform activities that relate to BPM. The game is described more fully in chapter 4.

1.4 Contribution of the Study

The contributions of the study fall into of three main areas. A theoretical contribution, a practical contribution and a methodological contribution. This section briefly highlight those contributions.

The first contribution is a theoretical contribution. It, at a high level, addresses the mixed empirical results regarding motivation, and learning outcomes that have been

found in DGBL studies (Wouters, Van Nimwegen, Van Oostendorp and Van Der Spek, 2013). The study drew on Deci and Ryan (1985), Self-Determination Theory, specifically their Cognitive evaluation theory (CET) and Organismic Interaction Theory (OIT) and tested it in order to build a better understanding of how intrinsic motivation might be transferred from one activity to a subject domain. Because there has been limited research done regarding how the inclusion of a DGBL artefact in a course effects that specific course, the study added further contributions by providing an indication of whether DGBL could affect students' motivation, perceived competence, and achievement in a particular academic course.

In order to examine both motivation and perceived competence this study drew on Deci and Ryan (1985)'s idea of both of these constructs. A further contribution comes from linking DGBL to student test scores as a proxy for their long-term learning of subject matter, and potentially showing the significance of motivation as an explanation for learning achievement.

The second contribution is a practical contribution. It concerns the potential for DGBL to have a positive effect on a course. Educators that might want to increase motivations and attitudes towards their study could incorporate a DGBL activity into that course. This has the potential to increase motivation within the course. In South Africa, student motivation within a course are considered to be relatively low (Wawrzynski, Heck and Remley, 2012). This is a concerning issue and hopefully one that DGBL has the capability to address. The South African context has had a limited amount of research conducted around DGBL (Hwang and Wu, 2012).

The final contribution is in the form of a methodological one. Specifically, the DGBL evidence base lacked longitudinal studies conducted in a real world course. Longitudinal designs are however necessary in order to explore the potential long-term effects of the use of DGBL on learning (Girard et al., 2013; Ke, 2009; Vu, Crow and Fredrickson, 2014). This study contributed by using base-line questionnaires in order to establish a baseline for each student's perceptions and motivations prior to the introduction of the digital learning game. Then, by adopting a longitudinal design, this study addressed some of the threats to internal validity associated with cross-sectional designs. More specifically, by testing students' learning at a later date, it

overcame the limitations associated with testing students immediately after the conclusion of an experiment and thus separating short-term from long-term learning.

1.5 LIMITATIONS AND DELIMITATIONS OF THE STUDY

There was no control group in the study due to the restrictions of conducting an experiment within a live university course. The instructor of the course was unable to split the group and assign only one of them to a DGBL environment. Thus, the study followed a natural experiment pre/post-test design with a single group.

The study measured the base-line variables in relation to the course. End-line data was taken after the introduction of the digital learning game. Therefore, the study examined how the introduction of the digital learning game activity effected students' motivations towards the course and not towards learning in general.

The study was focused only on students and not lecturers. The students were third year information systems students enrolled in a BCom or BSC at the university of the Witwatersrand.

The study did not consider the technical challenges associated with the setup of the game as well as the development and design of the game.

Due to the length of the course, which was three weeks, exposure to the game did not occur over extended periods of time. Although students could play the game as many times as they wanted after its introduction and before the assessment, engagement following the first exposure was voluntary.

1.6 OUTLINE FOR THE REPORT

Chapter 2 is the literature review chapter, which provides a definition of DGBL and the characteristics of digital games. It highlights the current state of the research into DGBL and provides an overview of the field of DGBL. It covers some of the past research of DGBL within the context of BPM and other related subjects and also describes the respective contributions and short comings of past work on DGBL.

Chapter 3 provides the theoretical underpinnings for the study. It describes each construct that was used in the study and develops the theoretical model that the study utilised. It also describes the development of the hypothesis of the study.

Chapter 4 outlines the methodology associated with the study design. It highlights the choices that were made regarding the research design. It explains how the constructs were operationalised and how this resulted in the construction of the research instrument. It also provides a description of the context of the study, namely the population that was involved in the study and a description of IBM's Innov8 2.0, which was the digital game that was administered. The data collection strategy and the data analysis strategy are also explained and it concludes with an explanation of the ethical considerations, validity and reliability, and biases attached to this study.

Chapter 5 presents the results of the data analysis. It provides results of the descriptive statistics and the t-tests, correlation analysis and PLS regression tests that were run in order to test the hypothesis of the study.

Chapter 6 conveys a discussion of the results of the current study, which focuses on a discussion around each of the research questions presented above.

Finally, Chapter 7 concludes the report and provides some recommendations for future research.

2 CHAPTER 2: LITERATURE REVIEW

This chapter seeks to provide both background and context for the current study. It first highlights the characteristics of digital games and then describes the different types of DGBL that have been used. It then provides a state of the field of DGBL by conducting a systematic review on other reviews in the field and on recent empirical studies. It then concludes by explaining the short-comings of prior work and how this study seeks to address some of those short-comings.

2.1 LITERATURE REVIEW ON GAME BASED LEARNING

Digital Game based learning (DGBL) is a growing field of study that is concerned with the use and application of digital games in an educational context. DGBL can be used by educators to provide support for various learning outcomes. Support is provided by presenting learners with a simulated environment for them to apply and practice the skills they have learnt, for example Liu, Cheng and Huang (2011) used a game to support students in learning computational problem solving skills.

Support can also be provided by attempting to increase students' motivation to learn and engage in a particular subject domain, for example Hung et al. (2014) found that learners had an increased motivation to learn after playing a mathematically orientated game. The former example aligns with the ties DGBL has with experiential learning theories or learning by actively doing and reflecting (Gee, 2007), and the latter is associated with the links DGBL has to motivating and engaging learners (Ryan et al., 2006).

Before examining the applications of DGBL and the various forms of support it could provide, the next section focuses on what exactly a game is. Therefore, this review begins with the definition of a digital game and characteristics of a digital game. It then covers the different types of GBL and discusses the distinction between DGBL and gamification, as these two fields are commonly muddled together.

It then provides the state of the literature into DGBL and concludes with a section detailing the short-comings of prior research and how this study aimed to address those short-comings.

2.1.1 What is a Digital Game?

The challenge with defining digital games arises when one considers the many different characteristics that can be found within them (Simons, 2007). There are some games that can only be played by a single person while others allow thousands of people to all be playing together. Some players might have to learn and improve on skills in some games while other games are left up to luck and chance. There are even games that might require learnt skills in some sections, while other sections are left up to chance.

This makes it challenging to establish what the defining characteristics of a digital game is or even for that matter the defining characteristics of a game. However, by drawing on research that has been done by scholars in the field of game studies we can establish a set of defining characteristics that are common to the majority of games, including digital games. These defining characteristics will be discussed first before briefly highlight some of the other characteristics that can be found in digital games.

2.1.1.1 Defining characteristics of a game

A classic understanding of what a game is was proposed by the Dutch philosopher Johan Huizinga. He purposed that games exist within a “magic circle” and that the magic circle can be thought of as a closed system of meaning that is limited by both time and space (Huizinga, 1955). This provides us with the first defining characteristic of games. They are characterized by a closed system of meaning. A good example of how this system of meaning is created can be drawn from the board game chess.

A standard game of chess consists of 32 figurines that are placed onto a black and white checkered board. These figurines have no meaning associated with them outside of a game of chess. However, when the game of chess begins, or one enters the magic circle, each piece is now governed by its own sets of rules and constraints. These rules and constraints are generally agreed upon and accepted by the players prior to starting a game.

The agreed upon rules and constraints that are contained within a game are the second defining characteristic of a game. A game’s rules and constraints ultimately determine how a player is able to interact with the game and how a player is able to

behave inside the game (Avedon and Sutton-Smith, 1971; Garris, Ahlers and Driskell, 2002). They are generally agreed upon by the players of the game prior to the commencement of the game. An example of a constraint in the game of chess consists of only being able to move the king piece one square at a time.

The third defining characteristic of games involves the interactions that the player has with the game (Charsky, 2010). These interactions are known as game mechanics and are defined by Sicart (2008) as "…methods invoked by agents, designed for interaction with the game state". A game mechanic therefore is an action that is activated by either a player, or an artificially controlled character, to interact with the game. Game mechanics are governed by a game's rules and constraints. An example of a game mechanic from chess would be moving the king piece one space to the right.

A player then uses game mechanics to overcome some kind of challenge inside the game system. This is the fourth defining characteristic of games and is generally associated with overcoming a challenge in order to win the game (Malone, 1981). In chess the challenge is to defeat the opponent's king, which if completed will cause the player to win the game and the opponent to loose. However, it is important to keep in mind that while not all games have a winning or losing state, most games pose some sort of challenge to over-come. Thus, the use of the word challenge is more appropriate than the use of the word win (Sicart, 2008).

The fifth and final defining characteristic of a game relates to the feedback provided by the game (Charsky, 2010). The game provides the player with some type of feedback in the form of a score or changes to the game system. This feedback is used to allow players to monitor their progress towards overcoming the challenges presented in the game (Prensky, 2003). In chess the feedback could be visually seeing all of your pieces that have been taken off of the board, or the other player saying "check" when they are able to attack your king piece.

In summary, a game is a closed system of meaning that is limited by time and space. There are agreed upon rules and constraints that are embedded in the game and these govern how the player/s are able to interact with the game (Garris et al., 2002). The interaction that the player has with the game are known as game mechanics. (Sicart, 2008). Players will use these game mechanics in order to overcome

challenges presented in the game while also being given feedback on their progress towards overcoming these challenges. These are summarized in Table 2.1

Therefore, a digital game is a closed system of meaning in the sense that when a player opens a game on a device they have essentially entered into a virtual world that has its own rules and constraints. The rules and constraints of that game are already built into it and might consist of something like “a player with zero health is dead”.

The rules and constraints govern how the game mechanics work, or how the player is able to interact with the game. An example of a game mechanic is “Drinking a potion will restore the health of the player”. The game mechanics are then used by the player in order to overcome some kind of challenge presented by the game, such as defeating an in-game enemy. The player’s progress towards overcoming the challenge is generally conveyed through feedback mechanisms embedded in the game. In the case of the challenge mentioned previously, the feedback might be the remaining health of the enemy.

Table 2.1 Game Characteristics and Examples

Game Characteristic	Digital Game Example
Closed system of meaning	Virtual world
Rules and constraints	When a player health is zero the player is dead
Game mechanics	Drinking a potion will restore the health of the player
Challenge	Defeating an in-game enemy
Feedback	Display showing the remaining health of the enemy

2.1.1.2 Other Characteristics of Digital Games

Having established the core characteristics of a game, digital games might also incorporate additional characteristics. These characteristics are not found in every digital game and some games might contain more than others. This section will explain some of the common additional characteristics that can be found in many digital games.

Narrative, Choice and Control

The narrative of a digital game is also known as the story-line or plot of the game and relates to the story that is told in the game. The narrative characteristic of a game is generally included in order to provide the player with a context for the game

and to give the player a particular purpose in the game (Simons, 2007). A classic example of a narrative in a game involves the player taking on the role of a protagonist in a story and then being presented with a challenge that often involves a confrontation with an antagonist. This classic example is often known as the “Hero’s Journey” which was originally conveyed by Campbell (1972) and has been used as the basis for many narratives found in digital games and other media.

The difference between the narratives found in digital games and those found in other media, such as books and movies, has to do with the level of engagement of the person consuming the narrative. In other media, the person engaged in the narrative is seen as a passive consumer and has no impact on the outcome of the narrative. The reader of a book, or watcher of a movie is in a sense an observer to the events that are unfolding in the narrative (Simons, 2007).

Narratives presented through digital games are not just passively observed, as players of these games tend to be seen more as active consumers of the narrative (Simons, 2007). The player tends to take on the role of one of the characters in the virtual world and they generally perceive the world through that character’s eyes. An illusion is created whereby the players of a game perceive themselves as constructing the narrative of that game. Some games even provide narrative dialogue choices that influence the outcome of the events in the game. This active involvement in the narrative enables digital games to be powerful tools for telling a story and for creating fantasy worlds that players feel a part of (Malone and Lepper, 1987). A digital game known as the *Witcher 3: Wild Hunt* demonstrates an example of narrative dialogue interaction, which can be seen in figure 2.1 below.

Figure 2.1: Dialogue Scene from *The Witcher 3: Wild Hunt (Created by CD Projekt Red ™)*

(Screenshot taken from: https://www.youtube.com/watch?v=N4ony2r0QFs)

Figure 2.1 shows the main player controlled character, Geralt, responding to a villager who has asked him a question. There are two choices available to the player in terms of responses and they have to pick one. Each response has a different outcome for that conversation and some responses might alter the outcome of the story of the game. *The Witcher 3: Wild Hunt* actually has 36 different endings that can occur based on the choices that the player makes throughout the game. It is considered by the gaming community as one of the most complex games to ever be made in terms of the evolution of the narrative and how it changes based on the choices of the player (Hayden, 2015).

The ability for players to make choices in digital games gives the player a sense of control over the outcomes of the game. There are different forms that this control can take. Players are able to control the narrative through dialogue decisions, as mentioned above, as well as through the actions the player can take. They are also able to create different strategies for certain situations in a game (Garris et al., 2002). The strategies that can be applied are determined by the mechanics of the game.

For example, in Figure 2.1 Geralt, the main character, has two swords on his back. One sword is made of silver and deals damage to monsters, while the other is made of steel and deals damage to other humans. Players need to choose the correct sword for the type of character they are facing. Therefore, players will have to know

which sword to use, or which strategy to apply, when encountering different monsters in the game. This is a very simplistic description of the types of strategies that can be found in digital games and many games require the use of complex strategies in order to succeed.

Digital games are very good at providing players with both choices and a sense of control in order to influence the narrative of the game. All three of these characteristics are important characteristic that games have and are part of the reason that digital games are good at creating immersive virtual fantasy worlds (Garris et al., 2002).

These characteristics also have potential usefulness to the learning process as players are able to experience making choices and taking on particular roles in a virtual situation without actually being physically present in that situation (Garris et al., 2002; Gee, 2007). Narratives have also been proposed as a way to potentially assist learners in organising educational material (Wouters and Van Oostendorp, 2013).

Competition, Collaboration and Social Interaction

Another additional characteristic of some digital games is the ability to interact with other players through the game (Cole and Griffiths, 2007). This interaction can generally be classified as competitive, collaborative or social interaction. Interaction in one game can even include all three of these characteristics. This is often the case in online games that require a team of players to compete with another team of players.

An example of this interaction can be seen in a game called *League of Legends.* Players are put into teams of five and have to compete with another team of five players in order to successfully destroy their opponents base. The first team to destroy the other teams base wins the match. This requires a team of five players to socially interact with each other in order to collaborate and work as a team. It also has the elements of competition as each team is competing against the other. A screenshot of a *League of Legends* match can be seen in figure 2.2 below.

Figure 2.2: Screenshot of League of Legends (Created by Riot Games ™) (taken from: https://www.youtube.com/watch?v=UTot4wiKDJo)

Figure 2.2 is a screenshot that has been taken from one player's perspective. The left-middle side of the screenshot includes four square icons. These represent the other players in the team and provide visual information on each of those player's health. You can actually see three of the players virtually standing together in the centre of the screenshot. The left bottom corner of the screenshot shows the chat conversation that enables collaboration and social interaction between these players. The opposing team has been placed on the other side of the map (a mini-map is on the right bottom corner) and are presented with the same layout as this. The first team to destroy the base of the other team wins.

Digital games can have different mechanics that enable direct and indirect competition between players (Liu, Li and Santhanam, 2013). The example presented above is a form of direct competition as the players are actually playing against each other at the same time.

Indirect competition is when players play the game by themselves and in their own time (Liu et al., 2013). They then have a rank against other players based off a score or time. The ranking is displayed on a leaderboard and the leaderboard then acts as a form of indirect competition between the players. Some games, including *League of Legends,* even have professional leagues that would rival many professional sports leagues (Liu et al., 2013).

Online games have large numbers of players that form part of their communities and this results in many forms of social interaction between the players (Cole and Griffiths, 2007). In some cases lifelong friends and partners have been made (Cole and Griffiths, 2007), and in other cases online games have strengthened qualities in individuals that are associated with leadership (Lisk, Kaplancali and Riggio, 2011). Cole and Griffiths (2007) found that the ability of online games to create an environment where the players feel comfortable expressing themselves and that is free from judgement in terms of age, gender, appearance and sexuality is what allows such meaningful social interactions to occur.

The characteristics of collaboration, competition and social interaction are also potentially useful to learning. Collaboration and social interaction characteristics have the potential to create collaborative learning environments, that include discussions and team work (Wouters and Van Oostendorp, 2013). Competition has also been found to motivate and engage learners (Eseryel, Law, Ifenthaler, Ge and Miller, 2014).

Visual, Auditory and Other Sensory Stimuli

A further possible characteristic for digital games concerns the sensory stimuli or visuals and auditory aspects of the game. Digital games often employ visual graphics and auditory stimuli to enhance the player's perception of being in virtual world (Garris et al., 2002). Some games do this through creating a realistic visual and auditory experience that is as close as possible to the real world. A good example of this can be seen in figure 2.1 with *The Witcher 3: Wild Hunt.* Other games use a more cartoon like visual representation of their world, such as *League of Legends* in Figure 2.2.

The level of realism of the visuals and auditory characteristics of the game generally depend on the resources available to the developers. The common trend is that the higher the level of realism required with the visuals, then the more resources the game developers need. Resources here refer to the processing power of the available technology, the size of the budget for the game, and the number of developers and designers on the development team. *The Witcher 3: Wild Hunt* had a development team that was over 200 people large.

High levels of realism though are not required to make a successful game that is enjoyed by the players. The mobile game *Clash of Clans* provides a good example to illustrate this point. *Clash of Clans* is a mobile game that was developed by a small team of developers in a new company called Super Cell. It has cartoon like graphics and does not possess a high level of realism, which can be seen in figure 2.3. However, it is regarded as one the most successful games in the last decade. It has a player base of well over a million people and generates approximately 3 to 5 million Euros a day (Cheshir, 2015).

The level of realism of the sensory stimuli has also been examined in terms of its usefulness to learning. Researchers have found that when using a game for learning that the level of realism is less important than the learning content and that cartoon like levels of realism are just as effective as photo realistic levels of realism (Vogel, Vogel, Cannon-Bowers, Bowers, Muse and Wright, 2006; Wouters et al., 2013).

Figure 2.3: Screenshot of Clash of Clans (Created by Supercell™) **(Provided by the Researcher)**

In Summary, digital games can possess other characteristics than the core characteristics mentioned in the previous section. Some of these include a narrative characteristic as well as allowing players to make choices and ascertain a certain level of control over the game. Others include the interactions that can occur between players, such as social interaction and competitive or collaborative play. To enhance the players' perception of being in a virtual world many games also evoke sensory stimuli characteristics, such as visual graphics and audio.

While these characteristics can be found in many types of digital games, they are not included in every digital game. Some games might only have one or two of these characteristics, while others might incorporate them all. Some of these characteristics of digital games have also been found to be potentially useful to learning in various ways (Gee, 2007; Wouters and Van Oostendorp, 2013).

2.1.2 Types of Game Based Learning

There are two broad categories of digital games that have been used in the field of DGBL. The first relates to games that have been designed for the purpose of entertainment, which are generally adapted into an educational context (Becker, 2007). The second category is known as educational games, or games that have been designed with a learning outcome in mind (Prensky, 2005).

Entertainment games or, as some studies refer to them, commercial off the shelf (COTS) games (Charsky and Mims, 2008; Becker, 2007), have been used in an educational context on several occasions (Charsky and Mims, 2008; Lee and Probert, 2010; Dziorny, 2006). While entertainment games do contain the ability to increase various types of learning (Gee, 2007), they are generally coupled with some type of assignment or activity when incorporated into an educational setting. This allows an educator to still take advantage of entertainment games in a DGBL context but it might require more effort to implement them. An example of this can be seen by Lee and Probert (2010), who discuss how the entertainment game *Civilisation III* was used in a history classroom to support the teaching of abstract concepts associated with the evolution of civilisations. A screenshot of *Civilisation III* can be seen in figure 2.4 below.

Figure 2.4: Screenshot of Civilisation III (Created by Atari™) **(Taken from: https://www.youtube.com/watch?v=zHywZz6X48A)**

Educational games on the other hand are designed with some type of learning outcome in mind (Ariffin and Sulaiman, 2013; Prensky, 2003; Vogel et al., 2006; Wouters et al., 2013). They have developed several aliases over time, namely “serious games” (Girard et al., 2013), “learning games”, “digital learning games” (Prensky, 2003) and “simulation games” (Kikot, Costa and Fernandes, 2014). The common aspect of each of these definitions is the fact that the game has been designed with a learning outcome in mind.

Initially, the difference between the terms were attributed to the context that the games were applied in and not the characteristics of the game. The term “digital learning game” and “educational game” was commonly associated with an educational context such as schools, colleges and universities (Prensky, 2003) while the term “serious game” and “simulation” have been associated with a businesses and industry context.

However, emphasis then shifted to the differences between the characteristics of educational games, which resulted in the agreement of two categories namely learning games and simulation games. It was found that the terms “serious game”, “learning game”, “digital learning game” and “educational game” are identical in their characteristics and make up one category, namely learning games. Simulation games were found to possess characteristics that are closely related to learning

games, but it is the overall aim of simulation games that separates them into a different category from learning games (Charsky, 2010).

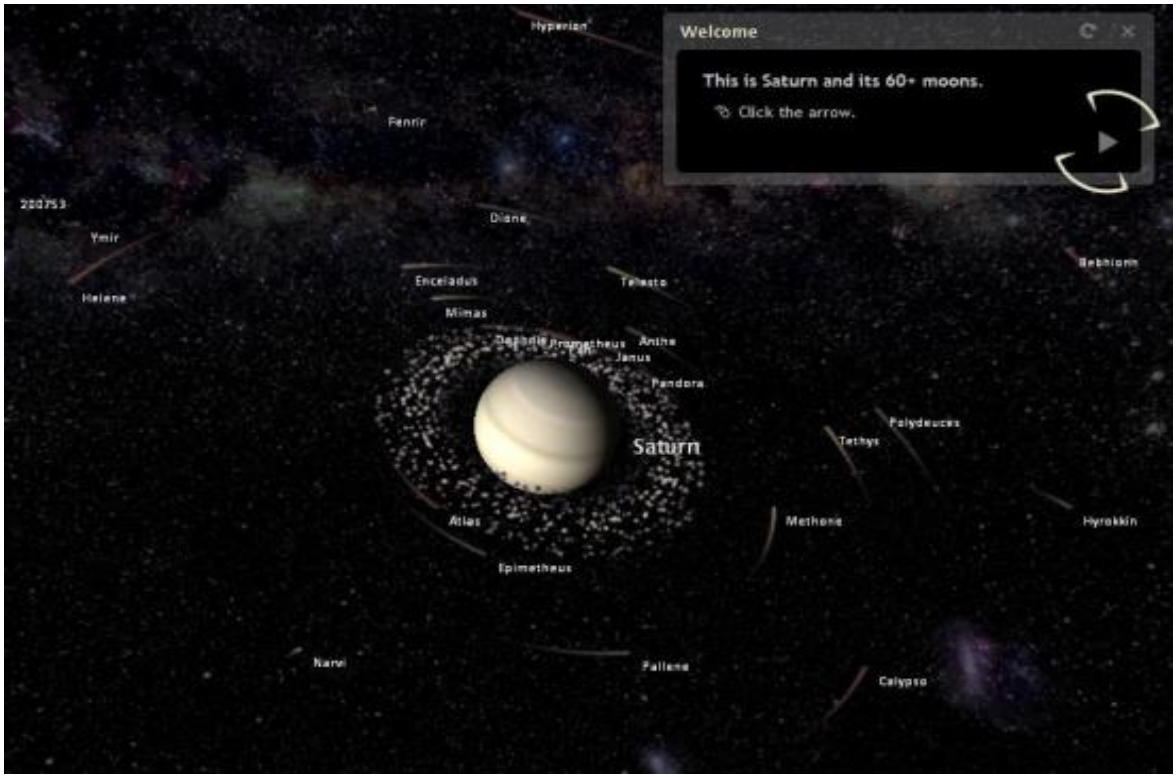
Simulation games are essentially games that aim to simulate an element of reality (Charsky, 2010). These games are designed to allow players to experience an element of reality in a safe environment. Early studies were generally focused around the use of “simulation” games, which aimed to simulate an activity from the real world in a digital setting (Greenblat, 1973). This enabled the users of these games to practice a specific activity while not having to worry about any of the real world risks associated with that activity (Gatto, 1993). A classic example of a simulation game used as an educational game would be a flight simulator, which is used by potential pilots to assist them in learning how to fly a plane (Caro, 1973; Hays, Jacobs, Prince and Salas, 1992). A screen shot of a flight simulator can be seen below in figure 2.5

Figure 2.5: Screenshot of a Flight Simulator (Created by Microsoft™) (Taken from: https://www.youtube.com/watch?v=taVepITZuyQ)

Simulation games generally tend to have very minimal learning content and instruction embedded inside the game (Liu et al., 2011). Players generally use simulators to practice skills they have learnt outside the simulation, for example trainee pilots using a flight simulator to practice flying a plane (Caro, 1973). Players also use simulators to experience an environment that they have learnt about outside the simulation. These environments would normally be inaccessible to most

people, for example using a space simulation game to provide learners with an experience of exploring the solar system (Rohman and Husni, 2012). An example of a Space Simulation can be seen below in Figure 2.6.

Figure 2.6: Screenshot of a Space Simulator **(Taken from: http://www.ilovefreesoftware.com/21/windows/interactive-space-simulator-universe-sandbox.html)**



However, it is generally quite difficult to simulate all elements of reality in one game and the realism of most simulation games generally depends on the learning outcome it is trying to achieve. Trade-offs are made based off the most important learning outcome.

For example, consider two hypothetical flight simulators where one's outcome is to simulate the take-off and landing of a specific plane while the other's outcome is to allow players to experience flying many different planes. The first might provide a realistic account of taking off and landing in that one plane but the player would be unable to change the type of plane being used. The second game would allow players to experience flying many different types of planes. However, it would probably provide a standardized take-off and landing mechanic for each plane and would be less realistic in terms of the specific procedures one would need to follow in each plane type. Therefore, it is always important to consider what the learning outcome of a simulation is and what it is actually trying to simulate.

While simulations generally require there to be content and skills taught externally to the game, learning games aim to include a large amount of instruction and pedagogy inside the game (Kiili, 2005; Prensky, 2003). These games generally aim to be able to function on their own in terms of the learning of content and skills. They require minimal assistance from external learning sources. Although due to the inclusion of learning instructions and pedagogical elements, these games tend to make a trade-off in terms of realism. For example Papastergiou (2009) uses a digital learning game to teach computer memory concepts to high school computer science classes. The game used an interactive environment to guide learners through instructional elements associated with computer memory concepts (Papastergiou, 2009). The game conveys learning activities and instructions that assisted students in learning the concepts associated with computer memory. It does not provide a simulation of how computer memory functions in reality.

However, the line between simulation games and learning games are not always clear as some games are able to possess characteristics from each of them. There are simulation games that provide embedded learning content and learning games that accurately simulate portions of reality. A good example of games that have characteristics of both are some business simulators as they have built in learning content and also simulate a specific aspect of a business in an accurate way. (Lin and Tu, 2012). This makes it difficult to regard these as two mutually exclusive categories as games can potentially possess characteristics from both categories.

In summary, the field of DGBL is concerned with the use of digital games in an educational context in order to support a particular learning outcome. Different types of games have been used in the field. These include entertainment games, or games designed for leisure that have been adapted into an educational setting, simulation games, which aim to simulate an aspect of reality and are generally coupled with external learning material, and learning games, which seek to provide the majority of the learning content within the game. The latter two types of games have both been designed with a particular learning outcome in mind. IBM's Innov8 2.0, the game used in this study, is regarded as a business simulation game. A detailed description of IBM's Innov8 2.0 is presented in chapter 4.

2.1.3 Game Based Learning Vs Gamification

A common misconception within the field of DGBL is that the concept of "gamification" is commonly seen to be an application of DGBL. However, this is not the case and while they do share some similarities they are quite different in their application.

Gamification is defined as the use of game mechanics within a non-gaming context in order to influence behaviour or motivation within that context (Werbach, 2014). This means that game mechanics, which as mentioned above are one of the characteristics that makes up games, are drawn out of games and used within a non-gaming context in order to motivate people to behave in a certain way (Attali and Arieli-Attali, 2015). While there are many game mechanics that have been used for the purpose of gamification, the most common of these mechanics take the shape of points, badges and leader boards (Werbach, 2014). These frequently appear in customer loyalty programs[2] and have begun to make an appearance in other areas as well.

The main point to keep in mind is that DGBL requires the use of an actual game. Whether the game is a learning game, a simulation, or an entertainment game that is being used in an educational context, there still must be a game that aligns with the defining characteristics of a game mentioned above. Gamification uses only a portion of those characteristics. Therefore, it should not be classified as DGBL and is rather a closely related but separate field. An example of gamification can be seen in Attali and Arieli-Attali (2015) who implemented a points system in order to see its effect on mathematical performance.

Having established a background on digital games and the different types of games that have been applied in the field of DGBL. The next section seeks to unpack the current state of the field of DGBL.

2.2 State of the Field of Digital Game Based Learning

In order to establish a complete and comprehensive state of the literature surrounding DGBL and its impact on student motivation, learning and competence, it

[2] For example, Discovery Vitality points system: https://www.discovery.co.za/portal/individual/vitality-how-it-works-overview

was necessary to conduct a systematic search of the literature. A systematic literature review is a type of literature review that uses a structured process to identify and analyse all available research on a particular research question (Kitchenham, 2007). This provides for an unbiased report of the literature so other researchers in the field can repeat the process (Okoli and Schabram, 2010).

The process for a systematic literature review, according to Okoli and Schabram (2010), first involves the identification of the research purpose and the creation of a search strategy, which should reveal all evidence relating to that research purpose. Secondly, the selection process for articles needs to considered, which includes the types of studies that should be included, or excluded, and what level of quality is expected within those studies (Okoli and Schabram, 2010). The quality assessment criteria that are used to judge the quality of the studies should also be presented and explained. Finally, the data from the articles should be extracted, analysed, and synthesised (Okoli and Schabram, 2010). This process enables the review to be as unbiased as possible, as well as being able to be repeated by other researchers (Okoli and Schabram, 2010).

The systematic review conducted in this study followed the process outlined above. The next sections cover the purpose of the review, the search strategy used in the review, the inclusion and exclusion criteria used to judge the studies that were identified, and an extraction and synthesis of the data from those articles.

The purpose of the review was to identify both studies and review papers that relate to DGBL in a context involving motivation, learning and competence in a tertiary education setting. It also aimed to identify studies that have been conducted in a BPM context.

The next section provides the search strategy that was used to identify literature relating to the purpose above. It then presents the data of the search, which is included in tables that provide summaries of each of the studies that were identified. It then provides a discussion on, or synthesis of, the literature using the identified studies to inform the discussion and concludes with a discussion highlighting the shortcoming of prior studies.

2.2.1 Search Strategy

The searching process that was followed aimed at identifying both published systematic and narrative literature review, as well as any meta-analyses that have been conducted in the field of DGBL and recent empirical studies. This was done in order to build on previous work conducted by researchers in the field and to inform the second part of the search process. The search process was aimed at identifying recent studies that focus on the use of DGBL in a motivational and learning achievement based context. The search was conducted on published and peer-reviewed studies, conference proceedings and book chapters up until the end of 2015.

DGBL can be considered as a multi-disciplinary field that would fall into research categories such as: Education, information systems, psychology and social science. Therefore, the following databases were selected as they are relevant to the multi-disciplinary nature of DGBL: EBSCO Host (Psychology and Behavioral Sciences Collection, SocINDEX with Full Text, Library, Information Science & Technology Abstracts, PsycINFO, ERIC, Full collection), ProQuest Central, Scopus Online, ScienceDirect and Web of Science.

Two search strings were used. The first was a combination of synonyms for both DGBL (String 1) and literature reviews (String 2A) in order to identify any previous reviews. The second search string was used to identify other studies that focused on DGBL and its impact on learning and Motivation, this was a combination DGBL synonyms (String 1) and a combination of synonyms for outcomes, evaluations and contexts (String 2B). Two searches were conducted, one included String 1 and String 2A, the other included string 1 and string 2B.

- String 1: ("Learning game" OR "Digital game" OR "Computer game" OR "Digital Game Based Learning" OR "Game Based Learning" OR "Serious Game")
- String 2A: AND ("Systematic Review" OR "Systematic Literature Review" OR "Narrative Review" OR "Meta-Analysis" OR "Literature Review")
- String 2B: AND (Evaluation OR Impact OR Outcomes) AND (Learning OR Skill OR Motivation OR Affect OR Competence) AND (Tertiary OR University OR College OR "Higher Education")

In String 2A, the term “Simulation” was excluded from the synonyms of DGBL as it inflated the results and captured papers examining mathematical simulations. The searches were also limited to examining abstracts, titles and keywords as this would provide more relevant results.

Inclusion and exclusion criteria were used to establish appropriate reviews and meta-analysis that fall within the purpose of this review. In order to be included, the reviews had to have conducted some type review. This could either be a narrative review, a systematic literature review or a meta-analysis. Studies also had to have a focus on DGBL and had to have a relation to motivational outcomes, learning outcomes or outcomes relating to competence within a tertiary educational context.

Reviews were excluded if they had an alternative focus such as, video games and violence, video game use as medical treatments or therapy, or the development and design of video games. Reviews that were found to have no implications for a tertiary level, or did not indicate a time frame, were also excluded.

Inclusion and exclusion criteria were also applied to the empirical studies. To be included they must have had a focus on DGBL and its impact on learning, motivation or competence in a tertiary level context. They had to also had to include empirical evidence. Papers were also included that fell between the time frame of 2010 and 2015. This was mainly done as other reviews were largely focused on studies conducted between 2000 and 2010 and many of the papers identified prior to 2010 that were uncovered by the search, were generally included in one of the 24 reviews that were included. Therefore, this study focused on empirical work between 2010 and 2015.

2.2.2 Results of the Search

The search identified 64 potential reviews and meta-analyses and after applying inclusion and exclusion criteria there were 21 reviews (12) and meta-analysis (9) that remained. The search identified 34 empirical studies that met the initial inclusion criteria, of these 10 were excluded which resulted in 24 studies being summarized and included. A flow chart outlining this selection process and the search results is included in appendix A.

A Summary of the reviews are presented in Table 2.2, a summary of the meta-analysis is presented in table 2.3, and a summary of the studies is presented in table 2.4.

Table 2.2: Summary of Included Review Papers

Ref	Type	Aim of Review	Findings	Time Frame	No of Papers Included	Conclusions
Boyle, MacArthur, Connolly, Hainey, Manea, Kärki and Van Rosmalen (2014)	SLR	What extent is a game based approach being used to teach statistics and research methods.	Discusses studies that used commercial games, serious games, animations, simulations and eLearning systems that have been used to support the learning of research methods and statistics. A wide range of skills were targeted as both research methods and statistics include a myriad of complex skills. Better performance in the targeted skill for the intervention group was indicated in most of the studies. Some studies also showed that engagement increased and enjoyment of the learning. Games seem to assist with understanding the scientific process.	2004-2013	26	The review shows that there is a lack of major studies in this area and more research needs to be done. Games and simulations provide active examples of learning research methods and statistics which are the best ways to teach these concepts. Future work should look at the game genres and specific game mechanics that could support these. They have good potential to improve the teaching.
All, Nunez Castellar and Van Looy (2014)	SLR	To map the methods that are being used to assess the effectiveness of DGBL.	Only included studies with a pre/post design and control group and focus on cognitive outcome. Methods were not homogenous. Control group tasks differed and did the way the DG was implemented. Cognitive outcomes were coupled with affective. Few studies looked at motivation towards course/school and most focused on motivation towards the game. Confounds include being embed into a larger program and how, the presence of an instructor and how, and the test for knowledge and it being standardised or not.	2000 - 2012	25	Comparisons between studies are difficult as the methods differ widely. Generalisations are limited and recommends that more standardisation on methods should be developed to assess effectiveness in cognitive outcomes. Many studies had missing information which also threatens validity.
Calderón and Ruiz (2015)	SLR	To examine studies that provided assessment and evaluations of serious games in order to select one to use.	Looks at application domains, types of games used, the method to evaluate them and what was evaluated. Found education and professional training to be highest domains as well as computer games as choice of medium. Learning outcome evaluations of knowledge were most common. Average sample size was <40 with post-test questionnaire as the most common.	Up to March 2015	109	Found an assessment method to analyse a software project management game. Also indicated that the review can be used to further research as a baseline and more research is needed to create a taxonomy of models to analyse serious game quality.
Connolly et al. (2012)	SLR	Positive impacts and outcomes of computer games and serious games with respect to learning and engagement	They included higher quality papers and then classified the papers in terms of their learning outcomes. They provide a refined version of the outcomes into 4 categories, knowledge acquisition, skill acquisition, affective motivational and physiological and behaviour change outcomes.	2000 - 2009	129	How should games now be implemented into educational contexts and in what way are they able to address the learning outcome mentioned
da Silva, Medeiros and Aranha (2015)	SLR	Investigation of games that can support the efficacy and teaching of programming	Indicates that all the games that were studied were effective in their respective studies except one mixed result. 7 different programming languages were found to be supported and the core of the studies were case studies. Higher education is the area where most of these occur and most of these are done face to face. Cognitive and social skills are addressed and some raise competence.	2009-2013	29	Indicates that games are an effective tool for teaching programming and that they have the potential to address the lack of motivation for programming based studies.
Kang (2013)	SLR	Examines motivation and attributes in GBL activities in order to examine the relationship between them	Gives a breakdown of all the studies and includes the game, target group and the attributes in the game. Discusses the GBL approach vs other traditional approaches and mentions several positive studies in terms of motivation. States that GBL approaches tend to be more engaging and motivating, which in turn leads to better gains in knowledge. Found evidence of some studies going into detail about attributes but more work is needed as the studies are limited.	2009-2013	20	GBL encourages learners and leads to better results. However, the specific game attributes that impact motivation are still not clearly defined. The only attribute that has been looked at is interaction, which is linked to engagement in the game. More work is needed to fully understand the attributes.
Ritzhaupt et al. (2014)	SLR	Identify trends and patterns of digital games being	Since 2004 there has been a steady increase in the number of studies. Most publications are located in Computers and Education and skill and action based games	2000-2010	73	Despite the rising number of studies, the field of GBL is still plagued by weak methodologies and vastly different studies. This makes it difficult to draw

		used in education	are the most popular. Elementary students had the highest frequency of study followed by undergrads. Experimental methods were the most used followed by case studies. These looked at achievement and affective outcome more than behavioural. K 12 education then having the most studies included with science and maths being the most addressed.			sound conclusions about the nature of DGBL and when it is effective. The results do indicate some descriptive stats but more rigorous work is needed in the field.
Shih, Liu and Chuang (2010)	SLR	Preliminary outcome based literature review on game based learning to identify what is being studied.	Less work has been done on motor skills as opposed to cognitive, affective and behavioural work. Most cognition studies were on subject matter performance and learning. Less on meta-cognition and problem solving. Affective included interests, attitudes and motivation and behaviour was emotion, responsiveness and communication. Motor skills related to speed and mastery.	2000-2010	25	Some aspects of cognition and affective outcomes are being researched but more qualitative work needs to be conducted on the areas that have received less attention, like meta cognition.
Tsai and Fan (2013)	SLR	Review studies published in international journals.	Research has been increasing at a fast pace after 2008 with 21 studies being found there. Secondary school and undergrads were the highest. Science and social studies was the highest domain. Quant methods are the most frequent	2003-2012	24	Shows that research is increasing and this study can act as direction pointer in terms of what future research should do.
Divjak and Tomić (2011)	Narrative	Looked at the impact of Mathematical computer games on achievement and motivation.	The paper analyses the studies it found on mathematical DGBL. These games have been found to increase learning, motivation and maths attitudes. The quant studies show no impact but qualitative studies all showed a difference. This was the case for both motivation and achievement.	1995-2010	32	Confirms that the games do increase both learning achievement and motivation. However, there were some studies that did not examine motivation and some studies found no significant impact. Qualitatively there was always a positive effect on motivation. Games should be used
Felicia (2012)	Narrative	Explains why and how the use of GBL is motivating and looks at the literature to provide empirical evidence.	Gives examples of studies that have found GBL increases motivation towards academic subjects. Covers some of the factors that make GBL motivating and gives examples of how GBL is more motivating than traditional teaching.	2005-2011	Does not indicate	Game based learning is a motivating and engaging activity that has the ability to motivate students. Teachers need to be given resources to use GBL.
Hwang and Wu (2012)	Narrative	Establish a state of the DGBL field in terms.	Identifies where the studies are coming from, what domain they are in, and how many are there. Shows how there has been increasing studies in the period 2000 to 2010. Shows the samples of the studies and the learning domains as well as the common countries of the studies.	2000 - 2010	137	Increasing research in more countries is needed.

Table 2.3: Summary of Meta-Analyses Identified in Search

Ref	Aim of Review	Brief Description	Time Frame	Studies included	Results	Conclusions
Backlund and Hendrix (2013)	Effectiveness of game based learning with a focus on a formal education context.	Partial meta-analysis. Found that Motivation yielded positive outcomes as well as support for learning outcomes associated with using games.	2002-2012	40	29 papers yielded positive effects on learning. 7 are neutral and only 2 were found to be negative.	Evidence that games can produce benefits to learning. However, researchers are calling for more longitudinal studies where games are actually placed into teaching situations in various ways. Single use vs multiple use of a game also needs further analysis.
Chian-Wen (2014)	Investigate whether DGBL can improve the learning of English in students that are not native English speakers. What moderating variables might have an effect on the learning.	Only includes quasi-experimental classroom based studies. Moderators included education level, instructor bias, game types and treatment duration and linguistic knowledge	Up to April 2014	25	Medium positive effect (0.695 under fixed effect and 0.777 under random effect). Ages and networked games were not significant. Games with a narrative had a larger effect size as opposed to drill and practice but not significant. Longer durations yield better results and procedural knowledge was better transferred through the games.	Substantial medium positive effect sizes were found for DGBL and large effect sizes were found for games designed to keep learners engaged and automate procedural knowledge. It is clear that some games work and others do not. More work needs to be conducted to establish the balance between what works and what does not.
Chiu, Kao and Reynolds (2012)	Examine the effects of drill and practice games on the learning of English as a foreign language and to examine the difference in DGBL types in teaching English.	Includes control groups, quantitative methods, and large samples. Also must include a game that assess English performance.	2005-2010	14	Publication bias, as published studies yielded a large effect size (d=0.964) as opposed to unpublished (d=0.333). Overall effect size was (0.674). Meaningful and engaging games had a much larger effect size(d=1.105)) than drill and practice games(d=0.442).	Findings suggest that meaningful and engaging games provide a greater level of interaction and therefore more learning takes place. It is therefore worthwhile to develop more of these games in the future. Also unpublished studies should be considered to avoid publication bias.
Girard et al. (2013)	Examine the effectiveness of serious games and video games and learning and engagement.	Only included games that aligned to the criteria they had laid out. The studies also had to have a pre/post-test, a control group and quantitative methods.	2007-2011	9	Focused on the 11 games found in the 9 studies. 3/11 has a positive effect on learning, 7/11 had no effect and 1/11 was mixed. 2/11 aroused higher levels of motivation and engagement than other methods. Also identifies three problems: The control group issue, Transfer of knowledge and skills, and the different serious games	Results on motivation have been positive from other studies that did not mean the inclusion criteria. There is still a lack of evidence on how serious games can be effective and more work is needed. Especially more longitudinal studies and learning and retention. Serious games have huge potential to increase the learning experience.
Wang and Tseng (2011)	Investigate the effect of game based learning as opposed to classroom instruction through a meta-analysis.	Studies needed to have a control group, face to face instruction with DGBL, needed to be sufficient data for a meta-analysis, Comparable outcome measures, and published.	1950-2009	14	On average the learning was achieved more effectively in the GBL context (g+=0.58). However, there was a large range of effect sizes. The lowest was d= -0.49 in favour of classroom settings, and the largest was d= 2.36 in favour of GBL.	The synthesis revealed that GBL, or game play can be an effective tool for learning. However, there are still differences between studies with some reporting classroom settings as being more effective. More investigation is needed to establish the exact effects of GBL.
Wouters et al. (2013)	Statistically summarise effects of serious games on motivation and learning	Included studies that had a control group and had a broad definition of motivation. The serious games were either stand-alone interventions or supported by other content. Combined knowledge and skill based outcomes.	1990-2012	38	More effective in terms of learning (d=0.29) and retention (d=0.36) and there was an effect size for motivation (d=0.26) but it was not significant compared to traditional teaching methods. However, there were cases where it was found to be motivating, namely against active instruction and standalone games. Potentially better in problem solving than drill and practice and gains are seen when implemented as a standalone or coupled over longer time durations	Specific instructional or contextual features, namely supplementing with other instructional activities and working in groups, increase the effect of serious games. More research is needed to determine if these features do foster learning activities.
Wouters and Van Oostendorp (2013)	Examined weather instructional sport enhances GBL through a meta-analysis.	Included studies that had a control group and had a broad definition of Instructional support. Examined both published and unpublished articles and tried to ensure that there was control of publication bias by adhering to a failsafe N. Combined knowledge and skill based outcomes.	1990-2012		Instructional support improves learning (d=0.34). Moderators were also found, the learning of skills benefits the most from instructional support (d=0.62) and when the instructional support was aimed at new content (d=0.46). Also found evidence of publication bias (Journals d=0.44, proceedings d=0.08, unpublished d=0.14). Refection, collaboration, modality and feedback all were significant instructional support tools.	Instructional support is should be present when the learning outcome is skills or knowledge. There is still more investigation in terms of what instructional support yields what type of improvement as this paper had a broad definition. However, game designers and implementers should be aware that games should include instructional support and we can investigate each element further.

Wu, Hsiao, Wu, Lin and Huang (2012)	Investigate the use of learning theory application in GBL design using 4 learning theories, behaviourism, cognitivism humanism and constructivism.	Examines theories that come from each of the 4 core learning theory domains. Included papers that looked at learning theories as a foundation in their studies.	1971-2009	91	Constructivism theories, when grouped together, were the most used as a foundation for design. These included, social development theory, discovery theory, cognitive apprenticeship, CBL, situated learning theory and actor network theory. Experiential learning theory was the most used theory which forms part of humanism learning theories.	Study shows that there is work being done to ground the design of educational games in learning theories and identifies the most common theirs that have been sued. However, a huge amount of studies failed to ground GBL in learning theories and this recommends that more active establishment of a learning theory foundation is needed when designing, or even using educational games.
Wu, Chiou, Kao, Hu and Huang (2012)	Provide a synthesis of GBL studies in terms of four learning theories. Behaviourism, cognitivism humanism and constructivism.	Included papers that had a learning theory foundation, have a suitable sample and be in a published document with strong methodology.	Up to 2009	91	Similar findings to previous study. Found here that the methods used were mostly descriptive when it came to the learning theory followed the use of experimental survey based approaches. Positive outcomes were largely reported for most studies.	Mainly studies were not focused on learning theories but those that were focused on constructivism and humanism. Used a descriptive approach to the theory followed by experimental methods. Outcomes reported were mainly positive. More studies grounded in learning theory and then testing the theory need to be conducted.

Table 2.4: Summary of Studies Identified by Review

Ref	Aim of Study	Constructs & Theories	Methods	Results	Recommendations
Vahldick, Mendes and Marcelino (2015)	Evaluate a Game that was developed to teach programming skills	Enjoyment of the Game, and playing behaviour, flow, game characteristics, Concentration, Autonomy	Groups selected with minimal programming knowledge - two experiments (n 23, n 16), single use of game	Game was entertaining despite the difficulty of the tasks	People have different times that they progress through games and should be integrated with the class grade/score
Boeker, Andel, Vach and Frankenschmidt (2013)	Compare GBL with traditional teaching in a medical student context	Student Attitudes, fun, motivation, self-assessed knowledge gain and a formal test, confidence.	RCT, n= 145 (82/63), longer term use of game	Game group performed better on the test, more positive attitudes toward the course in the game group and more fun in game group. Students also felt more confident in the knowledge domain.	GBL should be used more in topics that students might need extra motivation and increased confidence. How is longer term retention, or learning, impacted by GBL.
Chung-Ho and Cheng (2013)	Investigate the effects of GBL in Software Engineering	Motivation, Satisfaction and Learning Achievement. (ARCS)	Quasi-experimental two groups, one with a game and the other with no game and traditional content. Long use of game	Found that motivation was higher towards SE, also found the learning motivation impact Achievement, Achievement was better in the game group. Learners were more immersed in the learning activities. High levels of satisfaction and high levels of confidence in the course	Expand the experiment to other universities and subjects, improve the interaction of the game and further develop it.
Cornillie, Clarebout and Desmet (2012)	Investigates the impact of feedback included in a game to teach English as a foreign language	Perceived Usefulness, Constructive Feedback, competence, intrinsic goals, experience	Included both university and high school, all were part of the experimental group, pre/post-test and interviews.	Feedback was viewed as useful to the learning process and raised PU. Competence was effected by feedback and so was intrinsic goals setting.	Feedback is more effective the more useful learners think the game is, more work to confirm.
Cozine (2015)	The use of gameplay to improve knowledge and practical skills in homeland security students	Perceived comprehension of course material, and real world relevance.	112 undergraduates, cross sectional survey, and single game	Learning experience was enhanced, and skills were improved from game play	Confirm that GBL can improve learning, however more contexts need to be investigated.
Erhel and Jamet (2013)	Looked at the effect of different types of GBL instructions on learning and motivation, as well as the effects of feedback on the same	Motivation and Learning Achievement, instructions.	2 Experiments, one was learning instruction vs entertainment and the other feedback vs no feedback, single game activity.	Learning instruction and reflection improved vs no instruction, Feedback assisted in creating reflection and improved learning. Motivation was promoted by the game regardless of the instruction given or feedback used.	MA more interactive game should be used to confirm the results of the study,
Treviño-Guzmán and Pomales-García (2014)	Tested a simulation game focused on supporting and motivating learners in an industrial engineering course	Motivation towards IE, Understanding about IE.	44 undergrads, single use of game, n=30, pre/post-test design no control	Increased motivation to study or continue IE, as well as an increase understanding of the roles IE performs in a business. Knowledge transfer occurred from the game through interviews.	Future work should evaluate this both in other IE courses and other courses. This should be looked at in terms of if games motivate individuals in other subjects and investigate the effect on learning and longer term retention.
Hainey, Connolly, Stansfield and Boyle (2011)	Evaluate GBL to teach requirements gathering and analysis.	Knowledge of software requirements	pre/post design, control group with traditional, 5 experiments	GBL is a suitable approach to teaching it. Increased knowledge across all experiments, learners thought the game worked in the context.	Games are all very different and it is difficult to say that because one game works in one context that another game might work in the same. Further experiments are needed.

Hou and Li (2014)	Evaluate multiple aspects of a problem solving game for computer assembly knowledge	Learning effectiveness, game acceptance and flow. Usefulness, ease of use.	pre/post with no control, n=67, single use of game	Overall no effect on learning but some effect was found to be good for teaching students with limited background knowledge, but they needed to accept the game and experience flow while playing. Flow was correlated with game acceptance. High levels of agreement that it was useful.	Game acceptance can be used to evaluate a game and more work should be done, Study might have benefited from more game play (was only 10min). Test scores were used which might not be appropriate
Huang, Huang and Tschopp (2010)	Examined motivational processing and outcome processing with GBL on satisfaction	Motivation, Volition, Performance (MVP) & ARCS	264 undergrads, post-test only, single play	Motivational processing was found to be related to satisfaction as an outcome. Confidence was found to be weaker with satisfaction and relevance of the game was found to be the strongest predictor of satisfaction.	Extrinsic rewards of DGBL need to be considered to enhance this process. Studies should not focus on only motivational processing from MVP.
Huang (2011)	Examined motivational processing and cognitive load in GBL.	MVP	144, post -test only, Single use of game	Confidence levels were high, but the game might fool them into thinking that they are good. Attention was high and relevance was the lowest. satisfaction was at a moderate level.	Further work needs to be done on motivational processing and cognitive activities.
Kanthan and Senger (2011)	Examine the use of GBL on student satisfaction and academic improvement	Performance at mid-term and final exam and satisfaction	114, and 71, Internally matched control group.	Scores of the exam before the game were lower than score after the game. There was increased engagement, enhanced personal learning and reduced stress.	While the games showed improvements, there needs to be more work done in order to convince educators.
Kazimoglu, Kiernan, Bacon and Mackinnon (2012)	Provide qualitative feedback on a game developed for computational feedback in CS studies	Computational thinking	25 Open ended Surveys - First year students, Qualitative coding. Single use of game.	Participants reported that they Enjoyed playing the game and thought it improved Problem solving skills	More rigorous experiments need to be conducted
Liu (2014)	Impact on academic performance and flow in CS course about data structures	Academic performance and flow	110, long terms and two groups.	Gaming group had enhanced academic performance and flow compared to non-gaming group. Flow was also found to be related to academic performance but not significantly.	Satisfied that the game assisted their learning and it was enjoyable. More work needs to be done to investigate flow and academic performance
Mayer, Warmelink and Bekebrede (2013)	What is the perceived learning effectiveness of the games and what factors effect this	Attitudes, behaviour, skills, knowledge and serious game design	1000, pre and post design with various applications (some single some multiple)	Achievement was weakly correlated with motivation, high mark students found the game more useful than low marks, most did see the value in GBL. IM and anticipation of fun influence the learning and enjoyment of the game.	While the study has identified some factors that influence satisfaction, more work needs to be done especially with different types of games in different subject domains. Some students were found to have lower satisfaction after play, which implies that they expected more from the GBL environment.
Ozcelik, Cagiltay and Ozcelik (2013)	Effect of uncertainty in games on learning outcomes.	Uncertainty, motivation, attention	2 groups, 140, pre/post design. Single design	Uncertainty is positively related to learning and to motivation. As motivation increases then participants spend more time on questions in the game	Educational instructors should take more notice of uncertainty, games can support higher education activities and should be investigated further.
Ranchhod, Gurău, Loukis and Trivedi (2014)	Investigates the educational value that marketing simulations are able to generate	4 types of value, Experience generation, conceptual understanding, skills development and affective evaluation	305, long term, multiple measurements	EXP impacts strongly with CU and both impact SD. Perceptions of skills generated determine affective evaluation	Generalisable to other simulations that use the experiential experience.
Soflano, Connolly and Hainey (2015)	Evaluated an adaptive game to teach SQL. Game adapts based on student.	Adaptively and Learning	120, experiment and control, single design pre/post	Game produced better learning regardless of being adaptive but adaptive allowed for faster task completion	More work is needed on adaptive GBL activities. However, games are different in every context so more work is needed.
Salter, Pittaway, Swabey, Capstick and Douglas (2012)	Evaluate a game that is aimed to assist first years in linking biology information	Knowledge transfer	311, single group, single use post-test,	Results suggest that knowledge transfer is supported by GBL and student learning outcomes were enhanced	More work is needed as different games do not yield the same results. More work is needed on different types of games and more evidence is needed to convince educators
Tao, Yeh and Hung (2012)	Relationship between student characteristics and performance while using a GBL activity.	Perceptions, Motivation, characteristics of students.	43 respondents, single use survey, experiment with no control.	Some experience is needed to perform better in GBL, of the subject matter. Found that some students, those with high extrinsic motivations, did not like the game	More work is needed on the pedagogy behind using GBL in courses.
Titus and Ng'ambi (2014)	GBL reports on mediating engagement in a course on sports science (SA – UCT and UWC)	Engagement in learning	64, within subject using baseline and endline, once off use. Mixed methods with interviews.	Game aided the creation of knowledge in a fun way, game was found to strengthen collaboration and engagement in the course	Recommends that the engagement increasing aspect be investigated in other contexts and group randomisation.

von Wangenheim, Savi and Borgatto (2012)	Looks at the use of a board game to teach EVM in CS courses	Learning, Interaction, engagement, immersion, attention, relevance, motivation	28 participants, single use and survey design.	Motivation was positive, learning was also positive as well as social interaction, immersion, attention and relevance	Further evaluations of this game need to take place in order to generalise.
Wong, Yatim and Tan (2015)	Examined the use of GBL in an object orientated programing class	Player experience and motivation	40 students and a pilot test therefore minimal analysis.	Only indicates that the player experience and motivations were potentially impacted positively.	More work is needed on this game and the researchers plan to do further evaluations and tests
Woo (2014)	Content support for learning motivation and related game characteristics	MVP	63 University students, over 8 weeks, tests multiple times	Motivation and cognitive load in the game lead to higher learning. Attention does compromise other variables but relevance and satisfaction do not	More work is needed in order to generalise these findings.

2.2.3 Discussion of Literature

The search process identified a large amount of review papers (12) and meta-analyses (9). This indicates that the research into the effectiveness of GBL has been increasing substantially over the last 15 years. Previous reviews also indicated the increasing trend of research into the effectiveness of GBL between 2000 and 2010 (Hwang and Wu, 2012; Ritzhaupt et al., 2014; Tsai and Fan, 2013).

The results provided in these studies reflect positively on the effectiveness of DGBL and its impact on learning achievement and motivation. Connolly et al. (2012) grouped DGBL studies into outcome based categories. The outcome category associated with learning achievement is referred to as knowledge and skill based outcomes, and motivational outcomes are categorised as affective outcomes.

GBL has been found to be effective in addressing knowledge and skill based outcomes as well as affective outcomes (Connolly et al., 2012; da Silva et al., 2015; Felicia, 2012; Kang, 2013). Recent empirical studies also reported positive results on the use of GBL to address both motivational and learning achievement outcomes (Kanthan and Senger, 2011; Liu, 2014; Salter et al., 2012; Soflano et al., 2015; von Wangenheim et al., 2012; Boeker et al., 2013; Erhel and Jamet, 2013).

The results of the meta-analyses are also generally reflective of the positive effects of DGBL on motivation and learning achievement. Chiu et al. (2012) and Chian-Wen (2014) examined studies where DGBL had been used to support the teaching of English as a foreign language and both found large overall effect sizes positively supporting the use of DGBL. Wouters et al. (2013) examined both motivation and learning achievement across a range of studies that compared traditional classroom settings and DGBL. They found a positive effect size associated with both learning

achievement and motivation, but the effect size for motivation was found to be non-significant.

While there is empirical evidence suggesting that DGBL contributes positively to both motivational and learning achievement outcomes, a closer examination of the results of the meta-analyses and empirical studies begins to reveal some inconsistences in the evidence. Wang and Tseng (2011) saw an overall positive effect on learning achievement through the use of DGBL compared to traditional classrooms, but the range of the effect sizes indicated that in some cases traditional classrooms were more effective. In fact, in several of the reviews and meta-analyses there were reports of studies where DGBL was shown to have either no impact on motivation and learning achievement, or it performed worse than a traditional classroom setting (Backlund and Hendrix, 2013; Girard et al., 2013; Divjak and Tomić, 2011).

The review of recent empirical studies revealed one study that found no impact on motivation or learning achievement (Hou and Li, 2014). However, there were some meta-analyses that indicated that there is the potential for publication bias in DGBL literature, which could potentially skew the published evidence in favor of DGBL (Chiu et al., 2012; Wouters and Van Oostendorp, 2013).

A reason that these inconsistencies exist within the literature could be potentially explained by the specific contextual nature of DGBL (All et al., 2014). The context relates to the game being used, how it is being used, and what domain it is being used in. Each individual element of these contextual elements has a number of different possibilities. For example, the game used by Soflano et al. (2015) in order to support the learning of a database query language was found to be effective, and the game used by Boeker et al. (2013) to support learning by medical students was also found to be effective. However, if the games were switched from one context to the other, there would be probably be quite different results.

While this example is quite an extreme case, many researchers have stressed the importance of continued research into the many different contexts that DGBL could be applied in, which includes an appropriate game being applied in a potentially appropriate context. (All et al., 2014; Boyle et al., 2014; Connolly et al., 2012; Boeker et al., 2013; Treviño-Guzmán and Pomales-García, 2014). Some studies have even suggested that comparing DGBL to traditional classroom activities will

create inconsistencies in results, especially if the game is being used within an experiment that is not part of a formal course as opposed to being used in a formal educational context (Backlund and Hendrix, 2013). Therefore, continued research is needed into the effects and impacts of DGBL in various contexts.

Specifically, this study used DGBL within an information systems course, and was thus regarded as a subject in a technical domain (Hainey et al., 2011). Previous implementations of DGBL within an information systems, or technical, domain generally indicate positive results in relation to learning achievement and motivational outcomes (Chung-Ho and Cheng, 2013; Hainey et al., 2011; Liu, 2014; Soflano et al., 2015; Vahldick et al., 2015; Wong et al., 2015; Calderón and Ruiz, 2015).

2.2.4 Short-comings of prior literature

Taken together prior work has done few empirical studies concerning the integration of DGBL into a live course, particularly at a university level (Backlund and Hendrix, 2013; Girard et al., 2013). There have been few longitudinal studies that examine the effect of DGBL integration on student motivations, perceived competence and learning achievement at a university level (Girard et al., 2013; Boeker et al., 2013). There were also inconsistencies in effects observed and thus clearly a need for research to continue.

There has been limited amount of studies that address the effect DGBL has on motivation and perceived competence in relation to a subject domain. The studies that were identified have largely been focused around primary and secondary students' motivations and perceived competence towards mathematics (Kebritchi et al., 2010; Divjak and Tomić, 2011). Given the contextual nature of DGBL applications it is necessary to examine the impact of DGBL on feelings of motivation and perceived competence towards a subject domain in other contexts (All et al., 2014; Calderón and Ruiz, 2015; Connolly et al., 2012).

Therefore, the current study seeks to address the research gaps by providing empirical evidence concerning the effect of the inclusion of DGBL on students' motivation and perceived competence within the context of a BPM course. This study also seeks to address DGBL in a university environment, which has received less attention than primary and secondary schooling (Ritzhaupt et al., 2014). In

particular, the evidence on the effects of DGBL on perceived competence in the context of a BPM university course has had limited examination.

Another shortcoming associated with learning achievement relates to longer-term assessments. Research conducted into DGBL tends to test the knowledge of participants immediately after the use of DGBL (Connolly et al., 2012). This approach has been criticised as there is no way to assess students' retention of the knowledge they have learned (All et al., 2014). The current study also seeks to address the limited evidence on students' retention of knowledge over a longitudinal time period.

2.3 Conclusion

This chapter established a background to the study including a definition of a digital games and the different types of DGBL. It then provided an overview of the current state of the field of DGBL, highlighting the potential short comings of prior work and describing how the current study seeks to address those short-comings.

Having established how the current study fits into the field of DGBL, and how it addressed some of the research gaps in the field, the next chapter explains the theoretical underpinning of the study. It also derives the hypothesis and research model that was used to answer the research questions.

3 CHAPTER 3: THEORETICAL PERSPECTIVE AND MODEL DEVELOPMENT

This section provides an overview of the theoretical background that was used in the study. It first provides an explanation of the theories that have been used to underpin the study, namely Self-Determination Theory (SDT), Cognitive Evaluation Theory (CET) and Organismic Integration Theory (OIT), which are both sub-theories of SDT, and Presence. Then it uses these theories to derive each of the study's hypotheses, and brings in further support from previous studies that have been conducted. It concludes with a graphical depiction of the study's model and a table that summarises each hypothesis.

3.1 SELF DETERMINATION THEORY (SDT)

Self-Determination theory (SDT) is a meta-theory that aims to explain and understand human motivation in any context (Deci and Ryan, 2002). It consists of both an organismic framework and a dialectical interface in terms of human growth and development. The organismic perspective assumes that humans are organisms that actively seek to improve themselves by pursuing and engaging with challenges that allow them to realize their potential and capacity (Deci and Ryan, 2002). The dialectical interface is the fact that the social environment that the individual is in will either support or diminish this process of self-realisation (Deci and Ryan, 2002).

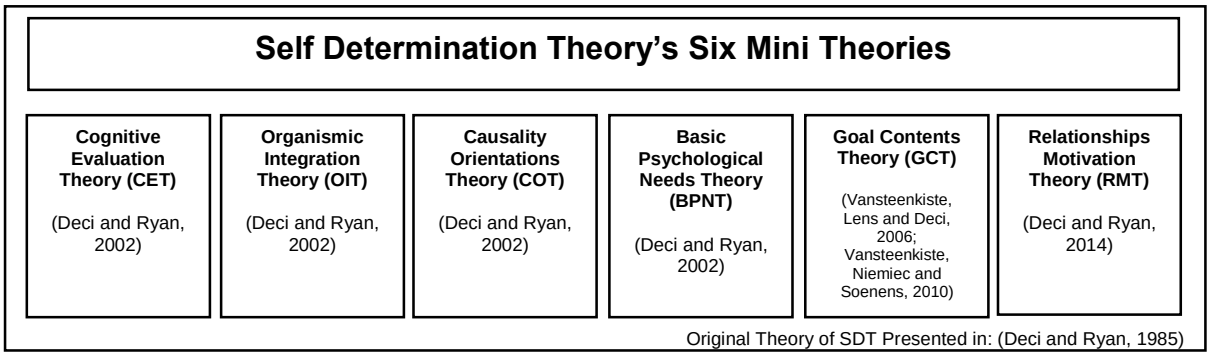
SDT was originally developed by Deci and Ryan (1985) and is concerned with human motivations. At a high level, SDT proposes three levels of human motivation. First there is the concept of "amotivation". Here there is an absence of any type of motivation. Second there is the concept of "extrinsic motivation", which is when an individual is motivated to perform due to some external outcome. Third there is the concept of "intrinsic motivation", which is when an individual wants to perform due to the inherent enjoyment they obtain from the performance (Deci and Ryan, 2000).

In order for an individual to be motivated, SDT proposes that three basic psychological needs must be supported by the social environment the individual is in (Deci and Ryan, 2002). The three needs relate to the sense that an individual feels like they are in control of a situation (autonomy), the sense that an individual feels like they are able to perform a particular activity (competence) and the sense that an individual feels a sense of belonging (relatedness) (Deci and Ryan, 2002; Deci and

Ryan, 2000; Ryan and Deci, 2000b). These needs can either be reinforced by the social environment, resulting in high levels of motivation, or diminished by it and thus resulting in potential amotivation (Deci and Ryan, 2002). These needs are further elaborated on in Section 3.2.

Since its conception, SDT has been developed to encompass six sub theories that each explain a specific phenomenon regarding human motivation (Deci and Ryan, 2002). While the sub-theories are concerned with different aspects of motivation, they all share the assumptions of the organismic framework and dialectical interface mentioned above. Therefore, each sub-theory assumes that humans are organisms that are motivated to actively improve and test themselves (Deci and Ryan, 2000; Ryan and Deci, 2000b). They also assume that this natural motivation can be reinforced or diminished by the support the social environment provides for the three basic psychological needs mentioned above (Deci and Ryan, 2000; Ryan and Deci, 2000b). Figure 3.1 provides a graphical depiction of SDT and all of its sub-theories.

Figure 3.1: SDT and Sub-Theories



This study is only concerned with two of the six sub-theories. The first is called Cognitive Evaluation Theory (CET), which relates to the interactions between the basic psychological needs and the concept of intrinsic motivation. The second is called Organismic Integration Theory (OIT) which is concerned with the concept of extrinsic motivation, the different forms it can take and its interaction with the basic psychological needs. Both of these theories will be discussed in the next two sections.

Prior to discussing the two sub-theories used in the study, it is important to consider the other four sub-theories not used. While the constructs from these other theories might prove to be useful to DGBL, the study was unable to include all of the sub-theories, as the scope of the study would have become too large. This study

restricted itself to an investigation into DGBL and BPM using two of the sub-theories of SDT considered to be most relevant to motivation in an academic context.

3.1.1 Cognitive Evaluation Theory (CET)

The concept of intrinsic motivation is underpinned by Cognitive Evaluation Theory (CET), which is one of six sub-theories included in the meta-theory referred to as Self Determination Theory (SDT). “Intrinsic motivation” is the most powerful form of motivation that an individual can feel towards an activity. When someone is intrinsically motivated they are willing to devote effort to an activity because of the interest and enjoyment derived from that particular activity (Deci and Ryan, 2000). This means that intrinsic motivation will affect behaviour in a far more powerful way than an external outcome (Deci and Ryan, 2000).

Cognitive Evaluation Theory is concerned with three psychological needs that cause variability in intrinsic motivation. These needs are known as a need for competence, a need for autonomy and a need for relatedness and, according to the theory, they must be satisfied in order to obtain feelings of intrinsic motivation.

Competence is defined as how skilled an individual feels towards a particular activity (Deci and Ryan, 2000). Feelings of competence are satisfied by individuals who experience an optimally challenging environment that contains positive feedback and is free from judgemental evaluation (Deci and Ryan, 2000). Autonomy is defined as how an individual feels they are able to make choices and enact their own will towards a particular activity (Deci and Ryan, 2000). These feelings are satisfied by an environment that enables choice and opportunities for self-direction (Deci and Ryan, 2000). Lastly, relatedness is defined as a sense of belonging (Deci and Ryan, 2000) and this need is satisfied by social interaction and acknowledgement by others.

Digital games are able to potentially address all three of the above mentioned needs. They are able to satisfy the need for competence by providing challenges and feedback for the players (Ryan et al., 2006). They are able to satisfy the need for autonomy by presenting an environment that can be explored in sequences of the players own choosing (Ryan et al., 2006). They are also able to provide a sense of belonging both in terms of players playing the same game in the same physical

location, or in terms of players playing the game over the Internet. This will satisfy the need for relatedness (Ryan et al., 2006).

However, amongst these three needs, competence is considered to be the most influential for developing intrinsic motivation within an academic context. A student's perceived competence is considered a significant predictor of academic performance in a particular subject domain and when perceived competence is low then academic performance diminishes (Miserandino, 1996). Previous findings have shown that perceived competence felt towards a specific subject domain has a positive relationship with learning achievement (Jansen, Louwerse, Straatemeier, Van der Ven, Klinkenberg and Van der Maas, 2013; Liu, Carmen and Yeung, 2015).

While intrinsic motivation is considered to be the most powerful form of motivation, self-determination theory suggests that individuals can be motivated by both intrinsic and extrinsic motivation (Deci and Ryan, 2000). Extrinsic motivation is when an individual is motivated by an external outcome and not from pure enjoyment or interest. Extrinsic motivation is discussed in the next section.

3.1.2 Organismic Integration Theory (OIT)

Organismic integration (OIT) theory is a sub-theory within SDT that is concerned with extrinsic motivation. Extrinsic motivation is a form of motivation where an individual is motivated to perform an activity due to an external outcome, and not due to the interest and enjoyment for that activity (Deci and Ryan, 2002; Ryan and Deci, 2000a). OIT proposes that there are four degrees of extrinsic motivation that can be found within individuals.

The first is known as "external regulation", which is when an individual is motivated by something that is completely external to them. Normally an individual that is motivated through external regulation is either trying to avoid some kind of punishment, or achieve some reward (Ryan and Deci, 2000a). The second is known as "external introjection", which is when an individual is motivated to perform an activity because they are either seeking approval from others, or want to avoid being shamed by others (Ryan and Deci, 2000a).

The third degree of extrinsic motivation is known as "external identification". This is when an individual is motivated by the value, or usefulness, of particular activity

(Ryan and Deci, 2000a). The final degree of extrinsic motivation is known as "external integration". This is when an individual is motivated to perform a particular activity due to the activity aligning with something they are intrinsically motivated to do (Ryan and Deci, 2000a). For example, consider an individual that is intrinsically motivated to get healthy and goes to gym in order to achieve this. The activity of going to the gym is regarded as external integration as the individual is not going to gym for the enjoyment of the activity but rather to achieve their objective of getting healthy.

The current study is concerned with the third degree of extrinsic motivation, external identification as usefulness, as it has been found to have an effect on intrinsic motivation (Deci and Ryan, 2000). The study used the construct of perceived usefulness in order to identify this form of extrinsic motivation. This construct is discussed in the next section.

3.1.2.1 Perceived Usefulness and Extrinsic Motivation

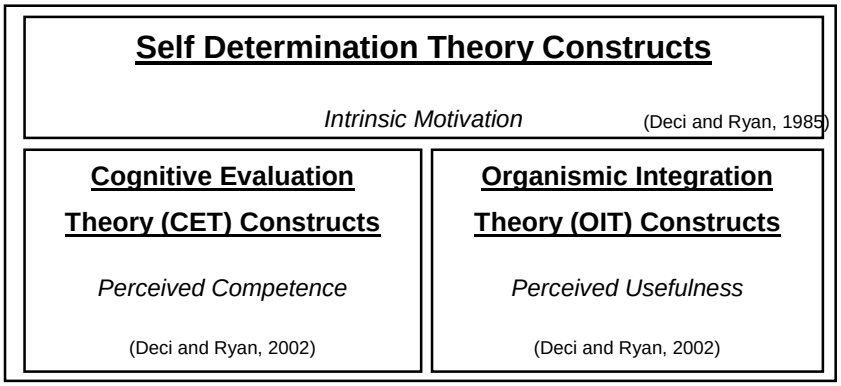
Perceived usefulness is an external outcome and is considered to be an indicator of extrinsic motivation (Deci and Ryan, 2000). An individual might find an activity to add value to something, or perceive it as useful, and then engage in the activity due to the value it adds and not due to the enjoyment of it (Deci and Ryan, 2000). The value added by the activity is considered as an external outcome, which motivates an individual to perform the activity. Being motivated by the perceived value of an activity aligns with the external identification degree of extrinsic motivation.

Deci and Ryan (2000) state that if something is perceived to be useful, or extrinsically rewarding due to the value it adds, then this might either undermine or enhance intrinsic motivation. Phrased slightly differently, this means that an individual could be motivated to complete an activity only for its perceived usefulness or, the perceived usefulness derived from an activity fosters a greater sense of interest, or intrinsic motivation, towards the activity. Therefore, the study draws on the construct of perceived usefulness as an indicator of extrinsic motivation.

To summarise, the current study draws on Self-Determination Theory, for the construct of intrinsic motivation and its dimensions of enjoyment/interest, as well as from CET, the constructs of perceived competence. From OIT the study draws on the concept of perceived usefulness as an indicator of extrinsic motivation. This is

represented by Figure 3.2. A further way in which SDT has influenced the current study is through the concept of Presence.

Figure 3.2: Constructs drawn from SDT and Sub-Theories



3.1.3 Presence

Ryan et al. (2006) adapted the construct of presence for self-determination theory, specifically adapting it to measure the presence felt while playing a digital game (See figure 3.3). Presence is largely concerned with measuring a user's level of engagement, or immersion, while playing a digital game. Presence that is associated with digital games has three dimensions. Firstly a physical presence dimension, which relates to how the player is able to move around inside the game (Ryan et al., 2006). Secondly an emotional presence, which relates to how emotionally involved the player is in the game (Ryan et al., 2006). Thirdly a narrative dimension of presence, which is how involved the player is with the story, or content, of the game (Ryan et al., 2006). Each of the three dimensions needs to be supported by a digital game in order for a it to induce a strong feeling of presence (Ryan et al., 2006).

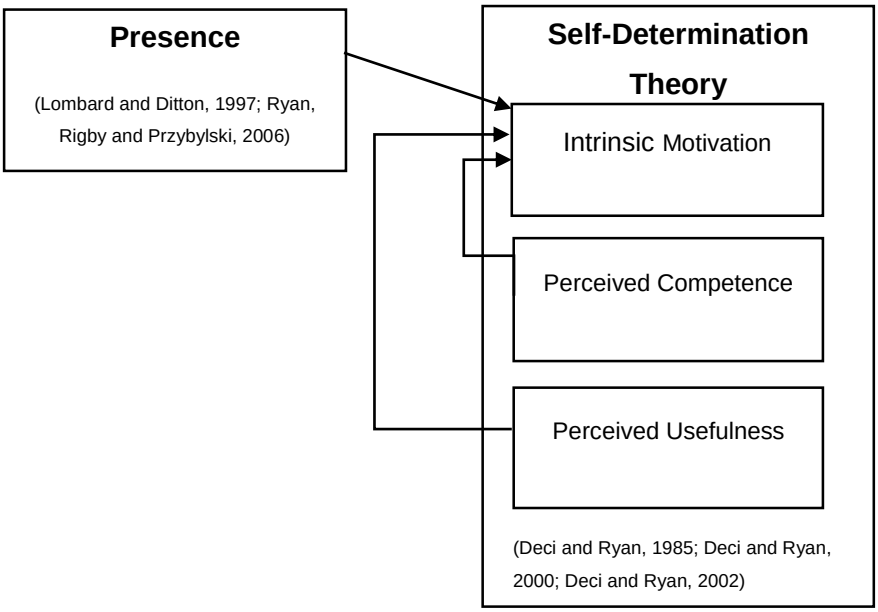
Presence, such as physical presence, has been related to other similar constructs, such as co-presence. Co-presence can be defined as an individual's sense of being immersed in virtual world with other players (Dalgarno and Lee, 2010; Warburton, 2009), or, phrased slightly differently, how an individual is able to perceive others in a game environment and how those others perceive that individual. Co-presence is less relevant in a single player game, such as the one used in this study, and thus the conceptualisation of presence in the current study is focused on the player's physical, emotional, and narrative presence as opposed to co-presence.

In order to examine engagement with a particular DGBL artefact there needs to be a way to identify how immersed a user is while playing a game. Presence is a construct that is concerned with the immersion of an individual in a particular activity.

The creators of the presence construct define it as the “perceptual illusion of no mediation” (Lombard and Ditton, 1997) which means that an individual is so immersed with a particular medium that they respond to that medium as if it was not present. In terms of GBL the digital game would be seen as the medium that users, or players, could be immersed in. The operational definition of presence can be observed by the level of immersion an individual feels while playing a digital game, or alternatively phrased, the sense that an individual feels like they are within the virtual game world as opposed to being a player outside the game world (Ryan et al., 2006).

The relationship between presence and intrinsic motivation indicates that higher levels of presence are significantly associated with higher levels of intrinsic motivation (Ryan et al., 2006). Therefore, in the current study presence was seen as an adequate construct to represent immersion in the digital learning game. These relationships can be seen in figure 3.3 below.

Figure 3.3: Relationship between Presence and SDT



Because this study was concerned with the impact of DGBL on student learning achievement or outcomes and student perceptions of their competence, it is necessary to reflect on the process through which students’ progress as they learn.

3.2 Learning Outcomes and the Four Stages of Competence

Gaining competence with new skills and knowledge, or the achievement of learning outcomes, is a complicated process. Individuals who need to become competent in a

new skill have been found to go through four stages of competence in relation to the skill that is being learnt. These stages are derived from the “The Competency Learning Model” (Gullander, 1974) and have been adapted into a model known as the learning model of competence.

Each stage of the model is seen as a step and an individual must pass through each stage before they have mastered a particular skill (Lindley, 2007; Zimmerman, Kennedy and Schremmer, 2010). The model has commonly been used to inform instructors and trainers about the stages their students will go through in order to gain mastery of a new skill (Lindley, 2007; Thomson, von Solms and Louw, 2006; Zimmerman et al., 2010).

The learning model of conscious competence has four stages. The first stage is known as the “unconscious incompetence” and in this stage the individual is not aware that they are incompetent in a specific skill. They are not even aware that they are lacking a skill and require active engagement and exposure with a particular task that uses that skill in order to move them to the next stage (Zimmerman et al., 2010; Furness, 2005).

The next stage is known as “conscious incompetence” and it is in this stage that the individual realises that they are incompetent in a specific skill. They also realise the relevance of the skill and their own deficiencies in the application of the skill (Lindley, 2007; Furness, 2005). The realisation of their own deficiencies allows the individual to begin to learn and practice the new skill. They are able to seek help from an instructor, or alternative resource, to assist them in learning the skill. Once they have practiced the skill and improved the deficiencies they are able to move into the “conscious competence” stage.

In the “conscious competence” stage an individual is able to perform the skill reliably by concentrating and focusing on that specific skill. The skill has not become automatic, or second nature but an individual will need minimal assistance in order to use the skill. At this stage an individual will be unable to reliably use the skill without thinking about it. A person would be able to show, or demonstrate, the skill to another person but would be unable to teach the skill effectively (Lindley, 2007; Zimmerman et al., 2010; Furness, 2005). After much more practice an individual is able to move to the final stage of competence.

“Unconscious competence” is the final stage of the learning model of competence and is when the skill become second nature and an individual does not have to actively think about it in order to perform the skill (Chapman, 2007; Furness, 2005). At this stage an individual is potentially able to teach the skill to others but might require reflection on how they were able to become unconsciously competent.

If an update to the skill is needed, due to advancements or some other reason, then an individual may have to regress back to stage 2, or even 1 depending on the different requirements of the new updated skill.

The four stages of conscious competence are represented in a matrix in figure 3.4 below.

Figure 3.4: The Learning Model of Competence **(Diagram adapted from: Chapman (2007))**

	Competence	**Incompetence**
Conscious	**Stage 3: Conscious Competence** An individual is able to reliably perform the skill at will and perform without assistance. They do however need to think and focus on the skill to perform it and will not be able to reliably use the skill without focusing. The individual must continue to practice the skill in order to move to stage 4.	**Stage 2: Conscious Incompetence** An individual is aware of the skill and the relevance of the skill. They are also aware of their deficiencies in the skill, generally from trying it. The individual knows roughly what level of the skill they need to be competent. They need to make an active commitment to learn and practice the skill in order to move to the next stage.
Unconscious	**Stage 4: Unconscious Competence** At this stage the individual is able to use the skill without thinking. It has become ingrained into their subconscious and can even perform other activities while doing the skill. There might need to be periods of reflection if the individual is needed to teach the skill.	**Stage 1: Unconscious Incompetence** Individual is unaware of the skill, any deficiencies they have in that skill, and the relevance of the skill. They might become conscious of their lack in the skill before any learning has taken place. They need to be exposed to the skill and be made to understand the relevance of the skill in order to move to stage 2.

Thus, participants in a study such as this were presumed to be moving through the stages of competence.

Drawing on the above-mentioned theories, the next section develops the research model and hypotheses for the study.

3.3 Hypothesis Development

Having established the underlying theories of the study, namely SDT, and its sub-theories of CET and OIT, as well as the concept of presence and the learning model of competence, the next section draws on those theories in order to derive the research hypotheses of the study.

3.3.1 Intrinsic Motivation (IM)

Intrinsic motivation can be defined as an individual's internal motivation towards performing and is associated with feelings of the interest and enjoyment, which implies that an individual will complete a task because it is enjoyable or interesting (Deci and Ryan, 1985; Deci and Ryan, 2000; Deci and Ryan, 2002). DGBL has been found to provide support for the three basic psychological needs that underpin intrinsic motivation.

It provides users with an environment where they are able to express their autonomy, or make their own choices (Ryan et al., 2006). It also provides an environment that allows users to try out new skills and feel a sense of mastery, or competence (Ryan et al., 2006; Papastergiou, 2009). Finally, it has been found to instil a sense or relatedness in the users, either through the virtual world itself or through other players that have engaged with the same digital game (Ryan et al., 2006).

Deci and Ryan (2002) indicate that if these three needs are indeed met then intrinsic motivation should be high. Therefore, by providing for autonomy, competence and relatedness, a digital game has the potential to increase the level of motivation in users of these systems as supported by prior empirical studies (Connolly et al., 2012; Papastergiou, 2009; Wouters et al., 2013; Hung et al., 2014; Kebritchi et al., 2010; Liu et al., 2011).

It has also been found that students with higher levels of intrinsic motivation are more engaged in the learning process. It has been found that students who are more engaged and motivated in the learning process potentially produce higher learning performance than students who are not motivated (Reyes, Brackett, Rivers, White

and Salovey, 2012; Hess and Gunter, 2013). Therefore, the current study proposed the following hypotheses relating to Motivation:

H1: The introduction of DGBL will have a positive effect on students' intrinsic motivation in the course.

H2: Intrinsic Motivation in the course will have a positive relationship with learning achievement.

3.3.2 Perceived Competence (PC)

The context of the study involved students that were learning a new skill for the first time. Therefore, based off the four stages of competence mentioned in the learning model of competence above, (Section 3.2) it was expected that students should initially be in the stage of unconscious incompetence and would not be aware of their abilities in BPM.

Kruger and Dunning (1999) found that when individuals are unaware of their own incompetencies, or in a stage of unconscious incompetence, they have a tendency to perceive themselves as having competencies in those skills. This tendency to over-estimate one's level of competency has become known as the "Dunning – Kruger Effect" (Dunning, 2011). This means that perceived competence was expected to be higher at earlier stages of the course than it was at later stages.

According to CET, perceived competence can be thought of as an individual's perception about how skilled they are at a particular task or domain (Deci and Ryan, 2002). Perceived competence is also regarded as a behavioural predictor of intrinsic motivation (Deci and Ryan, 1985; Deci and Ryan, 2002). DGBL provides an environment that challenges an individual, provides feedback and is free from negative judgements.

As students were exposed to the challenges in the game, they should become aware of the skills required for BPM and therefore become aware of their own incompetence. They should move from a stage of unconscious incompetence to conscious incompetence. Near the end of the course students were expected to have gained some level of conscious competence in some of the skills required for BPM, but it was unlikely for them to have progressed to stage 4, which is the unconscious competence stage.

Therefore, it was expected that first-stage perceived competence should be higher than later stages of perceived competence. The introduction of DGBL acting as a chance to apply skills should have a negative effect on students' perceived competence in the course as they move from unconscious incompetence to conscious incompetence. Therefore, the study proposed the following hypothesis:

H3: Baseline measures of perceived competence will reflect unconscious incompetence and thus will be higher than the endline perceptions of perceived competence, which reflect more conscious incompetence.

It has also been found that students that exhibit higher levels of competence tend to perform better on tests and exams (Chan, Song, Hays and Trongmateeru, 2014). This could be due to perceived competence having an indirect effect on achievement through intrinsic motivation, a direct effect on achievement, or an effect through unknown mechanisms (Wong, Wiest and Cusick, 2002). Therefore, the study proposed the following additional hypotheses related to perceived competence:

H4: Perceived competence in the course will have a positive relationship with intrinsic motivation in the course.

H5: Perceived competence will have a positive relationship on students' achievement in the course.

3.3.3 Perceived Usefulness (PU)

As per OIT, perceived usefulness is regarded as potential evidence of extrinsic motivation (Deci and Ryan, 2000). Specifically, an individual that perceives a DGBL application to add value to the learning process would be extrinsically motivated by the value it adds and not from the enjoyment of the task (Davis, Bagozzi and Warshaw, 1992).

Perceived usefulness can be defined as an individual's perception of whether a particular system or technology is deemed useful to them, or has added value to a particular task (Davis, 1989; Deci and Ryan, 2002; Ryan and Deci, 2000a). Perceived usefulness in the current context was concerned with whether the DGBL application had been useful in assisting students in learning. In particular, it was concerned with whether the students perceive the introduction of the digital learning

game to add value to the learning process and weather the digital learning game made the learning process more effective.

DGBL had the potential to support the learning process of the students by providing them with an environment that contextualises the skills they have learnt and allows them to practice those skills (Papastergiou, 2009). This means that if students perceive these qualities then they might perceive the digital learning game as having been useful to the learning process.

The perception of usefulness, or value that is added, in the learning process might act as an extrinsic motivator for the students. Deci and Ryan (2000) contend that extrinsic motivation has the potential to either undermine intrinsic motivation, or facilitate it. The extrinsic motivator has the potential to overpower intrinsic motivation and act as the only form of motivation that the students experience. Hence intrinsic motivation could decrease (Deci and Ryan, 2000). It also has the potential to increase intrinsic motivation as the extrinsic motivator could facilitate intrinsic motivation. Phrased slightly differently this means that students who found the game valuable to the learning process might only be motivated by that value (extrinsic only), or they might become more interested in the activity due the percieved value the game adds to the learning process (extrinsic facilitating intrinsic).

Past studies have also shown that actual experience with DGBL might affect students' perceived usefulness towards DGBL (Bourgonjon, Valcke, Soetaert and Schellens, 2010). Students who perceive DGBL as being useful, or not useful, will have certain expectations of the value that DGBL could bring to the learning process. Once students have had experience with DGBL this might alter their perceptions of the perceived usefulness of DGBL as the experience with DGBL could be below, or above, their previous expectations of its usefulness.

Finally, previous studies have also found that perceived usefulness relates positively to achievement (Liaw and Huang, 2013). This relationship is potentially attributable to the fact that if DGBL was found to be useful to the learning process then it could increase academic performance.

Therefore, the study proposed the following hypotheses related to perceived usefulness:

H6: The introduction of DGBL will have an effect on students' perceived usefulness of DGBL.

H7: Perceived Usefulness of the digital game will have an effect on students' intrinsic motivation in the course.

H8: Perceived Usefulness will have a positive relationship with students' achievement in the course.

3.3.4 Presence (PRES)

The construct of presence was used as a proxy to operationalise the immersion the students feel while playing the game. It can be defined as a state of complete immersion with a particular activity (Lombard and Ditton, 1997; Ryan et al., 2006). It has been found that higher level of presence, or immersion, felt during DGBL are associated with increased intrinsic motivation for individuals (Ryan et al., 2006; Connolly et al., 2012).

The basis behind this relationship is potentially attributable to digital games potential to provide support for the three basic psychological needs of competence, autonomy and relatedness, as it has been found that games that are able to provide support for these needs are able to instil high levels of presence (Ryan et al., 2006; Przybylski, Rigby and Ryan, 2010). When these needs are supported there should also be higher levels of IM, thus higher levels of presence are associated with a high IM (Ryan et al., 2006).

Media entertainment theory also states that media that is able to create high enough levels of immersion and enjoyment has the potential for that enjoyment to "spill-over" into other activities (Vorderer, Klimmt and Ritterfeld, 2004). Therefore, an immersive game has the potential to fuel an interest in the course.

Higher levels of immersion, or presence, have also been associated with an increase in achievement (Kiili, 2005). Therefore, the study proposed the following hypotheses related to presence and engagement:

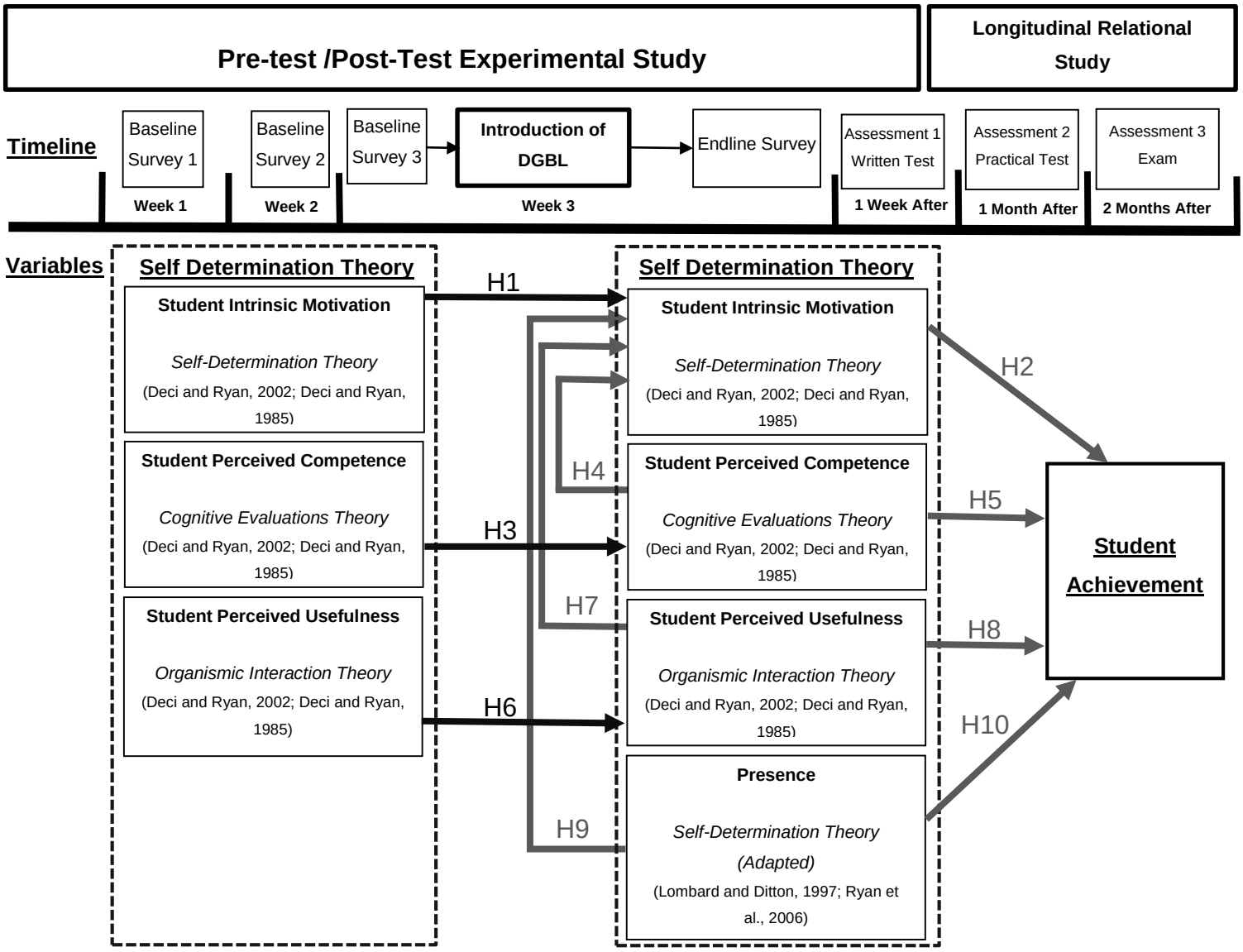
H9: Presence in the digital game will have a positive effect on students' intrinsic motivation in the course.

H10: Presence in the digital game will have a positive relationship with achievement in the course.

3.4 Diagram of Model

Having established the hypotheses of the study, figure 3.5 depicts the hypotheses in a graphical format. Figure 3.5 shows the timeline of the study, which will be explained in more detail in chapter four. It also shows the hypotheses that were derived in this chapter as well as the relationships between the variables of those hypotheses.

Figure 3.5: Graphical Depiction of the Model and Timeline



3.5 CONCLUSION

This chapter established that SDT, its sub theories of CET and OIT, Presence, and the Learning Model of Competence were the theories that underpin the study. It then used these theories to construct the ten hypotheses that were used to answer the research questions of the study. The research questions associated with each hypothesis, as well as a summary of each hypothesis, is provided in table 3.1.

Having established the hypotheses of the study, the next chapter will explain the methods the study adopted in order to test these hypotheses and provide an answer to the research questions.

Table 3.1: Summary of Hypothesis

No.	Statement	Research Question
H1	The introduction of DGBL will have a positive effect on students' intrinsic motivation in the course.	1
H2	Intrinsic Motivation in the course will have a positive relationship with learning achievement.	7
H3	Baseline measures of perceived competence will reflect unconscious incompetence and thus will be higher than the endline perceptions of perceived competence, which reflect more conscious incompetence.	2
H4	Perceived Competence in the course will have a positive relationship with intrinsic motivation in the course.	4
H5	Perceived Competence will have a positive relationship on students' achievement in the course.	7
H6	The introduction of DGBL will have an effect on students' perceived usefulness of DGBL.	3
H7	Perceived Usefulness of the digital game will have an effect on students' intrinsic motivation in the course.	6
H8	Perceived Usefulness will have a positive relationship with students' achievement in the course.	8
H9	Presence in the digital game will have a positive effect on students' intrinsic motivation in the course.	5
H10	Presence in the digital game will have a positive relationship with achievement in the course.	8

4 RESEARCH METHODOLOGY

This chapter aims to explain the methods that were used to carry out the study. The chapter presents a discussion around the research paradigm that informed the study and explains the research design that was then adopted. It provides a breakdown of the research instruments and how they were constructed and highlights the administration of the instruments. It then gives a description of the process that was followed to analyse the data and concludes with a section on the ethical considerations and limitations of the study.

4.1 RESEARCH PARADIGM AND PHILOSOPHY

A research paradigm is a set of beliefs and assumptions about the world that determine how the research process is conducted (Bhattacherjee, 2012; Maree, 2007). These beliefs and assumptions determine how the researcher views the world, which is commonly referred to as ontology (Bhattacherjee, 2012; Saunders, 2012). They also involve assumptions about how knowledge is generated from the research, which is referred to as epistemology. The current study fell into the positivistic paradigm. The epistemology and ontology associated with this paradigm are described in this section. It also then provides a discussion about why this paradigm was the most appropriate for the study and why other alternative paradigms were not appropriate.

The positivistic paradigm has an ontological view that sees the world as being real, independent and external to the researcher (Saunders, 2012). It assumes that the researcher can observe events that happen in the world objectively and that the reality that the researcher observes is the only reality that exists (Saunders, 2012; Maree, 2007). Phrased slightly differently, this means that a positivistic researcher is confident that the events they are able to see and observe are the events that are occurring in the world. The positivistic researcher also believes that they are able to measure granular things that occur in events and that they can remain as an objective observer that does not influence the things that they are measuring (Bhattacherjee, 2012).

This ontological perspective has frequently informed past work in DGBL experimental studies, where the researcher has remained an objective observer, and

making independent observations using quantitative measures (for example see Erhel and Jamet (2013) or Hainey et al. (2011)). The current study sought to maintain this objective perspective. It aimed to remain independent and objective in its observations and use quantitative measures in order to examine a circumstance.

The epistemological assumptions and beliefs of the positivistic paradigm follows the scientific method (Bhattacherjee, 2012; Saunders, 2012). This means that knowledge is generated through deductive reasoning and research is conducted with an outlook of determinism, which implies that when events occur they have been caused, or determined, by certain circumstances (Saunders, 2012). Law-like generalisations, or theories, are used to explain what circumstances can determine what kind of events (Saunders, 2012).

The process of positivistic research normally follows highly structured methods in order to ensure that it is replicable (Bhattacherjee, 2012; Saunders, 2012). It generally begins with the formulation of a question, or questions, about something that has been observed and is capable of being measured in a numerical way. Existing theory is then consulted in order to find a potential theoretical explanation, or law-like generalisation, that could potentially explain what has been observed (Saunders, 2012).

Based off the theoretical explanation that was consulted, hypotheses are derived and then tested. The tests require the collection of empirical evidence, which generally involves the collection of numerical, or quantitative data. The data are generally collected through experimental methods, field studies or survey based methods and analysed through appropriate hypotheses testing statistical methods (Bhattacherjee, 2012; Maree, 2007). The findings of the analysis will either support the hypotheses, and hence support the theoretical explanation, or not support the hypotheses and refute the theoretical explanation.

The agreement or contradiction of theory is the contribution of a positivistic research process (Saunders, 2012). An agreement with theory results in stronger empirical evidence supporting that theory's ability to make generalisations and predictions. A contradiction with theory generally results in the generation of new theory that might be better at making generalisations and predictions. The new theory would then go through the same deductive process in order to instigate its generalisability and

predictability (Saunders, 2012). This is the deductive approach to knowledge generation and the main process through which positivistic research generates scientific knowledge.

The current study has adopted a positivistic approach to research as it is the most appropriate paradigm for the context of the study. The questions that have been posed by the study seek to determine the extent that DGBL impacts students' motivation, perceptions and learning. These questions align to the positivist paradigm as there has been observations that DGBL has had a potential impact on the above mentioned constructs and that this potential impact is able to measured. The answers to these questions also have important implications to other researchers. As such, they should be generalisable and able to be used to predict the potential impact of DGBL in other situations, which also aligns to the appropriateness of the positivist paradigm.

Other studies conducted around DGBL also tend to adopt a positivist approach to research. Many of the studies have used different, but appropriate, theories to formulated hypotheses. They have used survey based methods, experiments and field studies in order to collect quantitative data to test the hypotheses (Connolly et al., 2012; All et al., 2014). These tests have resulted in some agreements and some contradictions with the theories that have been used. The current study sought to continue this positivistic deductive approach to the generation of knowledge in the field of DGBL. Building on the works of previous studies, it formulated hypotheses that took into account the theories that have been supported as well as the contraindications that have been found.

However, within the field of DGBL there have also been some studies that have used an interpretivist paradigm to guide their research (All et al., 2014). The interpretivist paradigm has evolved out of critiques to the positivist paradigm (Saunders, 2012). It has an ontological view that sees the world as being socially constructed and meaning is generated subjectively through language and culture (Saunders, 2012). Meaning, or reality, can therefore be interpreted differently by different people and reality is viewed as having many different interpretations depending on who is interpreting it (Bhattacherjee, 2012; Saunders, 2012). Interpretivist researchers do

not view research as an objective process but rather see themselves and their own subjective interpretations of reality to influence the research process.

The researcher's own interpretation of reality must be taken into account during the generation of knowledge and the epistemology associated with the interpretivist paradigm follows an inductive approach to reasoning (Bhattacherjee, 2012; Saunders, 2012). This inductive process generally starts out with the researcher immersing themselves in the context they wish to research. Qualitative data on language, symbols and cultural background is collected from that context (Maree, 2007). The data collection is generally done by the researcher through interviews with participants, document analysis and observations. The data is then analysed, or coded, in order to identify and understand the complex themes that could explain how reality is interpreted in that context.

The purpose of interpretivism is to construct a new and rich understanding of a particular context by interpreting and understanding the complex social subjective interpretations of reality that exist in that context (Saunders, 2012). Interpretivism arose out of the fact that positivism tends to overlook these socially constructed realities and implies that peoples' subjective experiences do not impact the objective elements of reality under measurement (Saunders, 2012; Maree, 2007). However, the two paradigms should not be viewed as one being better than the other but rather as two different paradigms of research that can be selected based on the purpose of a study (Saunders, 2012).

It is the purpose of this study that made it appropriate to adopt a positivist paradigm, as the study aimed to explore what circumstances determine the events surrounding the impact of DGBL on student motivation, perceived competence and learning. The objective of the study was to measure the impact that DGBL has. It was not to construct a new understanding of the social context that exists around DGBL. Therefore, the study was informed by the positivist paradigm because of its appropriateness to the questions being asked by the study.

4.2 Research Design

Having established that the positivist paradigm is appropriate for the study, the design of the study is presented in this section. The study was guided by the

positivist paradigm and an evaluation study design has been adopted in order to allow for the measurement of the impact of DGBL. Quantitative data was collected in order to test the hypotheses through statistical analysis.

In order to evaluate the extent to which DGBL impacts students' motivation, perceived competence, the study adopted a single group natural experiment pre-test/post-test design. This involved the application of three base-line surveys, each one week apart and prior to the introduction of a digital learning game, and the application of an end-line survey after the introduction of the digital learning game.

The study had a further longitudinal element in order to evaluate the impact of DGBL on students' learning, which sought to correlate students' achievements based on three assessments performed after the BPM course concluded. The assessments were a written test, a practical test and an exam. The scores obtained in the assessments were examined against the end-line data. Both of these methods will be discussed and justified in the subsequent section.

4.2.1 Single Group Natural Experimental Design

Experimental designs are considered to be the most rigorous types of research designs available to a positivist researcher, and other designs are often compared to them in order to judge their rigorousness (Saunders, 2012).The study adopted an experimental design because of the high level of rigour associated with it. These designs are also common in the DGBL and educational context (Connolly et al., 2012) and therefore were appropriate to be used.

Experiments are concerned with studying the effect of a change in an independent variable in order to assess its impact on a dependent variable, or dependent variables (Saunders, 2012). The introduction of the digital learning game was regarded as the study's independent variable and students' motivation, perceived competence, and perceived usefulness were regarded as the dependent variables.

Classic experimental designs include at least two conditions, one where the independent variable is included, which is referred to as the experimental or treatment condition, and another where there is no independent variable included, which is referred to as the counterfactual or control condition (Shadish, Cook and Campbell, 2002). A comparison is conducted between the dependent variable in the

experimental condition and the dependent variable in the counterfactual condition (Shadish et al., 2002). This is how experiments are able to evaluate the impact of the independent variable on the dependent variable.

Classic experiments are often conducted in a controlled lab based environments in order to ensure that there are no other variables that might undermine the relationship between the independent and dependent variables. These other variables are often referred to as confounding variables (Saunders, 2012). The fact that experiments are conducted in a controlled lab setting allow them to have a high level of internal validity, which means they have the ability to infer that changes in the independent variable have caused an impact on the dependent variable. This high level of internal validity is why experiments are regarded as the most rigorous methods as other methods, such as cross sectional designs, are only able to infer correlations between variables and not causation (Saunders, 2012).

However, in the social sciences it is often not possible to conduct experiments in a completely controlled lab based environment. In fact some researchers contend that controlled lab based experiments in a social science context have low external validity, or ability to generalise to outside the experimental lab environment(Levy and Ellis, 2011). This is mainly because a highly controlled lab based environment is not an accurate reflection of real life situations (Levy and Ellis, 2011).

Social scientists have designed other types of experiments that maintain the essence of the comparison between an experimental condition and counterfactual condition but have added in other design characteristics in order to maintain levels of internal validity when dealing with people. These design characteristics are aimed at reducing the effects of confounding variables.

The randomisation of participants into two groups, namely an experimental group (experimental condition) and control group (counterfactual condition), is one way to reduce the effects of confounding variables and maintain a high level of internal validity (Shadish et al., 2002). Another way is by anticipating the confounding variable and creating a control variable that is able to remove, or detect, the confounding effect (Shadish et al., 2002). Experiments that include two randomised groups representing the experimental group and the control group are known as

randomised control trials (RCT's) and are considered to be the most rigorous experimental designs available to social scientists (Shadish et al., 2002).

Due to the limitations of the study, it was not possible to randomise the participants into an experimental and control group. The experiment was conducted in a live BPM university course and was therefore limited by the way the course had been designed. While it was not possible to conduct a RCT in the current study there are other types of experimental designs that were able to be used in the current context. A natural experiment, or field experiment, was found to be appropriate for the context of the study.

A natural experiment is commonly used when it is not possible to use a second group as the control group nor is it possible to randomise the participants into control and experimental condition (Shadish et al., 2002). In a natural experiment base-line data are collected prior to the introduction of an independent variable and functions as the counterfactual condition. (Shadish et al., 2002). Endline data are then collected after the introduction of the independent variable and functions as the experimental condition (Shadish et al., 2002). While natural experimental designs do have lower internal validity than RCT's they are suitable in contexts where RCT's are unable to be conducted (Shadish et al., 2002).

Therefore, due to the limitations of conducting the study in a natural field setting and being unable to use a control group as the counterfactual, a natural experiment was deemed appropriate for the study. Base-line data were collected from the participants prior to the introduction of the digital learning game through three surveys. The study used three surveys, each administered one week apart, in order to build an accurate representation of participants' baseline data. End-line data were then collected after the introduction of the digital learning game also through a survey. The surveys measured the participants' levels of intrinsic motivation, perceived competence and perceived usefulness. The baseline and endline data were then compared through statistical analysis in order to detect differences between the two conditions.

The correct terminology for the design of the study is a single group natural experiment pre-test/post-test design, however many researchers just refer to these types of designs as single group pre-test/post-test designs or baseline/endline

designs. The pre-test/post-test design has been found to have been adopted a number of times in DGBL studies. Connolly et al. (2012) identified a high number of studies using this research design both with single groups and multiple groups that were under examination. This adds further support for the use of this design to evaluate the impact of DGBL on students' intrinsic motivation, perceived competence and perceived usefulness.

4.2.2 Longitudinal Relational Design

Having established the methods associated with evaluation of the impact of DGBL on the students' intrinsic motivation, perceived competence and perceived usefulness, it is now necessary to establish the methods associated with the evaluation of students' intrinsic motivation, perceived competence, perceived usefulness, and presence on their learning achievement. This evaluation is achieved through a longitudinal relational design that correlates the endline constructs mentioned above against scores that the students achieved on three separate assessments, which were conducted at different times after the completion of the BPM course.

Relational designs seek to examine the relationships amongst variables (Diem, 2002). This is done through correlation analysis in order to determine if the variables that were hypothesised to have a relationship with one another actually do. There are generally two types of relational designs that can be used. The first is known as a concurrent, or cross-sectional, design which involves the correlation of variables that were measured at the same point in time (Diem, 2002; Bhattacherjee, 2012). The second is known as a predictive relational design, or longitudinal design, which involve the correlation of variables that were measured at different points in time (Diem, 2002). Normally the variables that are measured at the first time point are then correlated with those measured later in order to determine if the earlier variables can be used to predict the later variables (Diem, 2002).

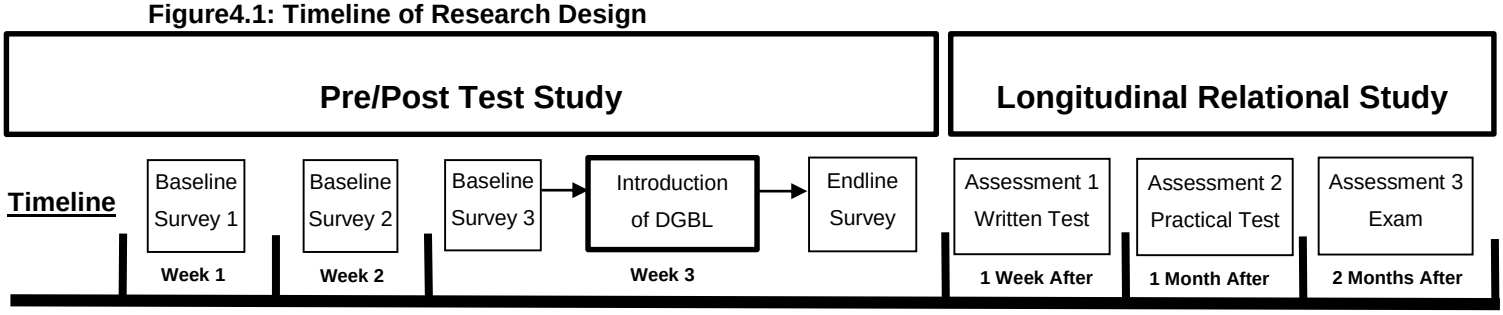
The longitudinal relational design was adopted by the study in order to evaluate whether students' levels of intrinsic motivation, perceived competence, perceived usefulness and presence have a relationship with the scores they obtained for three different assessments in the BPM course. The end-line data that were gathered during the experimental phase of the study were correlated with the scores for a

written test, a practical test and an exam. These assessments were written one week after the course, one month after the course, and two months after the course, respectively. This determined whether there was any effect on students' achievement in the course, which might be attributable to intrinsic motivation, perceived competence, perceived usefulness, and presence.

The longitudinal relational study was included to potentially reduce some of the threats to internal validity posed by the natural experimental pre/post-test design. Longitudinal studies have had limited use in DGBL research but an increase in these designs has been recommended by researchers (Calderón and Ruiz, 2015; Connolly et al., 2012). Relational designs have been popular in studies of entertainment games and are also claimed to be relevant to DGBL studies. (Connolly et al., 2012).

Figure 4.1, provides a graphical summary and timeline of the study.

Figure4.1: Timeline of Research Design



4.3 Context of the Study

Having established the research design of the study, the establishment of the context of the study occurs next. This includes a description of the course and sample of the study. It also provides a description of the digital learning game that was used in the study and provides the characteristics of that game.

4.3.1 The Course

The course provided the empirical context for the study as a 3rd year BPM course conducted within a 3rd year information systems programme. The course consisted of 21 contact hours consisting of both lectures and a weekly laboratory component. The objectives of the course as it was offered in 2015 were as follows:

- Define the architecture of a business process

- Analyse and model business processes using appropriate business process modelling notation
- Understand and apply various quantitative business performance assessment metrics
- Describe techniques for business process improvement
- Explain how IT supports business process improvement efforts
- Apply their understanding of BPM to examples in different business sectors

Three assessments were written for the course. A written test was written one week after the course concluded. A practical test was written one month after the course concluded, and an exam was written 2 months after the completion of the course.

These assessments were formal assessments that were part of the course. The researcher had no involvement with the compilation or administration of these assessments. Copies of the assessments can be found in appendix A.

4.3.2 The Population and Sample

A population of the study generally concerns the unit of analysis of a study, which can be individuals, organisation, or any granular unit that is capable of being analysed (Bhattacherjee, 2012; Saunders, 2012). Generally, the most granular unit of analysis that is studied in social science research is an individual person (Bhattacherjee, 2012).

Normally a sample is drawn from the population and this sample is used to draw inferences and generalisations about the entire population (Bhattacherjee, 2012; Saunders, 2012). However, due to the single group experimental design and limited randomisation, there was a limited ability for the study to generalise the results to any group beyond the current study's sample. Therefore, the population of the study, which will be referred to as the experimental group, consisted of the students that were registered in the BPM module.

The experimental group consisted of 32 undergraduate students enrolled for the BPM course within the 3rd year Information Systems programme at the University of the Witwatersrand.

The entire class was invited to participate in the study through both a verbal invitation, as well as participation invitation letter.

4.3.3 The Digital Learning Game: IBM's Innov8 2.0

The game selected for the study is called "IBM's Innov8 2.0" which is a simulation game designed to give students an environment to practice business process mapping in a real organisational context (Refer to IBM Website: http://www-01.ibm.com/software/solutions/soa/innov8/index.html). The game was seen to be appropriate for use in a university course and in the support of learning BPM as it been found to have been used successfully in previous studies (Boughzala, Chourabi and Lang, 2015; Joubert and Roodt, 2010; Lawler and Joseph, 2010), although the evidence base of the use of IBM's Innov8 2.0 is limited (Boughzala et al., 2015).

Previous work that was found on the use of IBM's Innov8 2.0 indicates that it engages students and is capable of immersing the students in the game (Boughzala et al., 2015; Joubert and Roodt, 2010; Lawler and Joseph, 2010). Previous studies have also indicated that the game is capable of assisting students with the understanding of BPM concepts and has increased levels of interest or intrinsic motivation in the students (Boughzala et al., 2015; Joubert and Roodt, 2010). Only one study analysed the game's ability to effect student's confidence, satisfaction and attention, which were all found to increase after gameplay (Boughzala et al., 2015).

The game essential gives the player control of a process analyst that has recently joined a company. Learners begin the game in a virtual office where they are able to move around freely. The learners are told that they have to analyse the call centre process in the office. Players are first tasked with collecting requirements for the process by interacting within a virtual office environment. They then have to optimise the process in terms of meeting various key performance indicators (KPIs) of the business. This is achieved by performing simulations and manipulating elements in the process model they created during the requirements gathering stage. Screenshots of both the virtual office environment (Figure 4.2) and the optimisation of the KPIs (figure 4.3) have been included.

Figure 4.2: Office Environment of IBM's Innov8 2.0

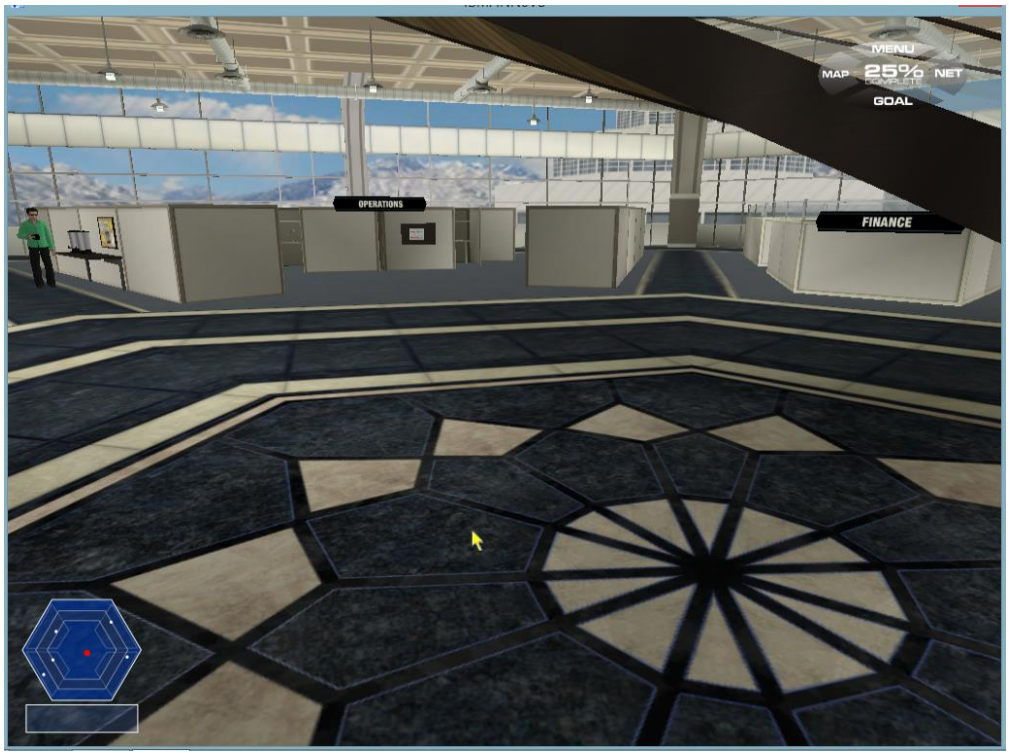
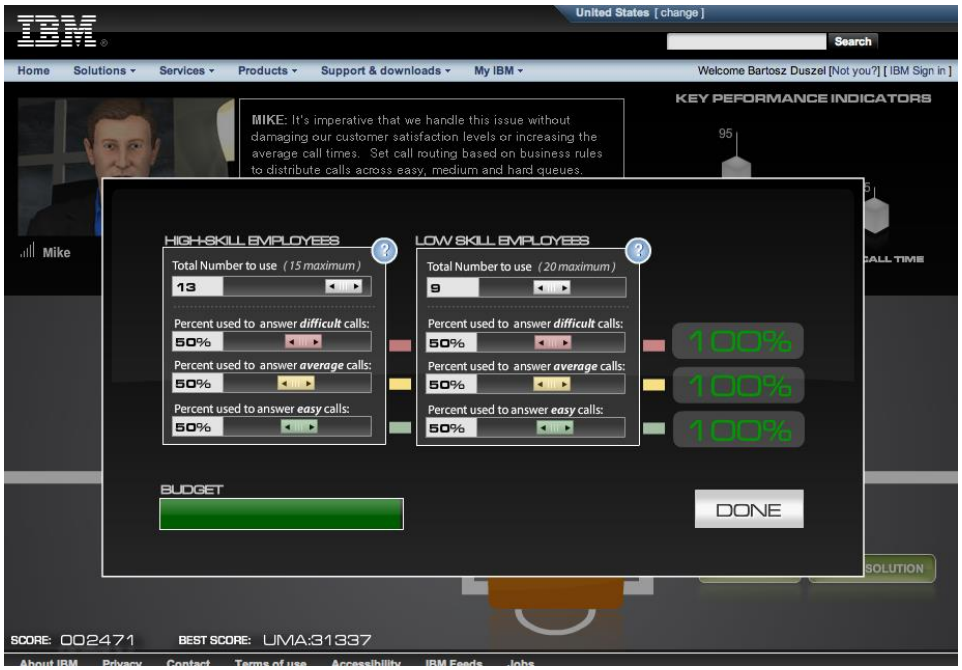


Figure 4.3: Optimisation of the KPI's in IBM's Innov8 2.0



The characteristics of the game are summarised in Table 4.1. With reference to section 2.2.1, the core characteristics of a game have been identified in the game and are included in the table along with some of the additional characteristics that are found in digital games.

Table 4.1: Core characteristics of a Game Identified in IBM's Innov8 2.0

Game Characteristic	Innov8 2.0
Closed system of meaning	Learners are limited to a virtual office environment consisting of two floors and several rooms
Rules and constraints	1. Learners are unable to interact with anything other than the objects they need to construct the process map. 2. Score increases the more effectively learners optimize the processes
Game mechanics	Players are able to move around freely in the office environment. They are able to interact with intractable objects, such as some of the papers on a desk and they can talk to other people.
Challenge	Finding the requirements needed to build the process model and then being able to optermise the business process model in accordance with the KPI's
Feedback	Displays the players score and also gives feedback from an in-game character regarding what the requirements are to build the process model. During the optimization process learners are given feedback about how well they are able to optimize the model. This feedback is in the form of a percentage symbol.

The game is a single player game that collects a score based on how well the player optimises the process model. The score can then be submitted to a leader board where the player is ranked based off their score. The scores are displayed to players but the leader board requires the players to log-on to a web portal. Therefore, there is potential for competition between players but the players themselves do not play the game together. The leader board feature was not used in the study.

The narrative of the game is focused around the learner being a new process analyst hired by the company. They are tasked with identifying the current business process and then optimising this process model. The game does not have much choice when it comes to dialogue as the responses are pre-defined and the player has no choice in them (Vuksic and Bach, 2012). However, the player is given control of the in-game character and can walk around and interact with the game objects based on the rules and constraints. The navigation around the office can be seen in figure 4.2, and has previously been found to be easy to understand and use (Boughzala et al., 2015). The learners are also provided with choices surrounding the optimisation of the model and are able to select various levels of optimisation for different aspects of the model. These choices can be seen in figure 4.3.

The sensory stimuli of the game try to achieve a certain level of realism but the game was developed in 2007. Therefore, the graphics of the game could be seen as being slightly dated. While studies have been found that indicate that the level of realism in a game does not impact the learning content (Vogel et al., 2006; Wouters and Van Oostendorp, 2013), there have also been studies that used IBM's Innov8 2.0 with mixed results. Boughzala et al. (2015) found that students that spent more time playing entertainment games disliked the graphics in the game but students with less experience with entertainment games did not seem to mind them.

The learning outcome attached to the game by the developers is to gain an understanding of the importance of BPM in an organisation and to understand the use of IT systems in the context of BPM (Vuksic and Bach, 2012).

The core challenges that the game requires the player to accomplish are: to strategically choose the right strategy to meet KPI's, select the appropriate budget for the KPI's, adapt a process in order to meet goals the game lays out and to identify the requirements for the process model (Boughzala et al., 2015). These challenges were found to be representative of the tasks that would be needed in order to perform BPM (Boughzala et al., 2015). Boughzala et al. (2015) found that the game should be given to BPM learners that have had some exposure to the skills needed for BPM and not to learners who have never been exposed to BPM.

Therefore, the study only implemented the game at the end of the BPM course and hoped that the simulation game would assist students in reinforcing their knowledge of BPM. The students were taught about the concepts of BPM in a traditional lecture. The game then acted as an environment where they can practice the skills of BPM in a "virtual" real life situation. This concept was in line with many other applications of business simulators in a learning context (Faria, 2001; Lin and Tu, 2012).

Despite being exposed to the game at the end of the course the learners were given the opportunity to choose to play the game anytime between the end of the course and the last assessment. The game was played under license in terms of the IBM academic initiative.

The applicability of using a learning game with BPM also needs to be mentioned. BPM is an applied subject where students need to apply the concepts they learn to real problems (Boughzala et al., 2015; Vuksic, Bach and Hernaus, 2014). IBM's

Innov8 2.0 provides a platform where students were able to apply BPM concepts in a context that mimics a real world problem. This was in line with studies that have used DGBL in the context of an applied subject, specifically subjects like computer science (Papastergiou, 2009) and mathematics (Kebritchi et al., 2010). It was also in line with previous studies that have used IBM's Innov8 2.0 and provided some empirical evidence (Boughzala et al., 2015; Joubert and Roodt, 2010; Lawler and Joseph, 2010).

4.4 Research Instrument

Having established the context of the study, the research instrument is then described. A questionnaire was used as the research instrument for the base-line surveys and the end-line survey. The items, or questions, that were used to in the study's research instrument as well as the other questions included in the instrument are discussed in this section. A copy of both the endline and baseline questionnaires can also be viewed in appendix A.

Questionnaires are commonly used in deductive research and consist of questions that are referred to as research items (Saunders, 2012). Questionnaires generally consist of set of questions, commonly referred to as items, that are standardised in terms of their responses (Saunders, 2012). Items generally fall into three categories, the first relates to the operationalisation of the constructs into research items that can be measured, the second relates to the demographic items, and the third relates to the control items. Each of these categories will be discussed

4.4.1 Operationalisation of Constructs

The items, or questions, that relate to the constructs in the study are generally underpinned by theory and are adapted from research instruments that have been tested to measure those constructs.(Saunders, 2012; Bhattacherjee, 2012). The conceptual constructs are operationalised through the research items included in the questionnaire (Saunders, 2012). The constructs are referred to as the conceptual definition and the research items are the operational definition of those constructs.

The adaptation of research items that have been previously constructed and tested ensure some levels of validity with the research instrument (Saunders, 2012). Construct validity is improved when using adapted research items. This means that

the constructs that the items are measuring are actually being measured (Saunders, 2012). Content validity is also ensured, which refers to the adequacy of the coverage of the variables.

The study adapted the research items included in the questionnaires from previously tested research instruments. The constructs that were addressed in the study are intrinsic motivation, perceived competence, perceived usefulness and presence. The research items, or operational definitions, for intrinsic motivation, perceived competence and perceived usefulness were adapted from the “Intrinsic Motivation Inventory”. This inventory is a set of research items that have been designed and tested to measure those constructs in an experimental study. They have been used many times in experimental research (Deci and Ryan, 2000) as well as several DGBL studies (Eseryel et al., 2014; Huang, 2011).

The construct of presence was operationalised through research items that were adapted from Ryan et al. (2006)’s Player Experience of Satisfaction of Needs (PENS) scale. The PENS scale is designed to measure presence in a virtual learning environment and has been used before in prior digital games studies (Ryan et al., 2006).

The base-line surveys included items for intrinsic motivation, perceived competence and perceived usefulness. The base-line questionnaire included five items relating to interest and enjoyment which are direct measures of intrinsic motivation (Deci and Ryan, 2000). It also included six items on perceived competence and six items on perceived usefulness of DGBL.

The end-line survey contained the identical five items for the construct of intrinsic motivation and the identical six items for the construct of perceived competence. However, the end-line questionnaire contained slightly different items for the construct of perceived usefulness. Here the items were adapted to measure the perceived usefulness of IBM’s Innov8 2.0 as opposed to the perceived usefulness of DGBL in general. The endline survey also included items 9 items that related to presence, where each dimension of presence, namely the physical, emotional and narrative dimensions, had three items each. The operationalisation of the items are provided in table 4.2.

Table 4.2: Summary of the Operationalisation of the Constructs

Construct	Conceptual Definition	Number of Items	Base / End-line data	Literature Source	Operational Definition
Intrinsic Motivation (IM)	Individual's Internal motivation towards performing and is associated with feelings of the interest and enjoyment. (Deci and Ryan, 1985; Deci and Ryan, 2000; Deci and Ryan, 2002).	5	Base-line and End-line (Identical)	Intrinsic Motivation Inventory: Enjoyment/ Interest (Deci and Ryan, 1985; Deci and Ryan, 2002)	**IM1**: I think business process mapping is quite enjoyable. **IM2**: I think business process mapping is very interesting. **IM3**: I think business process mapping is fun. **IM4**: While doing business process mapping I often think about how much I enjoy it. **IM5**: I think business process mapping is boring (-).
Perceived Competence (PC)	Individual's perception about how skilled they are at a particular task or domain. (Deci and Ryan, 1985; Deci and Ryan, 2000; Deci and Ryan, 2002).	6	Base-line and End-line (Identical)	Intrinsic Motivation Inventory: Perceived Competence (Deci and Ryan, 1985; Deci and Ryan, 2002)	**PC1**: I think I am pretty good at business process mapping. **PC2**: I am pretty skilled at business process mapping. **PC3**: I am satisfied with my performance at business process mapping. **PC4**: I think I do pretty well at business process mapping, compared to others. **PC5**: I think I am good at business process mapping. **PC6**: After working at business process mapping for a while, I felt pretty competent.
Perceived Usefulness (PU)	Individual's perception of whether a particular system or technology is deemed useful to them, or has added value to a particular task. (Davis, 1989; Deci and Ryan, 2002; Ryan and Deci, 2000a).	6	Base-line and End-line (Slight difference)	Intrinsic Motivation Inventory: Perceived Usefulness (Deci and Ryan, 1985; Deci and Ryan, 2002)	**<u>Baseline</u>** **PU1**: I believe that using digital games to learn could be of some value to me. **PU2**: I think that using digital games to learn could be useful. **PU3**: I think using digital games to learn could be important. **PU4**: I would be willing to use digital games to learn because it could have some value to me. **PU5**: I think that using digital games to learn could be helpful. **PU6**: I believe that using digital games to learn could be beneficial to me. **<u>Endline</u>** **PU1**: I believe that using IBM's Innov8 2.0 to learn was of some value to me. **PU2**: I think that using IBM's Innov8 2.0 to learn is useful. **PU3**: I think using IBM's Innov8 2.0 to learn is important. **PU4**: I would be willing to use IBM's Innov8 2.0 to learn again because it has some value to me. **PU5**: I think that using IBM's Innov8 2.0 to learn is helpful. **PU6**: I believe that using IBM's Innov8 2.0 to learn could be beneficial to me.

Presence (PRES)	A state of complete immersion with a particular activity. Presence in video games is split into three dimensions. Physical presence, which is Immersion felt toward physical movement in the game. Narrative Presence, which is immersion felt towards the story of the game, and emotional presence, which is immersion felt towards the emotional aspects of the game. (Lombard and Ditton, 1997; Ryan et al., 2006)	9	End-line	Player Experience of Satisfaction of Needs (PENS): Presence (Ryan et al., 2006)	**Physical Presence** **PRES1**: When playing IBM's Innov8 2.0, I feel transported to another time and place. **PRES2**: Exploring IBM's Innov8 2.0 world feels like taking an actual trip to a new place. **PRES3**: When moving through IBM's Innov8 2.0 world I feel as if I am actually there. **Emotional Presence** **PRES4**: I am not impacted emotionally by events in IBM's Innov8 2.0 (-). **PRES5**: IBM's Innov8 2.0 was emotionally engaging. **PRES6**: I experience feelings as deeply in IBM's Innov8 2.0 as I have in real life. **Narrative Presence** **PRES7**: When playing IBM's Innov8 2.0 I feel as if I was part of the story. **PRES8**: When I accomplished something in IBM's Innov8 2.0 I experienced genuine pride. **PRES9**: I had reactions to events and characters in IBM's Innov8 2.0 as if they were real.

All operationalised items were presented on a seven point Likert scale ranging from not at all true (1) to very true (7), unless otherwise stated. Likert scales are scales that measure a respondent's level of agreement with a verbal statement. The verbal statement being the operational definition of the items, which can be seen in table 4.1. They are commonly used in social science survey based research (Bhattacherjee, 2012)

4.4.2 Demographic Items

Demographic items are questions that relate to facts about the respondents (Saunders, 2012). These can include questions that concern the age of the respondent, the gender, the marital status, and any other fact that the study needs to find out about the respondent (Saunders, 2012).

The demographic items included in the base-line questionnaire are the participants' gender and age, as well as their previous experience with digital games in an entertainment context. Gender was presented with a male/female/prefer not to say option and age was presented in a frequency (18-19/20-21/22-23/24+/Prefer not to

say). The experience in playing games for leisure was measured as gameplay frequency during an average week (never to 6 or more hours a week). Three different questions were asked about gaming frequency, which included three different gaming platforms, namely console, PC and mobile gaming frequency.

The end-line questionnaire did not include the demographic questions from the baseline survey. However, it did include additional demographic questions concerning IBM's Inov8 2.0. These were as follows:

- Q1: Did you complete IBM's Innov8 2.0 successfully?
- Q2: Did you play IBM's Innov8 2.0 more than once?
- Q3: What was your final score for Innov8 2.0? (If you played the game more than once then take your highest score)
- Q4: Did you enjoy playing Innov8 2.0?

Questions one, two, and four each had responses consisting of yes, no, or I am not sure, while question three required a numerical response indicating the score that was obtained in IBM's Innov8 2.0. These questions were included in order to be able describe the experience the participants had while playing the game and to find out if participants were able to complete the game.

4.4.3 Control Items

Control items are generally included in experimental designs in order to control for potential confounding effects and then strengthen the internal validity (Shadish et al., 2002). They are also included for purposes of handling methods biases.

The study included two types of control items. The first is termed occupational self-efficacy and was included in order to control for any potential maturation effect. Maturation effects pose threats to internal validity and occur due to changes in the participants over a period of time (Shadish et al., 2002). This effects internal validity by adding a confounding effect into the study and diminishing a study's ability to infer that the independent variable had an effect on the dependent variable (Shadish et al., 2002). Therefore, the study used a measure of occupational self-efficacy (OSE) in order to control for any maturation effect in the participants.

There was one item included for OSE ("*I believe that I possess the necessary skills to pursue an IT career*"). This item was included in all of the baseline surveys and the

endline survey. It measures whether students perceive that they have the necessary skills to pursue an IT career. This variable should remain stable over the course of the study as third year IS students should have a relatively stable OSE that does not change over the short space of time in which the study is carried out. This is due to the skills and knowledge they have acquired over their studies. OSE is therefore controlling for any type of maturation effect, which involves changes in something due to the passage of time.

The second type of control that was included concerned the variable intuitive control. It has been found that the presence felt in a game is effected by the control system of a game (Ryan et al., 2006). Therefore, the study included a control variable known as “intuitive controls”, which measures how intuitive, or easy, the game was to control. Previous studies that have used IBM’s Innov8 2.0 have pointed out that the game was found to be easy to control (Boughzala et al., 2015). However, the current study wanted to ensure that participants in this study had the same experience as previous studies, and the control variable of intuitive controls was included in order to measure how easy the game was to control.

Three items for intuitive control (IC) were included only in the endline survey as they are only concerned with the control systems of the game. These were the same items used to measure intuitive control in Ryan et al. (2006)’s study. The items were as follows:

- IC1: Learning IBM's Innov8 2.0 controls was easy.
- IC2: IBM's Innov8 2.0 controls are intuitive.
- IC3: When I wanted to do something in IBM's Innov8 2.0, it was easy to remember the corresponding control.

4.4.4 Quality Control: Pre-test and Pilot Test

A pre-test and pilot test are used in order to ensure the face validity of a questionnaire (Saunders, 2012). Face validity refers to whether the questionnaire makes sense at face value, or that the participants are able to understand what is being asked by the questionnaire (Saunders, 2012). They are also able to ensure the content validity and construct validity, which concerns whether there is adequate coverage of the variables in the study and whether the items are measuring the constructs they have been operationalised from (Saunders, 2012).

However, because the study has adapted research items from the Intrinsic motivation inventory and from the PENS scale, both the content and construct validity have been tested in previous studies. Ensuring the face validity was the primary outcome of these tests.

A pre-test was conducted with academics having experience in conducting positivist survey research, particularly questionnaire research. There were some adaptations to the wording of the demographic items but the operationalised items and control items were deemed to be fine.

A pilot test was then conducted which consisted of a convenience sample of four honours students who completed the course in the previous year. Because these students had already come through the BPM course, they were deemed as appropriate to conduct the pre-test with. The students found no issues with the face validity of the items and were able to understand each item.

Having established the construction of the research instrument, the next section provides an overview of the administration of the instruments.

4.5 Administration of the Instrument

There are various strategies that are available to researchers in order to administer surveys. These include email administration, telephonic administration, postal administration and group-based face to face administration (Saunders, 2012). Telephonic administration involves calling potential respondents and filling out a survey over the phone, while postal and email administration involve posting, or emailing, a survey to potential respondents and waiting for the completed survey to be sent back (Saunders, 2012). Telephonic, email and postal methods were deemed to be not suitable for the experimental design of the study as they often have low response rates and are not effective for studies that need to match multiple responses from the same respondent (Saunders, 2012).

A group based face to face administration, however, is generally associated with a higher response rate and is more suitable for matching responses in an experimental design (Saunders, 2012). This involves the researcher administering a survey to a group of respondents and being present during the administration. The study

adopted this method to administer the three baseline surveys and the endline survey.

The choice to use online based surveys was also made in favour of using paper based surveys. This was done in order to allow for the matching of the responses. The e-learning system used at the University of the Witwatersrand, Wits-E, was used to administer the surveys. This allowed the responses of each of the three baseline surveys and the endline survey to be matched.

Three baseline surveys were administered one week apart. These surveys were administered in week one, two and three of the BPM course respectively, which was prior to the use of IBM's Innov8 2.0. The endline survey was administered after the introduction of the digital learning game in week three. All of the baseline surveys were administered at the start of the afternoon laboratory sessions for that week. IBM's Innov8 2.0 was used in the afternoon laboratory session of the third week and the endline survey was administered after that laboratory session was completed.

At the start of each of the laboratory sessions the researcher invited the potential participants to participate in the study. An information letter was given out to all of the potential respondents, which invited them to participate in the study and contained details about the research and what participation involved. The information contained in the letter also informed potential participants that the study was voluntary, that they could withdraw at any stage, and that there would be no disadvantages to the respondents if they chose not to participate. This was done in order to ensure the ethical integrity of the study, which is discussed later in the chapter. A copy of the information letter can be seen in appendix A.

The researcher also communicated this information verbally to the respondents at the start of each laboratory session. This was done in order to ensure that there was no confusion and that potential respondents were aware that the surveys were part of the study and not part of the course. They could therefore choose to participate in the surveys or not with no detrimental effect to the course.

The final aspect of data collection, involved student learning achievement. The students in the BPM course wrote three assessments as part of the course. The first assessment was a written paper based assessment, the second was a practical test, and the third was a formal exam. These assessments were written one week after

the course, one month after the course, and two months after the course, respectively. Copies of these assessments can be found in appendix A.

The researcher had no involvement in the compilation or administration of these assessments as they were part of the course and not the research study. The scores for each of the assessments were made available to the researcher after the completion of the assessments. This was done with permission from the head of the information systems division at the time.

The students' identifying numbers were used to match responses from each of the surveys and from the assessments, and once the matching process was completed the student identifier was replaced with a random identifier. The replacement of the student identifier was an ethical consideration of the study and was done in order to maintain respondent anonymity by removing any identifiable information from the dataset. The ethical considerations are discussed in more detail later in the chapter.

4.6 Data Analysis

Quantitative data requires the use of statistical methods and techniques in order to analyse the data and draw conclusions that are able to support, or not support, the hypotheses of the study (Saunders, 2012; Bhattacherjee, 2012). There are different statistical methods that are used depending on the type of study that was conducted and the type of data that were collected (Saunders, 2012).

There are generally four types of data variables that are associated with quantitative analysis and these fall into two broad categories. The first category is called categorical variables which consist of variables that are sorted into distinct categories (Field, 2009). Categorical variables consist of both nominal and ordinal variables. Nominal variables consist of data entities that are purely categorical and have no order associated with them, i.e. Names of places, or gender. Nominal data entities cannot be considered to be better or worse than each other (Field, 2009). The second type of categorical variable is known as an ordinal variable, which has the same characteristics of nominal variables but, unlike nominal variables, the data entities incorporate a ranked order (Field, 2009). For example, the positions in a competition are rank ordered in the sense that first place is a higher rank than

second place. While ordinal variables have data entities that can be ordered, there are not equal distances between the data entities.

The second category of variables are known as continuous variables, which consist of data entities that exist on a continuum (Field, 2009). The two types of continuous variables can be either interval or ratio. Interval variables have both an order to the data entities and equal distances between the data entities (Field, 2009). For example, the distance between 10 degrees Celsius and 15 degrees is equal to the distance between 20 degrees and 25 degrees. Ratio variables have the same characteristics of interval variables but the main difference is that the data entities can be in a state of absolute zero, or a state where the data entities contain nothing of the variable (Field, 2009). For example, weight is a ratio variable as a data entity that has a weight of zero kilograms is associated with having no weight. Because ratio variables have a state of absolute zero, they are able to be represented on a scale, or a ratio.

The type of variable that is included in a study as well as the design of the study determine the type of statistical test that needs to be used during hypothesis testing. The variables associated with the hypotheses were intrinsic motivation (IM), perceived competence (PC), perceived usefulness (PU), presence (PRES), and learning achievement. These are classified as continuous variables, with the only ratio variable being learning achievement and the rest being classified as interval variables [3]. The variables and designs informed the choice of statistical tests to be run on the data and these statistical tests, as well as the process of analysis, will be discussed in the remainder of this section.

4.6.1 Analysis Process

The first step in the data analysis involved the preparation of data for further analysis. This involved checking the data for any missing values and removing observations that had more than 10% of responses missing. The second step in the data analysis involved describing the sample profile. Descriptive statistics, namely

[3] There has been some debate about whether data collected from Likert scale items are either interval variables or ordinal variables. Most research texts classify these as ordinal variables; however, they also state that they are commonly used as interval variables in social science research. (Bhattacherjee, 2012; Saunders, 2012). Further research into the topic revealed that it is acceptable to regard Likert scale variables as interval variables and that the tests associated with interval variables are appropriate to be used on them (Murray, 2013; Norman, 2010).

the mean and frequency, were calculated from the demographic data in order to describe the profile of the respondents. This profile included their gender distribution, age, previous gaming habits and the questions relating to IBM's Innov8 2.0.

The third step in the data analysis involved checking the multi-item construct variables for discriminant and convergent validity. Convergent validity is a type of validity that ensures that each item in a multi-item scale, such as the ones used for IM, PC, PU, and PRES, are measuring the construct they should be measuring according to theory (Bhattacherjee, 2012; Saunders, 2012). Discriminant validity ensures that the items are not measuring another construct as opposed to the one they should be measuring (Bhattacherjee, 2012). Both of these form of validity were examined through the use of a principal component analysis, or factor analysis, which is an appropriate technique for ensuring convergent and discriminant validity (Bhattacherjee, 2012; Saunders, 2012).

After confirming the discriminant and convergent validity and removing the items that were found to not be valid, the fourth step concerned checking the remaining items that represented each multi-item construct for inter-item reliability. Inter-item reliability confirms that the items in a multi-item construct are consistent in terms of their measurements of the construct (Bhattacherjee, 2012). Cronbach's Alpha was calculated, which is a common test used to confirm inter-item reliability, and alpha values were examined to ensure they were above the acceptable level of 0.6 (Bhattacherjee, 2012; Saunders, 2012). After confirming the reliability, the remaining items were merged into an aggregated variable using a calculation of the average score for the individual items. The aggregated variables were then used for all subsequent analysis.

The fifth step involved providing descriptive statistics on each of the aggregated variables as well as learning achievement and occupational self-efficacy. This included measures of central tendency, such as the mean, the range, and the standard deviation, as well as measures of the shape of the distribution, namely the kurtosis and skewness of each of the variables. The measures of skewness and kurtosis were used to confirm the normality of the data. The confirmation of normality and the use of continuous variables allowed the adoption of parametric tests for the hypothesis testing. Parametric tests are statistical tests that are associated with

variables that have a normal distribution and that are continuous (Bhattacherjee, 2012). Non-parametric tests are run on categorical variables, or variables that are not normally distributed (Bhattacherjee, 2012; Saunders, 2012).

The sixth step involved the hypothesis testing on the experimental hypotheses, namely H1, H3, and H6. The experimental part of the study was concerned with whether there was a difference in the variables of IM, PC, and PU between the baseline measurements and the endline measurements. The tests selected to confirm whether there is a difference between baseline measurements and endline measurements were paired sample t-tests (Field, 2009).

Paired sample t-tests were conducted on IM, PC, and PU, and examined if there was any significant difference between baseline measurements one, two or three, and the endline measurement in order to test H1, H3, and H6.

The final part of the hypothesis testing, and the final step in the data analysis, involved testing H4, H7, and H9, in order to establish if the dependent variable of IM is related to the independent variables of PC, PU and PRES. It also involved testing H2, H5, H8, H10, in order to find out if the dependent variable of learning achievement is related to the independent variables of IM, PC, PU, and PRES. These tests involve the use of correlational analysis, which examine the relationship between two variables, namely an independent and a dependent variable, (Field, 2009), and multiple regression analysis, which examines the relationship between multiple independent variables and their effect on a dependent variable (Field, 2009).

Correlation analyses were run between IM, PU, PC, PRES and was run between IM, PU, PC, PRES and learning achievement in order to identify any potential relationships between the variables. A multiple regression techniques known as partial least squares (PLS) regression was then run on the entire model in order to confirm any of the relationships found in the correlational analysis.

PLS regression is a regression technique that combines features from both factor analysis and multiple regression (Abdi, 2003; Tobias, 1995). It is a technique that is considered to be stronger in predictions than standard multiple regression (Abdi, 2003; Tobias, 1995). It is more appropriate in the current study than multiple regression as it is capable of handling a smaller sample size far more effectively than standard multiple regression (Abdi, 2003).

The results from the PLS test[4] and correlation analysis were able to test H4, H7, and H9, or whether IM is dependent on PC, PU, and PRES. They also tested H2, H5, H8, and H10 or whether learning achievement is dependent on IM, PC, PRES, PU. Each assessment score, as well as a total score for assessment, was run through the PLS model, which results in a total of four PLS models being included.

Having established how the data in the study were analysed, the next section deals with the ethical considerations associated with the study.

4.7 Ethical Considerations

Ethical considerations are important to academic research that involve the use of primary data collection from human subjects, such as the current study. It is imperative that research is conducted in way that does not cause any harm to the participants in a study (Bhattacherjee, 2012; Saunders, 2012). The reason ethics is so important to scientific research is there have been incidents in the past where scientific research caused harm to participants and in order to ensure that this does not occur again the ethical integrity of academic research must be upheld (Bhattacherjee, 2012).

The current study is concerned with two ethical considerations that are common in research involving human subjects. The first consideration concerns the fact that the participants of the study must be able to make an informed choice whether they wish to participate or not (Bhattacherjee, 2012; Saunders, 2012). They must be given some information on the study prior to the data being collected that allows them to provide informed consent to participate (Bhattacherjee, 2012; Saunders, 2012). It is important that all research is conducted in a way where the participants have voluntarily chosen to participate and understand what that participation would entail (Bhattacherjee, 2012; Saunders, 2012). Participants need to also be aware that there would be no potential advantage, or disadvantage from choosing whether or not to participate (Bhattacherjee, 2012).

[4] Two types of statistical software were used, one for PLS and the other for all the other statistical analyses. The software used to run PLS regression was called SmartPLS 3 (Ringle, Wende and Becker, 2014). All other statistical analyses were performed in IBM's SPSS v23. (http://www-01.ibm.com/software/analytics/spss/products/statistics/)

As mentioned in section 4.5, the study invited potential participants to the study by providing information about the study through both a written letter and a verbal explanation. This happened before the start of each baseline survey, in case of a situation occurring where some potential participants were absent during any of the sessions. The potential participants were also told what participation in the study would entail, were informed that they could withdraw at any stage of the study, and that choosing to participate, or not, would have no benefits or disadvantages within the course.

A copy of the information letter given to participants can be found in appendix A. A consent notice was included in the survey at both the start and end, which explained again that the study was voluntary. It also stated that by submitting the online survey they were providing consent to participate and had understood the information provided verbally and through the letter.

The second ethical consideration concerns the anonymity and confidentiality of the data. Anonymity ensures that there will be no identifiable information about the participants in any of the output from the research study. Confidentiality means that if there is identifiable information, then it is only the researcher that would be able to see it and it would not appear in any output of the research study (Bhattacherjee, 2012; Saunders, 2012).

As mentioned in section 4.5, the student identifiers were used to match each of the baseline responses and the endline responses, as well as the scores obtained in each of the assessments. Once the matching was completed the identifier was replaced with a random identifier in order to maintain the participants' anonymity. While the student identifier was in the dataset, the confidentiality of the participants was maintained and only the researcher and the researcher's supervisor had access to the data. This information was also communicated to the potential participants in the information provided before the start of each baseline survey.

Permission to conduct the study was obtained from both the registrar of the university and the head of the Information Systems department. The permission from the registrar's office can be seen in a letter provided in appendix A. The permission from the head of the Information systems division was provided verbally.

The research study was also submitted to and approved by the Human Research Ethics Committee of the University of the Witwatersrand. Therefore, ethical clearance was granted for the study by the Research Office of the University of the Witwatersrand with the protocol number: H150226. The certificate can be found in appendix A.

Having established the ethical considerations of the study, the next section deals with the limitations and threats to validity associated with the study.

4.8 LIMITATIONS OF THE STUDY AND THREATS TO INTERNAL AND EXTERNAL VALIDITY

Internal validity is regarded as a studies ability to make casual inferences about the findings of the results, or to claim that a change in the independent variable leads to a change in the dependent variable (Bhattacherjee, 2012; Saunders, 2012). A limitation of the study is that there was a lack of a control group which poses a threat to the internal validity of the study.

Thus, due to the limitation, the study draws on an extra layer of longitudinal measurements in order to attempt to mitigate some of the threat posed to the internal validity of the study, e.g. between motivation and achievement. Moreover, the longitudinal design helps to establish the temporal precedence needed by the study in order to strengthen the internal validity. This was achieved by multiple measurements of baseline levels of the variables, which then function as a more accurate control between baseline and endline measurements. This mitigates some of the threat posed to internal validity by the lack of the control group, however having no control group still ultimately lowers the internal validity of the study, and thus lowers limits the casual inferences the study is able to make. Theoretical arguments presented in chapter 3 provided the main basis for the casual inferences made.

External validity can be thought of as a study's ability to generalise the results to other similar contexts (Bhattacherjee, 2012; Saunders, 2012). It was strengthened by the study being conducted in a real world setting but weakened by the specific context in which it had been implemented. Therefore, the results are not necessarily generalisable beyond this course.

Some of the other threats and biases that could potentially limit the study include: Maturation threat is when the participants mature over time and any changes are caused due the maturation of the participants over the time period and not due the introduction of the digital learning game (Bhattacherjee, 2012). The study included the control variable of occupational self-efficacy in order to try and potentially detect any maturation effects.

Testing threat could also impact the study and is where participants answer with the same responses on the end-line survey as they did on the base-line surveys (Bhattacherjee, 2012; Saunders, 2012). Thus, the study used the multiple measurements of baseline surveys split over weekly periods in order to try and create a more accurate picture of the variables under study before the introduction of the digital learning game.

Instrumentation threat could also be found in the study. This is when the results in participants' performance are due to the degree of difficulty in that specific instrument as opposed to the introduction of the digital learning game (Bhattacherjee, 2012). This could relate to the scores that participants obtain in the assessments in the course. Thus, the study is using data from three different assessments that are a combination of written and practical based in order to try and avoid this type of threat.

Regression threat is also a concern where the participants might give answers that are closer to the mean in the end-line survey as opposed to answers going in the anticipated direction. This is due to statistical aberration where participants give a higher score on the base-line survey than on the end-line survey, which results in inaccurate results (Bhattacherjee, 2012; Saunders, 2012). Thus, the study is using multiple measurements of baseline data to try and potentially mitigate this effect.

Another typical threat includes common methods bias, which is when the variability in the results is due to the methods used to measure the results (Bhattacherjee, 2012). Thus, the study used achievement data that was objective and independently obtained thus eliminating concerns about the data collection being responsible for shared variance between the dependent and independent variables.

Common self-administered survey limitations, for example, response pattern bias is when the participant might give the answer that they think the researcher would like as opposed to them giving an honest answer. There is also social desirability bias, where participants might give an answer that they think is socially desirable as opposed to giving an honest answer.

These are biases that all self-administered survey based research suffer from and are generally exhibited when the participants do not answer the surveys honestly (Bhattacherjee, 2012; Saunders, 2012). In the current study the participants might have thought that either the researcher expects a game to increase motivation, or perceived competence, or it is social desirable for a game to increase motivation or perceived competence, and answer accordingly. There is not much that can be done in order to detect or avoid this type of bias.

There is also the possibility for a self-selection bias, where participants with a high intrinsic motivation are more likely to consent to participate in the research study.

4.9 Conclusion

The positivist paradigm informed the study's research methods. The design that was deemed appropriate to address the research questions was a single group natural experimental pre/post design, with an additional layer of a longitudinal relational design. The research instrument, namely the three baseline surveys and the endline survey, were complied with multi-item operationalised constructs, which were used for intrinsic motivation, perceived competence, perceived usefulness and presence. Demographic items and control items were also included in each of the surveys. The administration of the research instrument, as well as the strategy for data analysis was discussed. The ethical considerations and limitations that impact both the external and internal validity of the study were also discussed.

Having established the methodology of the study, the next chapter covers the results that were found after implementing the strategy outlined in this chapter.

5 CHAPTER 5: RESULTS

This chapter presents the results of the analysis of the data. This chapter is structured into five sections. The first section is concerned with preparing the data for subsequent analysis. This largely involves methods used to clean the data and ensure there are no missing responses. The second section presents the sample profile, providing a description of the sample of the study. The third section is concerned with performing reliability and validity tests in order to create aggregated variables from the multi-item scales. The fourth section covers the demographic information regarding the aggregated variables. The final section presents the results from the hypothesis tests, specifically the results from the t-tests regarding the differences between baseline and end line data and the results of the regression tests which included both correlation tests and PLS regression tests.

5.1 CLEANING DATA

In order to prepare the data for subsequent analysis, it was necessary to check for any missing vales, which may have needed to be removed.

5.1.1 Missing Values

The first step that was followed was the removal of those participants that did not respond to any of the four surveys administered in the study. The population consisted of 35 students. Five of these students chose not to participate in any of the four surveys which were administered in the study. This left a total of 30 participants. The response rate for each of the surveys can be seen in Table 5.1 below.

Table 5.1: Response Rates

Survey	Reponses (n)	Reponses Rate (% out of 30)
Baseline 1	23	77
Baseline 2	16	53
Baseline 3	12	39
Endline	24	80

One individual chose not to complete some demographic items. However, there were no missing values for items on perceived competence, intrinsic motivation,

perceived usefulness, intuitive controls and presence in any of the completed surveys. Therefore, no further cases or items needed to be dropped.

5.2 Sample Profile

This section provides an overview of the profile of the participants. The sample was made up in total of 30 respondents. The gender distribution of the sample was made up of 66.7% of males, or 20 males, and 26.7% females, or eight females, and there were two respondents who preferred to not disclose their gender.

The age of the majority of the respondents was found to be in the range of 20 to 23. Roughly 90% of the respondents fell into this range. There was one respondent who was in the range of 24 to 25 and one other respondent was over the age of 25. There was also one respondent who preferred to not disclose their age. The age distribution of the respondents was appropriate given the year of study, i.e. third year undergraduate course. The age and gender distributions are provided in table 5.2.

Table 5.2: Age and Gender Distribution

Gender	Frequency	Percent (%)
Male	20	66.7
Female	8	26.7
Prefer Not to Say	2	6.6
Total	30	100.0

Age	Frequency	Percent (%)
20 to 21	13	43.3
22 to 23	14	46.7
24 to 25	1	3.3
>25	1	3.3
Prefer Not to Say	1	3.3
Total	30	100.0

The respondents were also asked to report the number of hours they spent on different gaming platforms per week (i.e. PC, mobile, console). The gaming profile of the respondents is represented by the graph in figure 5.1. One respondent chose not to answer any of the gaming habit questions. Therefore, the graph is made up of a total of 29 responses.

Figure 5.1: Hours Spent Gaming Per Week by Platform

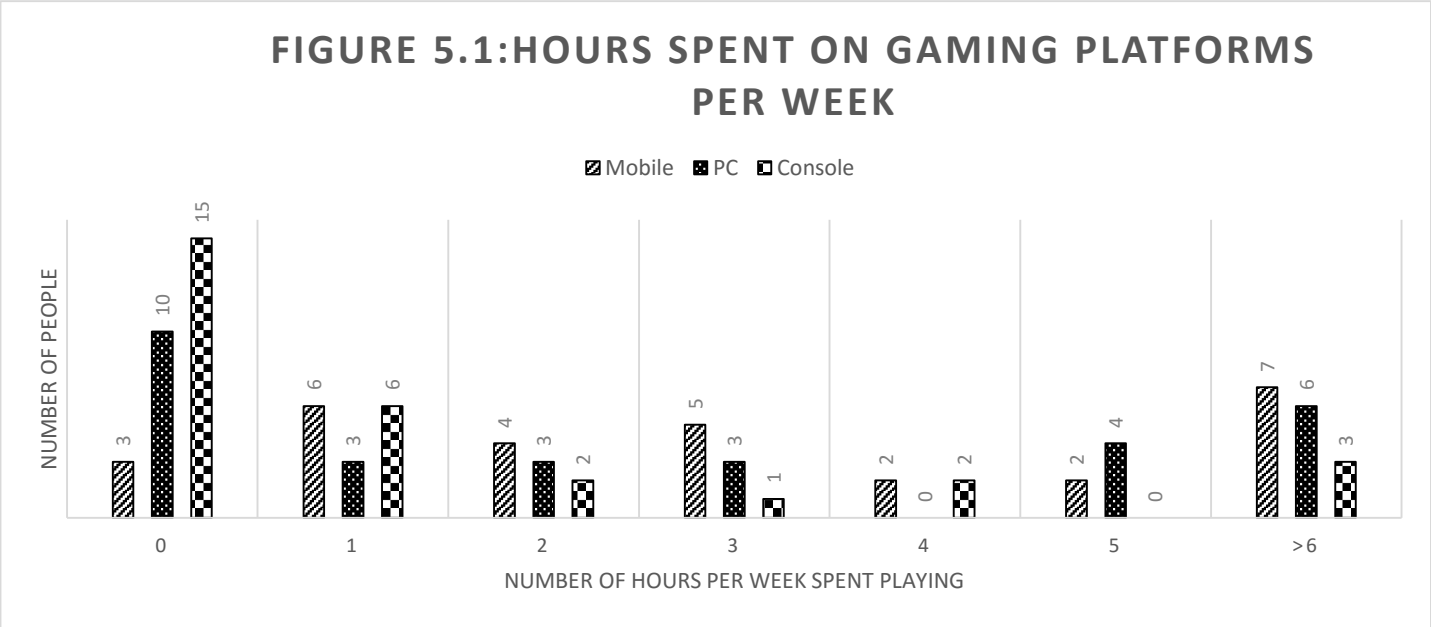


Figure 5.1 indicates that the majority of the respondents interact with mobile games for at least an hour a week as only three respondents, or ten percent, reported that they interact with mobile games for zero hours per week. Roughly 33% of the respondents spend no time on PC games and roughly half of the respondents spend no time on consoles. However, in order to ensure that all participants had some prior gaming experience the total number of hours spent on each platform have been added together and are displayed in figure 5.2.

Figure 5.2: Total Hours Spent Gaming Per Week

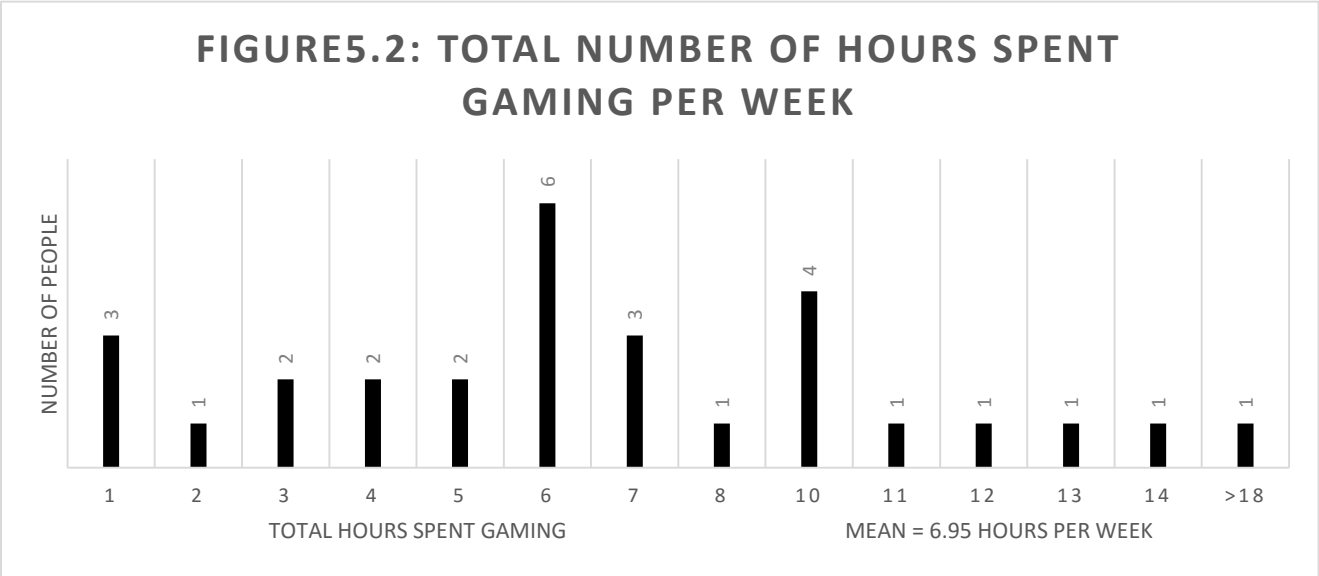


Figure 5.2 indicates that all of the respondents spend at least one hour a week engaging in gaming on one of the three platforms. It also indicates that some

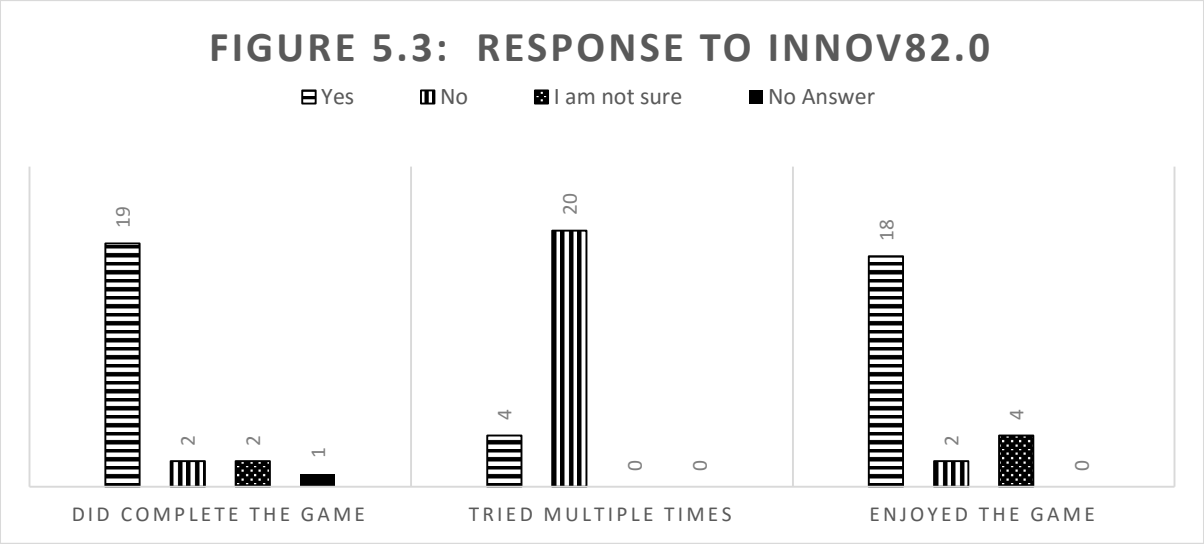
respondents tend to engage with games across multiple platforms every week. The average amount of time spent gaming per week across all of the respondents is 6.95 hours.

Console gaming is the least played platform with more people playing mobile games than consoles. However, the majority of hours spent gaming per week are on PC games. It is also important to note that every participant in the sample has some prior experience with playing digital games.

The respondents also indicated how they found the experience of playing “Innov8 2.0” and the results are summarised in Figure 5.3. The majority of the respondents completed the game (19) with only two respondents indicating that they did not complete the game and two were uncertain if they had. The majority of the respondents (20) only played the game once, with only four respondents indicating that they attempted the game multiple times.

Despite respondents indicating that they only played through the game once the majority of respondents found the game to be enjoyable (18). Only two of the respondents did not enjoy the game and four indicated that they were not sure if they had enjoyed it.

Figure 5.3: Responses to Innov8 2.0



Overall though it seemed that the response to “Innov8 2.0” was quite positive as most respondents were able to complete the game and many of them enjoyed it. There were even four respondents who chose to play the game again.

The scores that the respondents achieved in the game have been included in appendix B. The average score that the students obtained in the game was 11229 points with a standard deviation of 1055 points. The researcher and instructor of the course both played the game and obtained scores that were upwards of 20000 points, which indicates that the students' scores were quite low.

Having described the sample profile of the study's participants the next section describes tests of validity and reliability carried out on the study's variables of perceived competence, intrinsic motivation, perceived usefulness, intuitive controls and presence.

5.3 Aggregation of Multi-Item Variables

In order to conduct further analysis each multi-item variable had to be examined for unidimensionality, convergent and discriminate validity before a composite score for the variables could be calculated. For this purpose, factor analysis was conducted on each of the baseline surveys and the end line survey. This involved the running of principal component analysis (PCA). In order to check for the adequacy of running PCA sampling adequacy tests, namely the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's Test of Sphericity, were run. The results of the sampling adequacy tests for the baseline one, the endline survey and presence indicate that PCA is appropriate. Although small sample sizes existed for baseline 2 and baseline 3, stable PCA solutions were nonetheless obtained. The results of the sampling adequacy tests can be found in appendix B.

Reliability of the scales were also checked through Cronbach's Alpha. The detailed results of the PCA and the values for Cronbach's Alpha can be found in Table 5.3. The greyed out section of the table depicts that those items were not part of that particular survey and are not applicable.

Table 5.3: Results of Principal Component Analysis

Principal Component Analysis & Reliability												
	Baseline 1		Baseline 2			Baseline 3			Endline			
	PC	IM	PC	IM	PU	PC	IM	PU	PC	IM	PU	IC
PC1	.790	.403	.510	.604		.948			.897			
PC2	.849		.879			.825			.841			
PC3	.826		.906			.895			.723			
PC4	.843		.855			.882			.862			
PC5	.874		.920			.937			.903			
PC6	.892		.930			.918			.899			
IM1		.839		.879			.858			.953		
IM2		.897		.849			.930			.918		
IM3		.863		.779			.958			.830		
IM4		.749		.567			.796			.780		
IM5		.706		.520			.707			.776		
PU1					.899			.915			.831	
PU2					.865			.931			.897	
PU3					.928			.553			.834	
PU4					.900			.948			.931	
PU5					.875			.865			.911	
PU6					.916			.880			.947	
IC1												.899
IC2												.867
IC3												.898
Alpha*	.925	.868	.930	.768	.950	.948	.906	.923	.948	.913	.968	.932

Extraction Method: Principal Component Analysis. (values less than .4 were suppressed)

Rotation Method: Varimax with Kaiser Normalization.

* Cronbachs Alpha

The above PCA and reliability assessments confirm that no items were needed to be dropped from the calculation of aggregated variables for perceived competence (PC), intrinsic motivation (IM), perceived usefulness, and intuitive control (IC). While there was some cross loading of PC1 on both perceived competence and intrinsic motivation in baseline surveys one, the difference is greater than 0.3 therefore the cross loading is not of concern. There is a clear primary loading.

In baseline survey two there was similar loading of PC1 on perceived competence and Intrinsic Motivation. However, the item was retained in order to ensure consistency across the calculation of the composite variables so as not to add a potential confounding factor into subsequent analysis.

Secondly all of the Cronbach's alphas are above 0.7, which indicates that the multi-item scales were reliable. The composite variables were then calculated as the average of scale items weighted equally. These will be used for subsequent analysis from this point onwards, unless otherwise stated.

Finally, all of the items for the variable 'presence', collected in the endline survey, were analysed separately as these were cross loading with several of the other endline factors. The dimensions of presence are not orthogonal to each other but related elements of presence. Therefore, it was considered necessary to examine the presence items using a PCA with oblique rotation (promax). The PCA for the presence items are provided in Table 5.4. Sampling adequacy tests were conducted for the PCA which indicate that it was appropriate to conduct the test. The results can be found in appendix B.

Table 5.4: Results of PCA for Presence

Principal Component Analysis & Reliability for Presence			
	Component		
	Physical	Emotional	Narrative
PRES1	.895		
PRES2	.995		
PRES3	.915		
PRES7	.876		
PRES4	-.415	.874	
PRES5		.452	-.627
PRES6		.709	
PRES9		.521	
PRES8			.811
Alpha*	.934	.733	n/a

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 6 iterations

b. Kappa = 3

*Cronbach's Alpha

The presence scale consists of three dimensions. These dimensions are the physical presence the emotional presence and the narrative presence. These dimensions are all related to each other and hence the PCA was conducted with an oblique rotation.

The PCA of presence resulted in an unexpected outcome. The PCA found that the items measuring physical presence (PRES1, PRES2, and PRES3) and emotional presence (PRES4, PRES5, and PRES6) both loaded correctly. However, the items that were supposed to be associated with narrative presence (PRES7, and PRES9) failed to load on the narrative dimension. Item PRES8 was the only item to load on the narrative dimension. PRES7 was found to be more associated with the physical dimension, and PRES9 was found to be more associated with the emotional dimension.

An examination of PRES7 ("*When playing IBM's Innov8 2.0 I feel as if I was part of the story*") and the other physical presence items indicates that there are similarities and that respondents could have potentially been thinking about a physical presence as opposed to a narrative one. The same is true when looking at the emotional presence items and PRES9 ("*I had reactions to events and characters in IBM's Innov8 2.0 as if they were real*"). Therefore, the decision has been taken to include PRES7 within the calculation of the physical presence composite variable and PRES9 is to be included in the calculation of the emotional presence composite variable. PRES8 ("*When I accomplished something in IBM's Innov8 2.0 I experienced genuine pride*") will represent the narrative dimension on its own. These composite scores will be used in subsequent analyses but individual items are described in the next section.

The reliability of the narrative dimension of presence is unable to be calculated due to having only one item. The reliability of the other two dimensions has been calculated using Cronbach's alpha. Both of the scores are above the threshold of 0.7 and can also be seen in Table 5.4.

5.4 Descriptive Statistics

The following section provides the descriptive statistics for the study.

5.4.1 Intrinsic Motivation

Table 5.5 presents measures of central tendency and normality for the composite intrinsic motivation scale at each of the four time periods labelled B1, B2, B3 and E.

Table 5.5: Measures of Central Tendency and Normality for the Intrinsic Motivation Scale

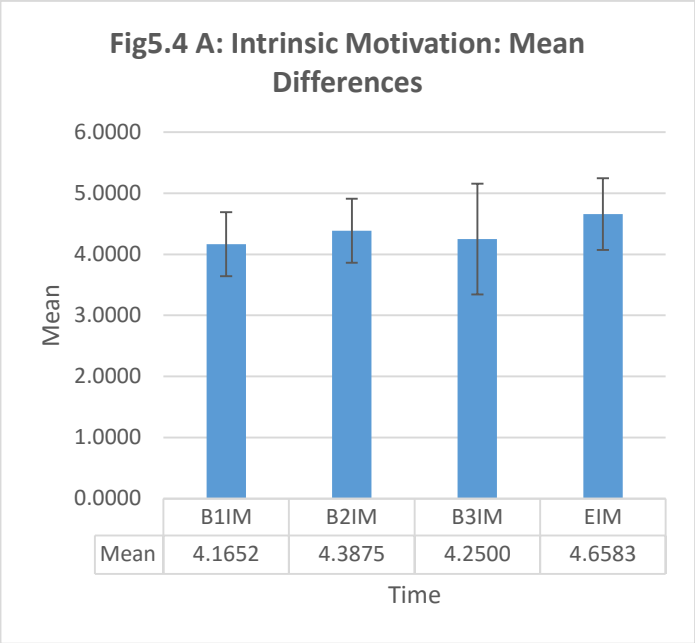
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Baseline 1 (B1)	23	5.20	1.60	6.80	4.1652	1.21304	-.291	.481	.485	.935
Baseline 2 (B2)	16	4.20	1.20	5.40	4.3875	.98107	-2.451	.564	7.711	1.091
Baseline 3 (B3)	12	4.40	1.80	6.20	4.2500	1.42733	-.552	.637	-.904	1.232
Endline (E)	24	4.60	2.40	7.00	4.6583	1.38875	.206	.472	-.640	.918

The range for IM in baseline one was the largest as the range was less than 5.2 in all of the other surveys. The endline survey had the highest minimum intrinsic motivation value (2.4) and the highest maximum value (7) when compared to any of the other surveys.

The skewness and kurtosis values for baseline one and baseline three as well as the endline data are between +/-1 and +/- 3 respectively, which indicates that they are relatively normal. Baseline two is negatively skewed (-2.451) and has a positive kurtosis (7.711). This indicates that baseline two does deviate from a normal distribution as there is little variance and the responses are clustered close to the mean.

The differences between the means and the change in mean values over time are displayed in figure 5.4 below.

Figure 5.4: Mean Differences and Changes in Mean for the Intrinsic Motivation Scale



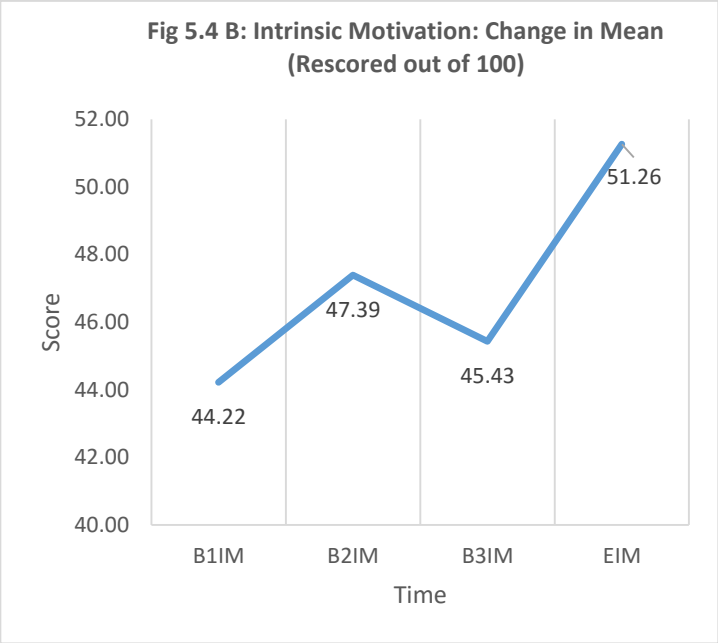


Figure 5.4A displays the means for IM for each of the surveys as well as the confidence intervals for those means. The graph shows that the confidence intervals overlap for each of the means but there is a change of the mean between the time periods. Even if not a significant, to better observe the change in the mean IM scores over the time periods, the means were converted to a score out of 100 using a scale conversion formula which can be found in appendix B. These are displayed in figure 5.4B.

It is now easier to see that IM initially went up between weeks one (44.22) and two (47.39) and then decreased in the third week (45.43) before going up at the end. The endline mean is the highest at (51.26) after the introduction of the game. This suggests a small but visible effect of the game on IM.

5.4.2 Perceived Competence

Table 5.6 displays the measures of central tendency and normality for the “Perceived Competence” scale at four time periods.

Table 5.6: Measures of Central Tendency and Normality for the Perceived Competence Scale

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Baseline 1 (B1)	23	3.83	2.00	5.83	4.1159	.84452	-.108	.481	.952	.935
Baseline 2 (B2)	16	3.00	3.00	6.00	4.3646	1.05272	.280	.564	-1.394	1.091
Baseline 3 (B3)	12	3.67	2.50	6.17	4.6111	.99832	-.673	.637	.482	1.232
Endline (E)	24	3.67	2.00	5.67	4.0139	1.16087	-.169	.472	-1.417	.918

The range of perceived competence in baseline one was the highest out of the measures. The range was equal for the baseline three and endline scores but there was a 0.5 reduction in both the minimum and maximum values of perceived competence in the endline score. The endline maximum value (5.67) was the lowest of all the scores of perceived competence.

The skewness and kurtosis values for all of the surveys are between +/-1 and +/- 3 respectively, which indicates that they are relatively normal.

The differences between the means and the change in mean values over time are displayed in figure 5.5 below.

Figure 5.5: Mean Differences and Changes in Mean for the Perceived Competence Scale

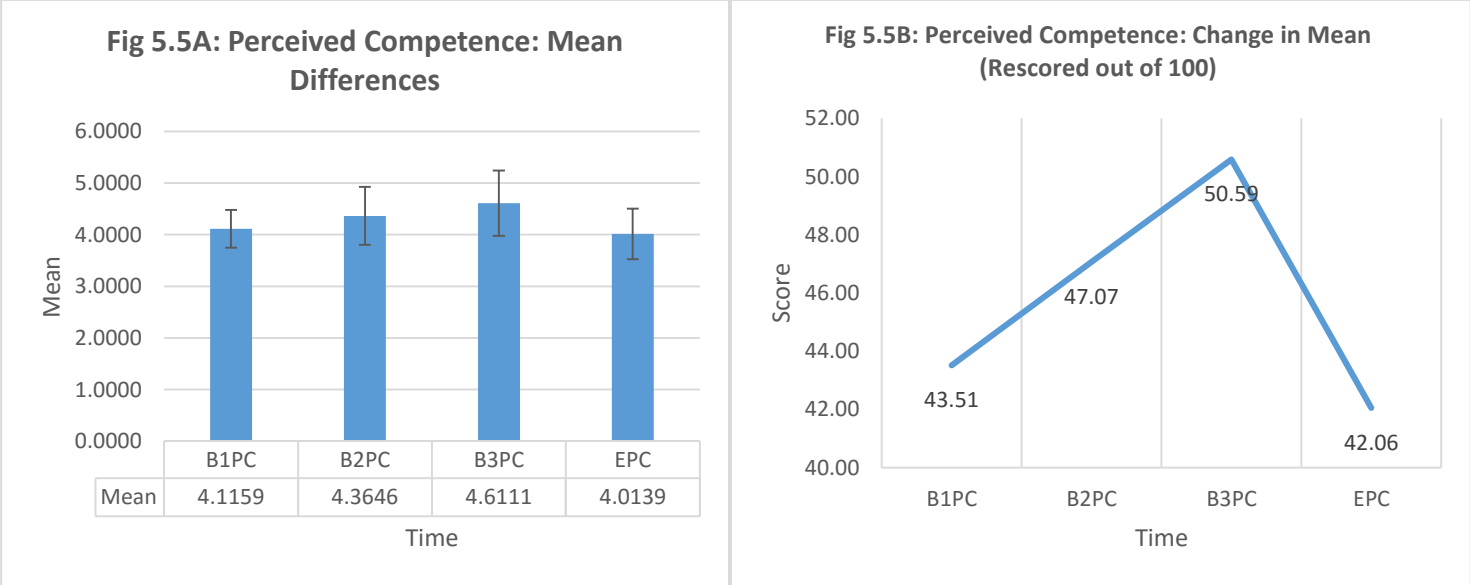


Figure 5.5A displays the mean values and confidence intervals for the four-time period that perceived competence was measured at. The scores were then converted to a value out of 100 using a score conversion formula, which can be found in appendix B. These are displayed in figure 5.5B.

Prior to the introduction of the game based learning tool, or intervention, perceived competence was increasing at roughly three units per week. After the introduction of the intervention, the level of perceived competence went down to its lowest level (42.06). This could relate to the participants moving from a state of unconscious incompetence to conscious incompetence from being challenged in the game. Despite this, as shown in figure 5.4B, IM increased. Thus, the game appears from the descriptive statistics to have differential effects on IM and PC.

5.4.3 Perceived Usefulness

Table 5.7 displays the measures of central tendency and normality for the Perceived Usefulness of game based learning scale at three time periods. These data were collected only at baseline two (B2), baseline three (B3) prior to the endline (E). At B2 and B3 the participants had not been exposed to the game but were indicating perceptions about DGBL. At E, they had already played the game.

Table 5.7: Measures of Central Tendency and Normality for the Perceived Usefulness Scale

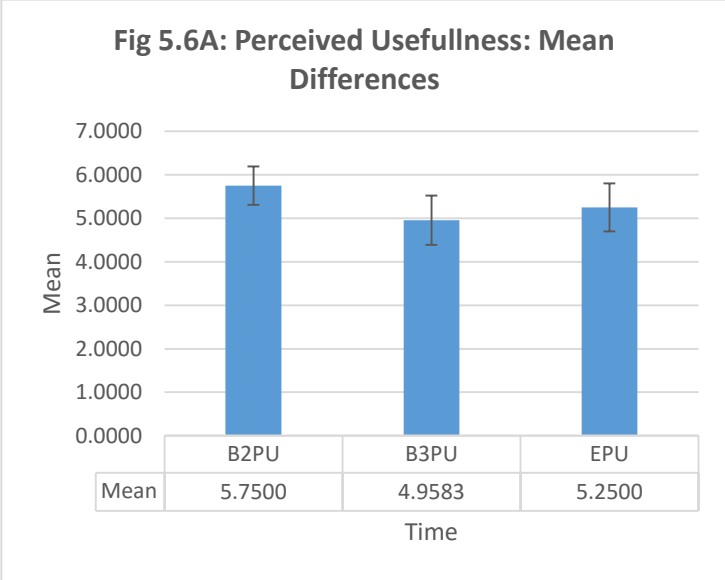
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Baseline 2 (B2)	16	2.50	4.50	7.00	5.7500	.82327	.017	.564	-1.292	1.091
Baseline 3 (B3)	12	2.67	3.50	6.17	4.9583	.87075	-.284	.637	-.862	1.232
Endline (E)	24	6.00	1.00	7.00	5.2500	1.30588	-1.842	.472	4.439	.918

The range of the endline data is the largest (6) and is almost double the range of the Baseline 2 (2.5) and Baseline 3 (2.67) data. The minimum value for the endline data is much lower than the other minimum values while the maximum is quite similar.

The skewness and kurtosis values for baseline two and three are between +/-1 and +/- 3 respectively, which indicates that they are relatively normal. Endline data is negatively skewed (-1.842) and has a positive kurtosis (4.439). This indicates that baseline two does deviate from a normal distribution as responses clustered around the mean.

The differences between the means and the change in mean values over time are displayed in figure 5.6 below.

Figure 5.6: Mean Differences and Changes in Mean for the Perceived Usefulness Scale



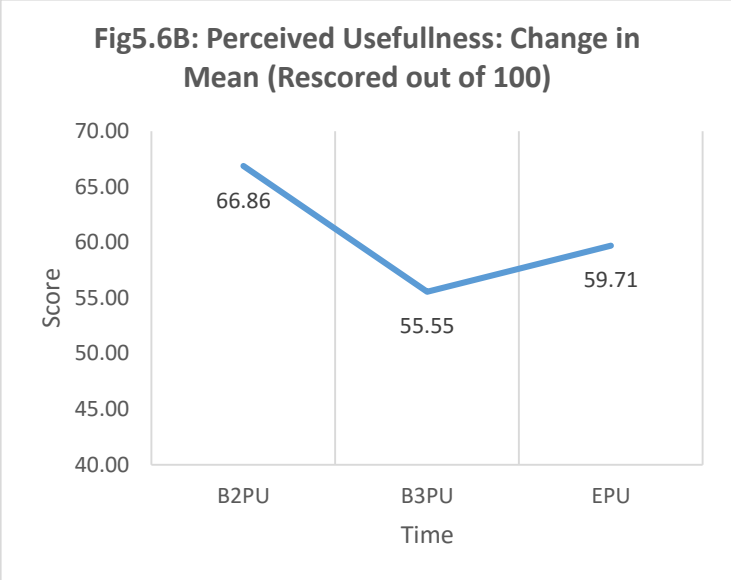


Figure 5.6A displays the mean values and confidence intervals for the three time periods that perceived usefulness was measured at. The scores were then converted to a value out of 100 using a standard rescore formula, which can be found in appendix B. These scores are displayed in figure 5.6B.

Perceived usefulness decreased by roughly nine units between baseline two and baseline three. It then increased by roughly 4.2 units after the introduction of the game based learning intervention, but it did not increase to its original level. This suggests some unmet expectations around the usefulness of a game to their learning between B2 and E. Later tests will examine the relationship between PU of the game and endline IM.

5.4.4 Intuitive Controls and Presence

An item-by-item analysis of the Presence scale is provided first, which examines the measures of central tendency for each item. Then the measures of central tendency and normality for the intuitive controls variable and the Presence composite variables are displayed. These variables were measured only after the intervention in the endline survey. The item analysis of the Presence scale is presented in table 5.8 below.

Table 5.8: Item-by-Item Analysis of Presence

	PRES	Range	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
When playing IBM's Innov8 2.0, I feel transported to another time and place	1	6	4.42	1.558	2.428	-.772	.472	.318	.918
Exploring IBM's Innov8 2.0 world feels like taking an actual trip to a new place	2	6	4.50	1.504	2.261	-.712	.472	-.027	.918
When moving through IBM's Innov8 2.0 world I feel as if I am actually there	3	5	4.38	1.439	2.071	.034	.472	-1.129	.918
I am not impacted emotionally by events in IBM's Innov8 2.0 (R)	4	6	3.83	1.834	3.362	.268	.472	-.836	.918
IBM's Innov8 2.0 was emotionally engaging	5	6	4.29	1.706	2.911	.017	.472	-.740	.918
I experience feelings as deeply in IBM's Innov8 2.0 as I have in real life	6	6	3.67	1.761	3.101	.193	.472	-.924	.918
When playing IBM's Innov8 2.0 I feel as if I was part of the story	7	6	5.00	1.445	2.087	-1.322	.472	1.543	.918
When I accomplished something in IBM's Innov8 2.0 I experienced genuine pride	8	5	4.96	1.268	1.607	-.614	.472	.156	.918
I had reactions to events and characters in IBM's Innov8 2.0 as if they were real	9	6	4.04	1.899	3.607	-.023	.472	-.941	.918

The item-by-item analysis reveals that most of the items are normally distributed. All of the kurtosis values fall within the range of +/- 3 and, with the exception of PRES7, all of the skewness values fall within the range +/- 1.

An examination of the items reveals that on average the game was able to engage the participants on the physical dimension. Participants indicated that they felt as if they had been transported to a new place while playing the game (PRES1, PRES2) and that they were able to move around freely in this new place (PRES3).

The participants' emotional engagement while playing the game was less on average than the physical engagement. Participants felt lower levels of emotional engagement in the game (PRES4 and PRES5) and they did not experience the same feelings that they would have in real life (PRES6). The participants appeared to have been engaged by the story of the game (PRES7, PRES8 and PRES9) but

due to the results of the earlier principal component analysis not all of these items were perceived to be associated with the narrative element of the game.

The principal component analysis resulted in the narrative presence subscale to only have one item (PRES8), while both the physical sub scale (PRES1,2,3,7) and emotional subscale (PRES4,5,6,9) are composite scores of four items. A potential reason for this to occur has to do with the wording of both of those items.

The wording PRES7 (*When playing IBM's Innov8 2.0 I feel as if I was part of the story*) could have caused the item to be potentially perceived by the participants as them being "physically" present in the story. The physical aspect here could have been perceived in the same way the other physical presence items were (PRES1, PRES2, PRES3).

The wording of PRES9 (*I had reactions to events and characters in IBM's Innov8 2.0 as if they were real)* could have been perceived by the participants to be associated with the "emotional" engagement in the game. The item is very similar to PRES6 ("*I experience feelings as deeply in IBM's Innov8 2.0 as I have in real life")* which is associated with the emotional dimension of presence.

PRES8 ("*When I accomplished something in IBM's Innov8 2.0 I experienced genuine pride")* is the only item that was perceived by the participants as being associated with the narrative dimension of presence. Therefore, as per the earlier PCA findings, PRES1, PRES2, PRES3, PRES7 make up the composite variable of physical presence. PRES4, PRES5, PRES6 and PRES9 make up the emotional presence composite variable and PRES8 will represent the narrative presence variable. These composite scores are presented below in Table 5.9.

Table 5.9: Measures of Central Tendency and Normality for Intuitive Controls and Presence Scales

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Intuitive Controls	24	5.33	1.67	7.00	5.5139	1.49711	-1.276	.472	1.036	.918
Physical Presence	24	5.50	1.50	7.00	4.5729	1.35831	-.655	.472	.056	.918
Emotional Presence	24	5.50	1.50	7.00	3.9583	1.34259	.330	.472	.043	.918
Narrative Presence	24	5	2	7	4.96	1.268	-.614	.472	.156	.918

The intuitive control score, a measure of how easy it is to control the game, had a relatively high mean value (5.5139) which indicates that there were quite high responses. The intuitive control score is also negatively skewed (-1.276) which also indicates that there were relatively high responses. Although, there were some respondents that did not find IBM's Innov8's controls to be intuitive, which is evident by the range (5.33) and the minimum (1.67).

All of the presence subscales have skewness and kurtosis values that fall within the acceptable range of +/- 1 and +/- 3 respectively. The narrative presence subscale has the highest mean value (4.96). The lowest mean value is associated with the emotional presence subscale (3.9583) and the physical presence subscale (4.5729) falls in-between the two.

On average, the game was intuitive to the participants and this may relate to their prior experience with digital games. The intuitive control system of the game could also contribute to the game's ability to engage a sense of physical presence. While the participants on average did feel like a part of the narrative of the game, the games narrative was less effective in creating an emotional presence felt while playing the game.

The emotional component is quite low, and implications for IM will be examined later in the PLS test. Intuitive controls are higher and implications for IM and possibly PU will be explained later.

5.4.5 Achievement

The achievement scores were obtained from a test (score 1), a practical exam (score 2) and a written exam (score 3). Each of these occurred after the endline survey was administered. Test one occurred one week after the endline survey, the practical test occurred one month after the endline survey and the written exam occurred two months after the endline survey. These three assessments made up the total achievement score for the course.

The weight of the BPM component in the course was 12.5%. Each score made up a different amount of this 12.5 % and these weightings were used to calculate a total achievement score. Score 1 counted for 2.5% of the course, Score 2 counted for 4% of the course and Score 3 counted for 6% of the course. Therefore, the calculation of the total achievement variable was made up by weighting Score 1 at 20%, Score 2 at 32% and Score 3 at 48%.

While the entire population (n = 30) participated in both score one and three, two members of the population were absent for score two (n=28). Therefore, these participants were given the average of the class for score 2 (77.7679).

The measures of central tendency and normality for each score and the total achievement variable are provided in table 5.10 below. A correlation matrix is then displayed for each of the variables in table 5.11.

Table 5.10: Descriptive Statistics for Achievement

	N	Percentage of Total Contribution	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic (%)	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Score 1 (Test)	30	20	22.50	85.00	53.8333	17.10431	.159	.427	-.722	.833
Score 2 (Prac Exam)	30	32	28.75	93.75	77.7679	16.31571	-1.663	.427	2.892	.833
Score 3 (written Exam)	30	48	47.50	82.50	65.0667	9.20619	.078	.427	-.611	.833
Total Achievement	28	100	45.66	78.62	66.8844	7.74330	-.813	.427	.673	.833

Score 2 had the highest mean value (77.77) and the highest range (65) out of all of the scores. Score 1 had the lowest mean value (53.83). The marks for the three individual scores have a more dispersed distribution than the total achievement

score, which is evident by the total achievement score having a lower standard deviation (7.87) than the other scores.

The skewness and kurtosis values of score 1 and score 3 indicate that they do not deviate from a normal distribution. Their values of skewness and kurtosis are in an acceptable range of +/- 1 and +/- 3 respectively. Score 3 is also negatively skewed (-1.663) and has a positive kurtosis (2.892), which indicates it is partially skewed and that it might deviate from a normal distribution.

Table 5.11 below provides Spearman's correlation coefficients for Score 1, score 2, score 3 and the total achievement score. Spearman's correlation was run due to Score 2 having a non-normal distribution.

Table 5.11: Spearman's Correlation for Achievement

Spearman's Correlations					
		Score 1	Score 2	Score 3	Total Achievement
Score 1 (Test)	Correlation Coefficient	1.000	.094	.131	.466**
	Sig. (2-tailed)		.621	.491	.010
Score 2 (Prac)	Correlation Coefficient		1.000	.029	.639**
	Sig. (2-tailed)			.878	.000
Score 3 (Exam)	Correlation Coefficient			1.000	.623**
	Sig. (2-tailed)				.000
Total Achievement	Correlation Coefficient				1.000
	Sig. (2-tailed)				

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

The only significant correlation is between each of the scores and total achievement. This is to be expected as the scores were used to calculate the total achievement score. There are no correlations between Score 1, Score 2 and Score 3. These correlations indicate that neither score 1 (written test) or score 2 (practical exam) can be used to predict score 3 (Exam).

In order to confirm the conclusion from the correlation table above a Wilcoxon Signed rank test was run between score 1 and score 2, score 2 and score 3 and score 1 and score 3. This was to check whether these scores are different from one another. The results of the test are displayed in in table 5.12 below.

Table 5.12: Wilcoxon Signed Rank Test for Achievement

Differences Compared	Test	Significance	Decision
Score 1 & Score 2	Wilcoxon Signed Rank Test	0	Reject null
Score 1 & Score 3	Wilcoxon Signed Rank Test	0.005	Reject null
Score 2 & Score 3	Wilcoxon Signed Rank Test	0.001	Reject null

The Wilcoxon Signed Rank test confirms that score 1 and score 2, and score 2 and score 3 are significantly different from each other, which was to be expected as score 2 is a practical assessment and score 3 and 1 were written assessments. However, Score 1 and score 3 are significantly different from each other, which could be attributed to the time frame between them. The students did better in Test 3 and being more highly weighted assessment it may have been more important to them.

5.4.6 Occupational Self-Efficacy (Control Item).

Table 5.13 displays the measures of central tendency and normality for the Occupational Self Efficacy (OSE) item ("*I believe that I poses the necessary skills to pursue an IT career"*) for Baseline 1 (B1), Baseline 2 (B2), Baseline 3 (B3) and the endline (E).

Table 5.13: Descriptive Statistics for OSE

	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Baseline 1 (B1)	24	3	7	5.58	1.139	1.297	-.802	.472	.477	.918
Baseline 2 (B2)	16	3	7	5.25	1.571	2.467	-.118	.564	-1.448	1.091
Baseline 3 (B3)	11	3	7	5.00	1.414	2.000	.000	.661	-1.050	1.279
Endline (E)	24	3	7	5.25	1.073	1.152	-.316	.472	-.789	.918

Table 5.13 indicates that the mean's for OSE at each of the time points tend to be about five. The skewness and kurtosis values are within an acceptable range of +/- 1 and +/- 3 respectively. This indicates that they are normally distributed. Students across the time period indicate relatively high levels of OSE.

In order to check if the scores measured at baseline 1, baseline 2 or baseline 3 were different from the endline scores paired sample t-tests were run. The results are displayed in Table 5.14 below.

Table 5.14: Results of t-test for OSE

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Baseline 1 (B1) to Endline (E)	.550	1.701	.380	-.246	1.346	1.446	19	.164
Baseline 2 (B2) to Endline (E)	-.231	1.878	.521	-1.365	.904	-.443	12	.666
Baseline 3 (B3) to Endline (E)	.300	1.160	.367	-.529	1.129	.818	9	.434

The t-tests presented in Table 5.14 confirm that there is no difference in OSE between Baseline 1 and the Endline, Baseline 2 and the Endline, and Baseline 3 and the Endline. Thus OSE is quite stable over the time periods and potentially indicates that the changes in other variables might not be from any maturation effects. It will serve as a useful control in subsequent PLS tests.

The next section will present the results of the tests that were conducted in order to test each of the hypotheses.

5.5 Hypothesis Testing

5.5.1 T-tests

This section is grouped by each variable that requires a paired t-test. Namely Intrinsic motivation, perceived competence and perceived usefulness. The purpose of these tests is to determine whether there are any significant differences in the variables of interest before and after the game based intervention.

5.5.1.1 Intrinsic Motivation

Table 5.15 provides the results of the paired sample test of Intrinsic Motivation. Each baseline score was compared against the Endline score in order to see if there were any differences. IM was found to be flat. Therefore, H1 is not supported. The introduction of the game did not have an immediately significant effect on IM, and the observed increase is considered marginal. Therefore, this does not conclusively indicate the game's value in increases to IM.

Table 5.15: Results of t-tests for IM

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Baseline 1 (B1) to Endline (E)	-.27368	1.25647	.28825	-.87928	.33191	-.949	18	.355
Baseline 2 (B2) to Endline (E)	-.12308	1.56106	.43296	-1.06642	.82027	-.284	12	.781
Baseline 3 (B3) to Endline (E)	.09091	.91810	.27682	-.52588	.70770	.328	10	.749

5.5.1.2 Perceived Competence

Table 5.16 provides the results of the paired sample test of Perceived Competence. Each baseline score was compared against the Endline score in order to see if there were any differences. A significant decrease in PC from B3 to E and from B2 to E. Therefore, H3 is supported.

There was an increase from B2 to B3 and the drop from B3 to E is very large. Therefore, the game has an almost immediate effect on PC and is a useful tool for educators in terms of allowing learners to become conscious of their incompetence. The value of the game is in its ability to expose learners to the deficiency in their skill level and potentially make them conscious of their incompetence.

Table 5.16: Results of t-tests for PC

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Baseline 1 (B1) to Endline (E)	.04386	1.32619	.30425	-.59534	.68306	.144	18	.887
Baseline 2 (B2) to Endline (E)	.78205	.87767	.24342	.25168	1.31242	3.213	12	.007
Baseline 3 (B3) to Endline (E)	.60606	1.08595	.32743	-.12349	1.33561	1.851	10	.094

5.5.1.3 Perceived Usefulness

Table 5.17 provides the results of the paired sample test of Perceived Usefulness for DGBL. Each baseline score was compared against the Endline score in order to see

if there were any differences. PU dropped, H6 not supported as effect is in opposite direction.

Initial excitement may not be achieved but the actual experience of the game is not an extreme disappointment to students as they do see its potential value. Following playing the game they retained adequate enthusiasm about its potential to improve learning.

Table 5.17: Results of t-tests for PU

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Baseline 2 (B2) to Endline (E)	.92308	1.71137	.47465	-.11109	1.95725	1.945	12	.076
Baseline 3 (B3) to Endline (E)	-.10606	1.82006	.54877	-1.32880	1.11667	-.193	10	.851

5.5.2 Correlation Analysis

5.5.2.1 Intrinsic Motivation, Perceived Competence and Perceived Usefulness

Table 5.18 provides the results of the Pearson correlation analysis. The correlation analysis was conducted on endline data only. There were no correlations found between IM and PC or IM and PU. Therefore, H4 and H7 are not supported.

Contrary to CET, intrinsic motivation was found to not be related to perceived competence. Perceived usefulness was also not found to have an effect on IM, which indicates that extrinsic motivation neither crowded out not supported intrinsic motivation in the study.

Interestingly, perceived competence was found to have a significant positive relationship with perceived usefulness. While this relationship was not hypothesised it potentially indicates that students who had high levels of perceived competence found the game to be useful and students who had low levels of perceived competence did not perceive any learning value from the game.

This relationship is even more interesting because perceived competence decreased after playing the game. Therefore, not only was the game able to expose students to their own incompetence but the students found this exposure of their deficiencies in

skill to be useful to the learning process. This indicates further that IBM's Innov8 2.0 is a useful tool for educators.

Table 5.18: Results of Correlation Analysis of IM, PC, PU

		Intrinsic Motivation	Perceived Competence	Perceived Usefulness
Intrinsic Motivation	Pearson Correlation	1	.117	.350
	Sig. (2-tailed)		.585	.094
	N	24	24	24
Perceived Competence	Pearson Correlation		1	.434*
	Sig. (2-tailed)			.034
	N		24	24
Perceived Usefulness	Pearson Correlation			1
	Sig. (2-tailed)			
	N			24

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

5.5.2.2 Intrinsic Motivation and Presence

Table 5.19 provides a correlation statistic for each presence item on Intrinsic Motivation and Table 5.20 provides the correlation for IM on the three subscales of presences, namely narrative, emotional and physical. Presence is important to IM, especially physical and emotional. Therefore, H9 is supported.

This indicates that the physical presence felt while playing IBM's Innov8 2.0 and the emotional presence are both positively related to intrinsic motivation with the emotional presence having both a stronger effect size and being highly significant. Thus the emotional presence in the game is a strong determinant of intrinsic motivation.

Previous findings indicated that the emotional presence was lower than both narrative and physical presence felt in the game. This could potentially explain why there was no significant difference in IM in terms of H1. The lower emotional presence might have reduced the effect of the game on intrinsic motivation.

Table 5.19: Results of Correlation Analysis of Presence and IM

		Intrinsic Motivation (n=24)
PRES1	Pearson Correlation	.475*
	Sig. (2-tailed)	.019
	N	24
PRES2	Pearson Correlation	.302
	Sig. (2-tailed)	.152
	N	24
PRES3	Pearson Correlation	.415*
	Sig. (2-tailed)	.044
	N	24
PRES4	Pearson Correlation	.359
	Sig. (2-tailed)	.085
	N	24
PRES5	Pearson Correlation	.510*
	Sig. (2-tailed)	.011
	N	24
PRES6	Pearson Correlation	.616**
	Sig. (2-tailed)	.001
	N	24
PRES7	Pearson Correlation	.511*
	Sig. (2-tailed)	.011
	N	24
PRES8	Pearson Correlation	.288
	Sig. (2-tailed)	.172
	N	24
PRES9	Pearson Correlation	.662**
	Sig. (2-tailed)	.000
	N	24

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

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

Table 5.20 provides the correlation coefficient for physical presence on IM, Emotional presence on IM and Narrative Presence on IM.

Interestingly, the dimensions of physical and narrative presence were found to be positively related to perceived usefulness. Physical presence also correlates with IM, which implies that physical presence felt towards the game is important to both intrinsic motivation and perceived usefulness. Therefore, the game would need to be able to immerse students into the virtual world in order to generate motivation and for the game to be perceived as useful to the learning process.

Another interesting finding is that for a game to have an effect on Intrinsic Motivation there needs to be a sense of emotional immersion, but for a game to be perceived as being useful there needs to be a strong sense of immersion felt towards the narrative of the game.

Perceived competence was found to be significantly related to intuitive controls and to narrative presence, implying that the narrative immersion in the game and the ease of the control system are important to PC. Physical presence could also be viewed as being significant to PC. This implies that the more immersive the game the greater the chance that the students remain unconsciously incompetent or overconfident in competence. Games that are not easy to control and that do not have an immersive environment and narrative will potentially be able to bring to light the deficiencies in skill level, while games higher in control or narrative might contribute to overconfidence.

Contrary to previous findings, intuitive controls were found to not be correlated with any of the dimensions of presence, thus indicating that it might not be suitable as a control for presence.

Table 5.20: Results of Correlation Analysis of PRES and IM, PU, PC and IC

		Intrinsic Motivation	Perceived Usefulness	Perceived Competence	Intuitive Controls
Physical Presence	Pearson Correlation	.466*	.783**	.545	.164
	Sig. (2-tailed)	.022	.000	.006	.443
	N	24	24	24	24
Emotional Presence	Pearson Correlation	.721**	.402	.122	.011
	Sig. (2-tailed)	.000	.052	.569	.959
	N	24	24	24	24
Narrative Presence	Pearson Correlation	.288	.541**	.513*	.249
	Sig. (2-tailed)	.172	.006	.010	.242
	N	24	24	24	24
Intuitive Controls	Pearson Correlation	.345	.071	.447*	1
	Sig. (2-tailed)	.099	.741	.028	
	N	24	24	24	24

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

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

5.5.2.3 Correlations on Achievement

Table 5.21 presents the correlation analysis of each of the achievements scores on IM, PU, PC, OSE and each of the dimensions of presence. There were no significant relationships found between any of the variables and any of the test scores. Therefore, indicating no support for H2, H5, H8, and H10. These findings will be examined further through the use of PLS regression tests.

Table 5.21: Results of Correlation Analysis on Achievement, IM, PC, PU, OSE and PRES

	Spearman's rho	Score 1	Score 2	Score 3	Total Achievement
Intrinsic Motivation	Correlation Coefficient	.203	.178	.013	.199
	Sig. (2-tailed)	.341	.406	.951	.352
	N	24	24	24	24
Perceived Usefulness	Correlation Coefficient	-.087	.077	-.203	-.145
	Sig. (2-tailed)	.685	.721	.340	.499
	N	24	24	24	24
Perceived Competence	Correlation Coefficient	-.093	.058	-.131	-.078
	Sig. (2-tailed)	.664	.788	.541	.717
	N	24	24	24	24
Physical Presence	Correlation Coefficient	-.208	.110	-.373	-.260
	Sig. (2-tailed)	.330	.607	.072	.220
	N	24	24	24	24
Emotional Presence	Correlation Coefficient	-.093	.061	-.023	.058
	Sig. (2-tailed)	.665	.776	.914	.787
	N	24	24	24	24
Narrative Presence	Correlation Coefficient	.078	.261	-.141	.068
	Sig. (2-tailed)	.718	.218	.512	.751
	N	24	24	24	24
Occupational Self Efficacy	Correlation Coefficient	-.105	.333	.030	.162
	Sig. (2-tailed)	.624	.111	.889	.449
	N	24	24	24	24

5.5.3 PLS

In order to confirm the findings from the correlation analysis a PLS model was used. There are four models presented in this section, where each one represents a model with a different score. There is also an additional model that was run in order to confirm the relationship identified between PU and PC. The models display the effect sizes and t-statistics along the paths. The t-statistics have been placed in brackets next to the effect sizes. The numbers on the factors, which are the boxes indicating the items for the constructs, represent the t-statistic that resulted from the factor

loading. Tables that include all of the statistics for each model have been included in appendix B.

5.5.3.1 Model with Score 1: Written Test

Table 5.22 displays the R squared for both IM and score 1 and figure 5.7 displays the PLS model run with score 1. IM was found to have a significant R squared, which indicates that 57.2% of the variance in IM can be explained by PU, PC and PRES. However, an examination of the effect sizes in figure 5.7 reveal that only PRES was found to be significant with a large effect size (0.945) and a t-value that is much greater than 1.96. PU and PC have t-values that are lower than 1.96, indicating that they are not significant predictors of IM. These results support the initial correlation analysis and provide support for H9.

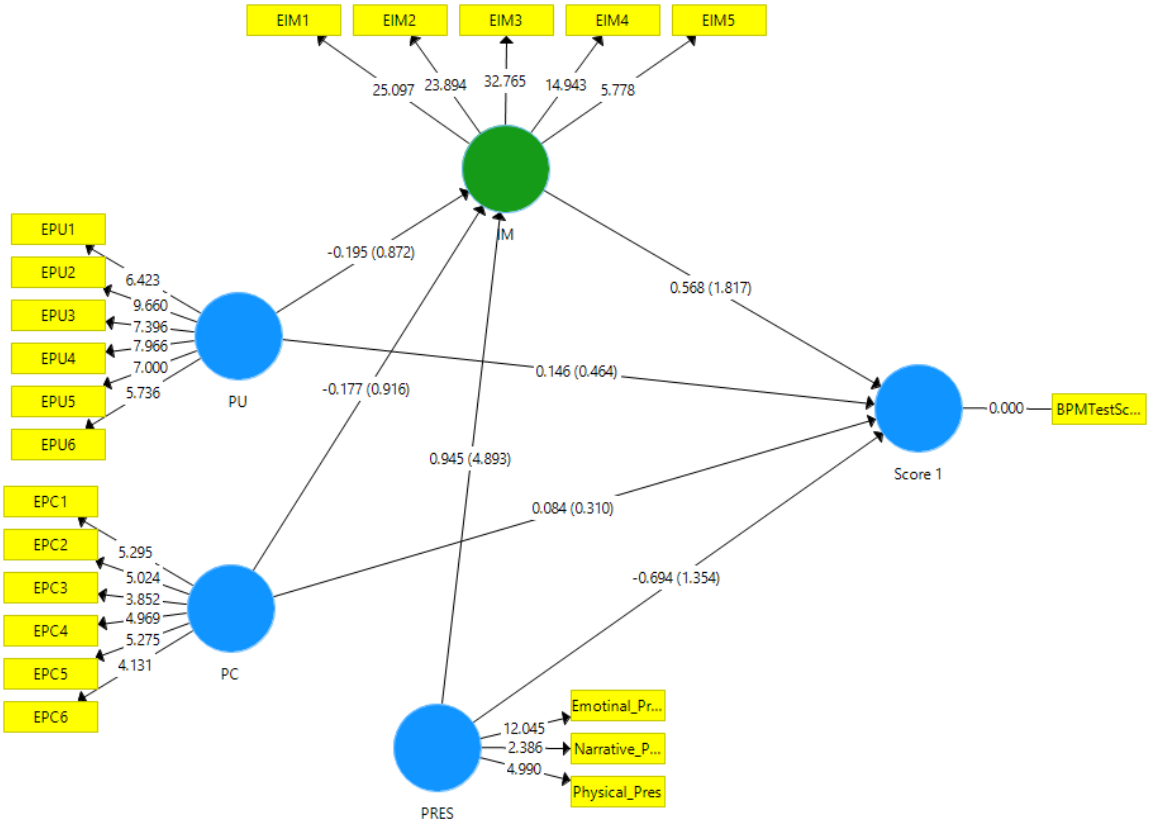
The R Squared for Score 1 indicates that 15.8% of the model explains the variance in Score 1, however this value was not found to be significant. PC, PU, IM, and PRES were found to be non-significant predictors of score 1, which supports the findings of the correlation analysis conducted previously and provides no support for H2, H5, H8, H10.

While IM and PRES were found to be insignificant, they both have relatively large effect sizes. IM has an effect size of 0.568 and with a t-value of 1.817 this is a significant effect size at the $p<0.10$ level. This indicates that IM might be partially indicative of the results obtained in written test one week after the conclusion of the course. PRES has a large negative effect size (-0.694) but the t-value was quite below 1.96. This is interesting as presence possibly facilitates overconfidence and consequently impacts negatively on the learning outcomes.

Table 5.22: R Squared for Model Including Score 1

	R Squared	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
IM	0.572	0.641	0.095	6.001	0.000
Score 1	0.158	0.283	0.154	1.026	0.305

Figure 5.7: PLS Model with Score 1



5.5.3.2 Model with Score 2: Practical Test

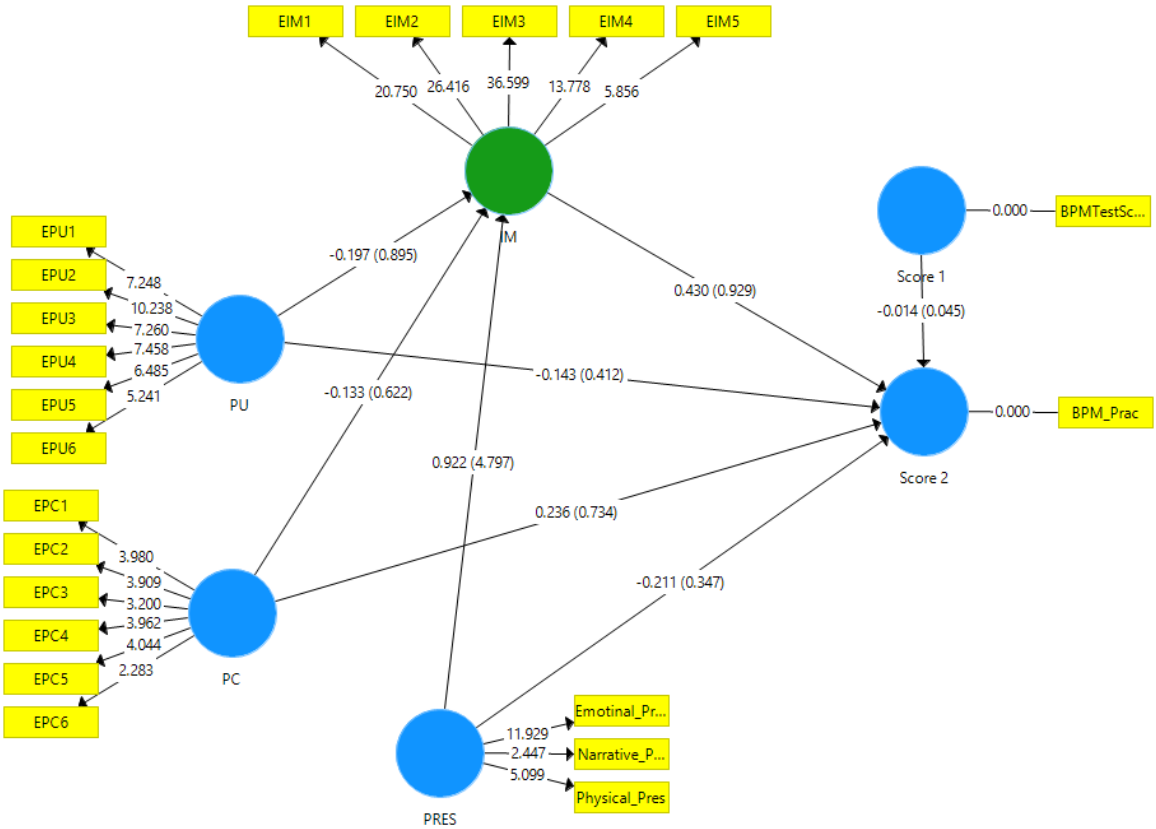
Table 5.23 indicates that the R squared for IM is largely unchanged in this model, and PRES was once again the only significant variable associated with IM.

While the R squared and all of the variables were still found to be insignificant for score 2, interestingly the effect size, or t-statistic, of both IM and PRES has decreased, which is indicated in figure 5.8. This implies that the further away from the playing of the game, the less likely the IM felt at the end of the course is able to predict the score of achievement.

Table 5.23: R Squared for Model Including Score 2

	R Squared	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
IM	0.560	0.642	0.095	5.598	0.000
Score 2	0.128	0.323	0.197	0.650	0.516

Figure 5.8: PLS Model with Score 2



5.5.3.3 Model with Score 3: Exam

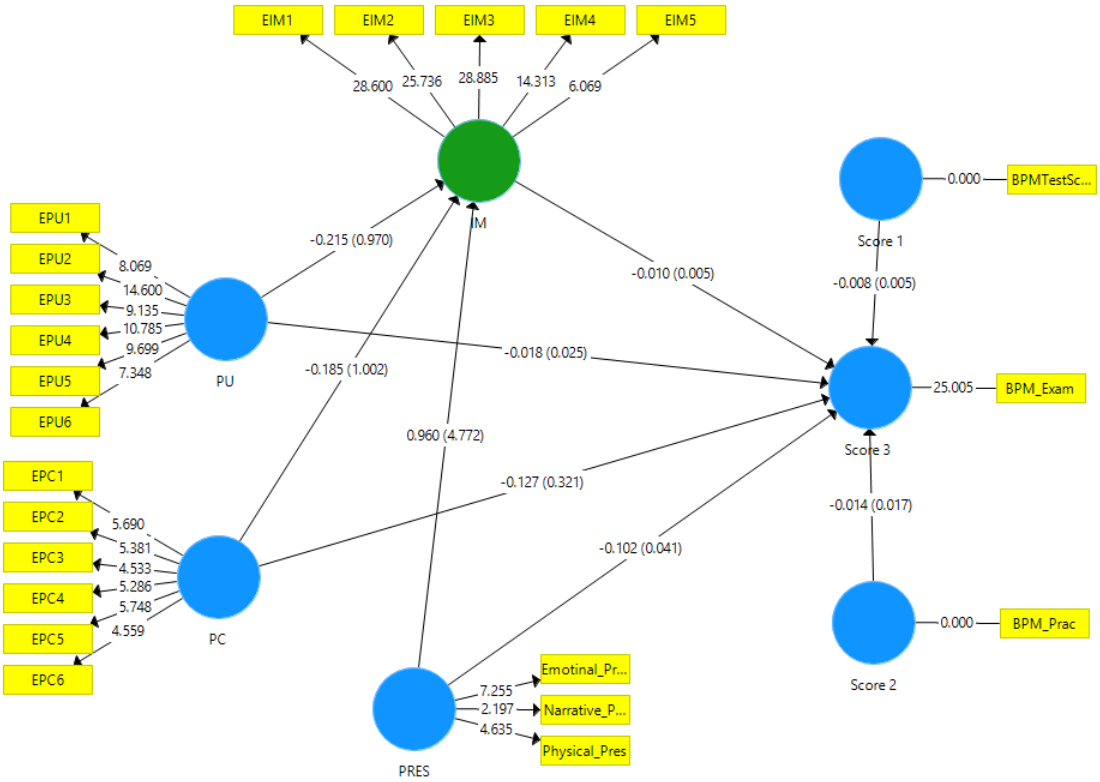
Table 5.24 indicates the same results from IM, both with the R squared and with PRES being the only significant predictor.

The R Squared for score three is 4.8%, which means that the further away from the end of the course the assessment is, the weaker IM becomes as an indicator of the achievement. IM measured at the endline is better at predicting recent scores than scores that occur on assessments 2 months after the completion of the course. Figure 5.9 displays the PLS model with score 3.

Table 5.24: R Squared for Model Including Score 3

	R Squared	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
IM	0.566	0.632	0.101	5.598	0.000
Score 3	0.048	0.342	0.312	0.153	0.878

Figure 5.9: PLS Model with Score 3



5.5.3.4 Model with Total Score

The results of the final PLS model with the total score indicates a similar finding to the previous models and can be seen in figure 5.10. IM is still found to be significantly influenced by PRES, with an R squared of 56.6% as indicated by table 5.25. PRES also has a large significant effect on IM, which indicates that PRES in a game is important to creating IM within the subject domain.

The R Squared for the Total score is 21.1%, which is higher than any of the models with an individual score, but this R squared was still found to be non-significant. The relationships between IM, PU, PRES, and PU with the total score were all found to be non-significant. However, IM still has a positive effect on the total score and PRES has a negative effect on total score.

This implies that while PRES has a large effect on IM, which in turn has a positive effect on the learning in the course, PRES also has the potential to reduce the learning in a course.

While PC has a non-significant effect with total score, an examination of the effect size indicates that it has a positive relationship with total score. A positive

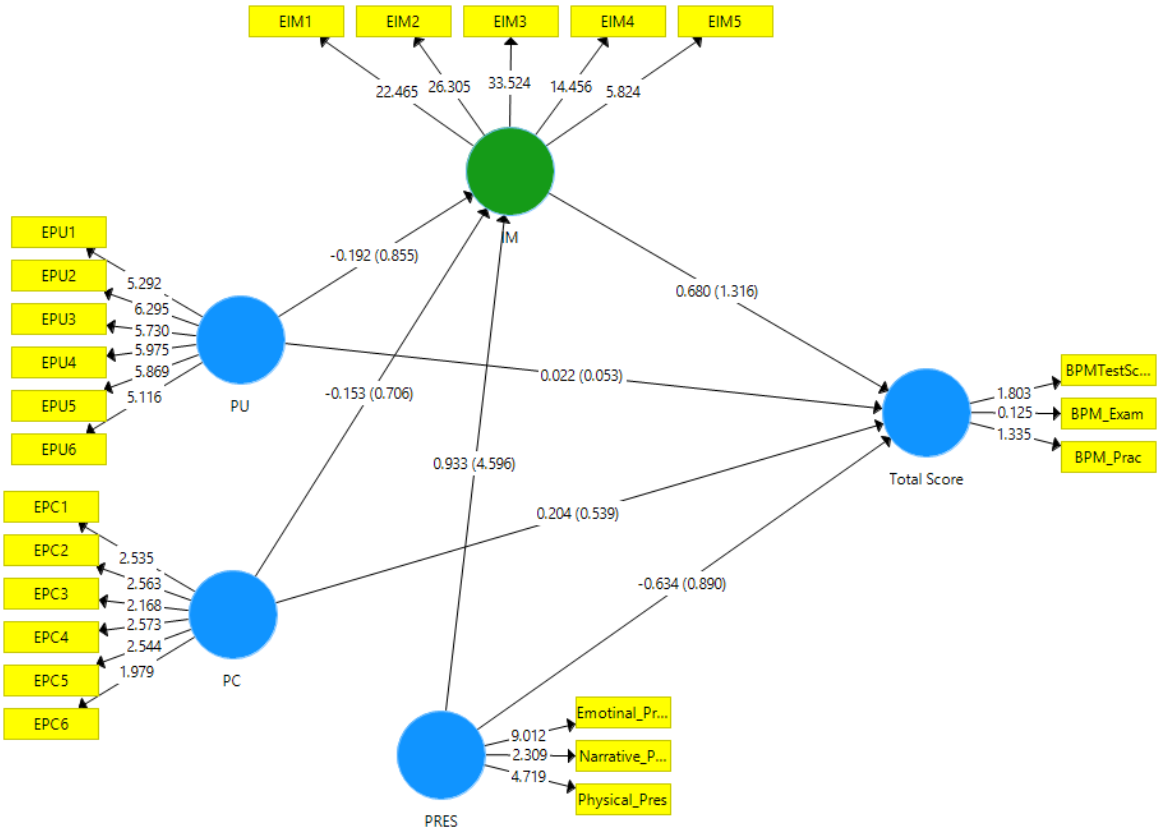
relationship can also be seen between PC and Score 2 (figure 5.8). This indicates that PC might have a potential relationship with the practical assessment.

PC and PU also had a non-significant negative effect with IM. This was consistent across all three models and indicating that both PC and PU might have potentially negative relationships with IM.

Table 5.25: R Squared for Model Including Total Score

	R Squared	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
IM	0.566	0.640	0.100	5.684	0.000
Total Score	0.211	0.474	0.175	1.206	0.228

Figure 5.10: PLS Model with Total Score



5.6 CONCLUSION

The results of the study were presented, including a description of the sample, tests of validity and reliability, demographic statistics, and hypothesis tests. The chapter identified the hypotheses that were both supported and not supported and a summary of the hypotheses as well as a brief comment is presented in Table 5.26.

Having established the results of the study, and which hypotheses were supported, or not supported, the next chapter presents a discussion based on the findings of the study.

Table 5.26: Summary of Supported and Non-Supported Hypotheses

No.	Statement	Result	Comment
H1	The introduction of DGBL will have a positive effect on students' intrinsic motivation in the course.	Not Supported	IM increased but was not a significant increase from baseline to endline
H2	Intrinsic Motivation in the course will have a positive relationship with learning achievement.	Supported	IM had a large effect on certain learning achievement, significant at the $p<0.1$.
H3	Baseline measures of perceived competence will reflect unconscious incompetence and thus will be higher than the endline perceptions of perceived competence, which reflect more conscious incompetence.	Supported	PC was significantly lower at the endline compared to the baseline
H4	Perceived Competence in the course will have a positive relationship with intrinsic motivation in the course.	Not Supported	PC had no significant effect on IM, but a small negative effect size was visible.
H5	Perceived Competence will have a positive relationship on students' achievement in the course.	Not Supported	PC does not significantly impact on learning achievement
H6	The introduction of DGBL will have an effect on students' perceived usefulness of DGBL.	Not Supported	PU did visibly increase a slight amount but the effect was not significant
H7	Perceived Usefulness of the digital game will have an effect on students' intrinsic motivation in the course.	Not Supported	PU had a small negative effect, but not significant.
H8	Perceived Usefulness will have a positive relationship with students' achievement in the course.	Not Supported	PU has no effect on students learning achievement
H9	Presence in the digital game will have a positive effect on students' intrinsic motivation in the course.	Supported	PRES has a large and significant effect on IM at endline.
H10	Presence in the digital game will have a positive relationship with achievement in the course.	Not Supported	PRES had a large negative effect on learning achievement but not significant.

6 CHAPTER 6: DISCUSSION

The research study aimed to investigate the extent that the introduction of DGBL had an effect on students' intrinsic motivation, perceived competence and perceived usefulness within a BPM course at a university level. It also aimed to examine the extent that perceived competence, perceived usefulness, and presence felt in the game had an effect on intrinsic motivation, as well as the extent that intrinsic motivation, perceived competence, perceived usefulness, and presence felt in the game had an effect on students learning achievement in the course.

The data collected from the baseline surveys, the endline survey, and assessments were analysed through appropriate statistical tests in order to test the ten hypotheses. The results were presented in the previous chapter and indicated that H2, H3, and H9 were supported in terms of significance, while the other seven hypotheses were not. This chapter presents a discussion around each of those hypotheses. It is grouped by each of the eight research questions the study asked and discusses the implications of findings in terms of each question. It then provides an additional discussion section on some of the unexpected findings and concludes with the broader implications for the findings.

6.1 RESEARCH QUESTIONS

6.1.1 RQ1: To what extent does the inclusion of DGBL effect students' motivation in the course?

Hypotheses one (H1) stated that the introduction of DGBL would have a positive effect on students' intrinsic motivation in the course. While the hypothesis was found to not be supported, the introduction of DGBL did have a small visible positive effect on the IM towards the BPM course. This is in line with previous studies that reported that DGBL impacted positively on students' motivation towards a particular subject discipline (Chung-Ho and Cheng, 2013; Treviño-Guzmán and Pomales-García, 2014), albeit not always significant (Wouters et al., 2013).

This implies that DGBL is a potential tool available to educators to raise intrinsic motivation, or interest and enjoyment, that students might feel towards a course or subject. This might be a particularly helpful tool to be used in subjects that are

technically inclined, as students tend to be have lower motivations and also be less interested in these subjects (Divjak and Tomić, 2011). Previous implementations of DGBL in other technical contexts indicate a similar finding, specifically subjects like industrial engineering (Treviño-Guzmán and Pomales-García, 2014) and software engineering (Chung-Ho and Cheng, 2013). This adds further support to previous findings around DGBL and its impact on IM by indicating that DGBL might also be able to raise levels of interest in the context of BPM.

6.1.2 RQ2: To what extent does the inclusion of DGBL effect students' perceived competence in the course?

Hypotheses three (H3) stated that baseline measures of perceived competence would reflect unconscious incompetence and thus would be higher than endline measures of perceived competence, which reflects more conscious incompetence. This hypothesis was found to be supported and implies that the introduction of IBM Innov8 2.0 into a BPM context exposed students to the deficiencies in their skill levels of BPM and was able to change their perceptions of competence, possibly by having moved them from a stage of unconscious incompetence to a stage of conscious incompetence. Therefore, DGBL may have functioned as a form of feedback for the students in terms of their skill levels and was able to make them more aware of the skills they needed for BPM.

While previous research around the use of DGBL as a form of feedback for skill is limited, there have been studies that suggest this is a potential ability of DGBL (Erhel and Jamet, 2013). Cornillie et al. (2012) conducted a largely qualitative study on the use of DGBL to support the teaching of English as a form of feedback and found that students perceived DGBL to be similar to a summative assessment and that the feedback in the game was related to students' perceived competence. The current study actually addresses one of the recommendations made by Cornillie et al. (2012) and provides support that DGBL could be used as a form of non-judgemental feedback for students to become consciously aware of their skill level in a particular task or subject.

The implications for this findings are that the use of IBM Innov8 2.0 can be used within the context of a BPM course as a potential tool to provide feedback to students about their skill levels regarding BPM. Digital games already have in built

feedback mechanisms as feedback is regarded as a core characteristic of digital games (Garris et al., 2002). Basically, the challenge characteristic of the game would be focused on an academic challenge, and then the feedback the game provides would be related to that academic challenge (Erhel and Jamet, 2013). Other studies have indicated the potential for DGBL to provide constructive feedback in an academic setting (Erhel and Jamet, 2013; Cornillie et al., 2012).

A further implication of the finding suggests that IBM's Innov8 2.0 as a digital learning game, should be introduced after students have had some exposure to a BPM course, or context. Introducing the game at the start of a course when students are complete novices has been found to be ineffective in previous research (Boughzala et al., 2015; Tao et al., 2012). This could suggest that students need to spend some time being exposed to the ideas surrounding BPM. As they progress through a course, their levels of perceived competence increase and the game provides a non-judgemental form of feedback to expose them to potential skill deficiencies and move them beyond a stage of unconscious incompetence.

6.1.3 RQ3: To what extent does the inclusion of DGBL effect students' perceived usefulness of DGBL?

Hypothesis six (H6) stated that perceived usefulness will be effected by the introduction of DGBL. It was found to not be supported but the results do indicate a visible change in perceived usefulness over the time-period. Perceived usefulness has been found previously to have a relationship with students' previous experience with DGBL (Cornillie et al., 2012). Previous studies have indicated that students would have certain expectations of DGBL and after being exposed to a digital learning game these expectations would either have been met or not (Bourgonjon et al., 2010). This suggests that in the current study there were expectations that were potentially met and potentially not met, which might be a possible explanation for DGBL having no impact on PU.

The implications of this is that students who have high expectations of the usefulness of DGBL might be less satisfied with DGBL if it does not meet those expectations, and be less willing to use DGBL in the future (Mayer et al., 2013). Students need to be made aware of the potential usefulness that a digital game might provide, as this has been found to act as a form extrinsic motivation for the

students (Huang et al., 2010). Educators should consider how the game is introduced and what other forms of instructional scaffolding should be put in place in order to foster feelings of usefulness (Wouters and Van Oostendorp, 2013).

6.1.4 RQ4: To what extent does perceived competence in the course effect students' motivation in the course?

Hypothesis four (H4) stated that perceived competence would have a positive effect on intrinsic motivation. Contrary to expectations, this was found to not be supported and there is an indication of a small negative relationship with IM. This finding is unexpected as it is contrary to both other studies in the field of DGBL, which found a positive relationship between perceived competence and intrinsic motivation (Boeker et al., 2013; Chung-Ho and Cheng, 2013), and to the theory of SDT, which states that PC will positively relate to intrinsic motivation (Deci and Ryan, 2002).

The findings appear to suggest that within the specific context of a BPM course, perceived competence with BPM might not necessarily be needed in order to foster feelings of intrinsic motivation. In the context of a 3rd year information systems course, perceived competence might take a back seat to other factors influencing intrinsic motivation.

6.1.5 RQ5: To what extent does students' presence in the game effect their motivation in the course?

Hypothesis nine (H9) stated that presence in the game would have a positive effect on intrinsic motivation. This was found to be supported with a strong positive effect of presence on intrinsic motivation. This result is in line with previous studies (von Wangenheim et al., 2012; Connolly et al., 2012) and in line with Ryan et al. (2006)'s adaptation of presence into SDT and its relationship with intrinsic motivation.

This effect occurs because presence, or immersion, in a game, i.e. feeling part of the game, can fuel an interest in the course that the game aims to support. (Przybylski et al., 2010; Ryan et al., 2006). This effect is likely to occur because immersion in and feeling part of the game may occur when basic psychological needs, e.g. for autonomy and relatedness, are met through the game. These in turn provide for higher levels of intrinsic motivation. A higher level of presence in the game indicates that IBM's Innov8 2.0 was potentially able to provide support for these three basic

psychological needs. Therefore the spill over effect as suggested by media entertainment theory (Vorderer et al., 2004) appears to have been supported.

This implies that digital learning games need to be immersive in order to create feelings of interest and enjoyment within a subject domain, specifically they need to be both emotionally and physically immersive. Therefore, when selecting a game for a particular context attention needs to be directed at examining a games' ability to create feelings of immersion and presence, in particular emotional and physical presence. This might ensure that the game is better able to support the basic psychological needs that create feelings of intrinsic motivation and for those feelings in the game to spill over into perceptions and interests in that discipline.

The theoretical implication of the finding suggests that the inclusion of the construct of presence is appropriate within the context of intrinsic motivation and of SDT. This adds further support for the inclusion of the construct into SDT and using it to investigate the ability for digital games to provide support for the three basic psychological needs that determine intrinsic motivation (Ryan et al., 2006).

6.1.6 RQ6: To what extent does students' perceived usefulness of the game effect their motivation in the course?

Hypothesis seven (H7) stated that PU would have an effect with IM. This was found to not be supported but there was a small negative relationship with IM. This suggests that PU, acting as an indicator of extrinsic motivation, might be crowding out the feelings of intrinsic motivation rather than fostering them (Deci and Ryan, 2000).

6.1.7 RQ7: To what extent does the inclusion of DGBL effect students' learning achievement through its effect on students' motivation and perceived competence in the course?

Hypotheses two (H2) and five (H5) were related to this questions. H2 stated that intrinsic motivation would have a positive effect with learning achievement, which was found to be supported, and H5 stated PC would have a positive effect on learning achievement, which was found to not be supported.

Intrinsic motivation has been found to impact positively with academic performance and achievement in a DGBL context (Chung-Ho and Cheng, 2013; Wouters et al., 2013). This effect occurs because increased interest and enjoyment of a subject

leads to increased engagement in the learning process and subsequently better academic performance (Reyes et al., 2012; Hess and Gunter, 2013). The implications associated with this study are interesting as the findings suggest that intrinsic motivation has a temporal effect on learning achievement. The further away an assessment was from the end of the course, the lower was the direct effect of intrinsic motivation on achievement.

Perceived competence was found to have no impact on learning achievement, which is contrary to previous studies. However, the findings suggest that PC had some implications for practical assessments and not for written. The practical manner of DGBL may have increased its value as a learning tool for practical based assessments as opposed to written assessments.

6.1.8 RQ8: To what extent does presence in the game and perceived usefulness towards the game effect their learning achievement?

Hypotheses eight (H8) and ten (H10) were related to this question. H8 stated that perceived usefulness would have a positive relationship with learning achievement, which was found to not be supported. H10 stated that presence would have a positive relationship with learning achievement, which was found to not be supported.

Perceived usefulness was found to have no impact on learning achievement. This is contrary to previous studies that indicated that perceived usefulness would have a positive relationship (Liaw and Huang, 2013). This suggests that perceptions of the usefulness of IBM's Innov8 2.0 does not lead to actual benefits to learning achievement.

Presence was found to not have an impact on learning achievement, but the findings suggest that there is a potential negative effect between presence and learning achievement. This could indicate that immersion in games that is possibly not directly aligned with achievement and could potentially detract from the learning performance of the student. Another possible explanation is that high levels of presence in the game could potentially motivate students to be more interested in only the game rather than achieving in the course.

Even though presence increases intrinsic motivation, neither presence nor intrinsic motivation easily translate into achievement, especially as the positive effects of intrinsic motivation on achievement wear off over time.

6.2 Other Findings

While it was not hypothesised, the findings indicated a significantly positive relationship between presence and perceived competence, as well as between perceived competence and perceived usefulness (these relationships are indicated by the additional model included in appendix B).

The relationship between presence and perceived competence suggests that presence, or immersion with the digital learning game, might contribute to feelings of perceived competence. A potential explanation for this effect occurring might relate to the fact that immersion in a learning game might be needed in order for students to use them as a from of feedback and alter their perceptions of competencies (Cornillie et al., 2012). A game that is not immersive might result in no changes to students' perceptions of their own competencies.

The relationship between perceived usefulness and perceived competence suggests that individuals who have high levels of perceived competence perceive the digital learning game to be more useful to the learning process. A potential explanation of this effect could relate the differences between high achieving students and low achieving students found in previous studies (Mayer et al., 2013). High achievers might be better at perceiving their own level of competence and they also might be better able to perceive the value that the digital learning game adds to the process of learning (Mayer et al., 2013).

6.3 Conclusion

This chapter provides a discussion around each of the research questions the study aimed to address. Having established a discussion around these questions, the next section concludes the study by presenting the implications of the study, recommendations for future research and the limitations of the study.

7 CHAPTER 7: CONCLUSION

The study aimed to investigate the impact of the introduction of digital game-based learning (DGBL) and its effect on students' perceptions of competence, usefulness, and enjoyment, as well as their achievement. The context of the study was a third year Business Process Management (BPM) module, within an information systems course at the University of the Witwatersrand.

In order to achieve this aim, the study formulated eight research questions and derived 10 hypotheses. The formulation of the hypotheses was informed by previous studies that have been conducted in the field of DGBL. It was also underpinned by Deci and Ryan (2002)'s self-determination theory (SDT) of human motivation, which included two of the sub-theories of SDT, cognitive evaluation theory (CIT) and organismic interaction theory (OIT), as well as Ryan et al. (2006)'s adaptation of the construct of presence into SDT.

The methods the study adopted to test the hypotheses were informed by a positivistic paradigm and followed a single group natural experiment pre-post design and a longitudinal relational design. The study was conducted in a 3rd year information systems course with a sample of 24 students. Three baseline surveys were used to measure students' levels of intrinsic motivation, perceived competence and perceived usefulness. This was done prior to the introduction of IBM's Innov8 2.0, the digital learning game used in the study. These baseline surveys were administered one week apart, prior to the introduction of the game. After the game was introduced, an endline survey was used to capture students' levels of intrinsic motivation, perceived competence, perceived usefulness and presence with the game.

Learning achievement was measured through the use of three assessments conducted after the end of the BPM course. The first was a written assessment done one week after the course, the second was a practical test done one month after the course, and the third was an exam written two months after the completion of the course.

After the data was collected it was analysed using t-tests, correlation and PLS techniques in order to test the hypotheses of the study. These results, as well as the hypotheses were then discussed in light of recent literature.

The current chapter seeks to conclude the study. It first provides the implications of the results to research and practice and then gives recommendations for future work. The limitations of the current study are then presented and a conclusion presented.

7.1 IMPLICATIONS

7.1.1 Implications for Research

The study has several implications for research. The first implication concerns DGBL research, where the study provides support for the use of DGBL as a form of constructive feedback for students in a formal educational setting. Therefore, adding support for the continued investigation of DGBL and its impact on learning achievement and motivation.

The second implication concerns the use of self-determination theory (SDT), and its sub-theories of cognitive evaluation theory and organismic interaction theory. The study provides further support for the use of SDT to investigate the introduction of DGBL and its impacts on student motivation in the context of a live university course. This study also provides support for the positive effect that intrinsic motivation has on learning achievement, when there is a close proximity between DGBL and the assessments and an alignment between the context of the digital learning game and the course.

The final implication for research concerns the use of the presence within SDT. The study adds support towards the use of presence in DGBL context and it provides support for its positive relationship with intrinsic motivation. It also provides support for the spillover effect of interest and enjoyment between a digital learning game and the context it is applied in. Therefore, the study adds more justification to the use of presence as a potential indicator of digital games being able to support the three basic psychological needs which, according to CET, should result in higher levels of intrinsic motivation. It also adds justification for the spillover of interest and enjoyment between a digital learning game and the course it is applied in.

Intrinsic rather than extrinsic motivation appears to be a more useful construct around which to design studies of digital game hypotheses on learning achievement.

7.1.2 Implications for Practice

The study adds further support for the use of DGBL in an educational context. It indicates that DGBL might be a useful tool for educators to use for both increasing interest towards a subject discipline and for acting as a form of summative assessment or feedback on skill levels. The study also implies that the digital learning games need to be immersive in order for them to be effective when used as tools of this type and educators need to consider this when selecting them.

The contextual nature of DGBL, means that the study also adds support for the use of IBM's Innov8 2.0 in the context of a BPM course. The game could act as a way to expose students to the skills associated with BPM in a fun and non-judgmental way. It also assists educators in implementing IBM's Innov8 2.0, by indicating that the game is implemented after some exposure to topics surrounding BPM has occurred.

A final implication for this findings is the potential for DGBL to act as tool to monitor students' perceptions of competence as they proceed through a course. Educators can use data on perceived competence observed after game play to make adjustments to teaching and assessments practice. If digital learning games are not used to promote for self-regulation of perceived competence from the feedback provided, it is possible that the learner remains in a stage of unconscious incompetence and then might make uninformed decisions, create more conflict and potentially create risk. DGBL has the potential to address this, but more research would need to be conducted. Especially, for example, across different school contexts and even in a workplace context.

7.2 Recommendations

The current study recommends that continued research be conducted in DGBL and the various contexts that it can be applied in. IBM's Innov8 2.0 should be examined in a context where there are multiple play sessions. This would be in order to continue investigations into the potential for IBM's Innov8 2.0 to potentially expose students to skill deficiencies, and how this might contribute to progression from a state of unconscious incompetence to a state of conscious competence. This

recommendation could also extend into investigating the correct pedagogical use of both IBM's Innov8 2.0, and other digital learning games, specifically as a potential form of feedback, or summative assessment.

Another potential recommendation concerns the findings relating to presence in the game and intrinsic motivation. Future work should investigate the relationship between presence in digital learning games and the support that digital learning games are potentially able to provide in terms of autonomy, relatedness and competence. This could be informative from the perspective of "what game characteristics might support the three basic psychological needs" and then how the support creates higher levels of presence. Future work should also consider the spillover effect of interest and enjoyment between the game and the context of the course. Work should be done to determine how immersive games need to be in order for the spillover to occur.

Future work should also consider a comparative study that compares different games within the same context and within different contexts, in order to establish the effects of each game within each context. This would begin to build a better picture about what games might be appropriate, or not appropriate, in which contexts.

The effects between an immersive game and its impact on students' perceptions of their competencies, as well as how those perceptions of competencies might then impact perceptions of how useful a digital learning game is, also warrants future investigations. These effects were identified in the other findings section of the study and should be examined by future research.

Future work should also consider investigations into DGBL and BPM using the other four sub-theories of self-determination theory that were not used within this study. While self-determination theory is considered as the most comprehensive theory of motivation, there are also other theories of motivation, such as Herzberg's two factor theory of motivation (Herzberg, Mausner and Snyderman, 1959), and the Expectancy theory of motivation (Vroom, 1964), that future work could draw on to investigate the motivational impacts of DGBL. Moreover, the concept of co-presence could also be investigated, especially in a digital game context with multiple players.

The time frame adopted in this study was a period of three weeks being constrained by the course schedule. Future studies may consider the use of DGBL in a course over longer periods.

Finally, future work should be conducted with larger sample sizes and similar experiments should be conducted with different games in different contexts. These last two recommendations are based off the limitations of the study, which are highlighted below.

7.3 Limitations

One of the limitation of the study concerns the lack of a control group and the small sample size. While these do limit the generalisability, steps were taken in the methods of the study in order to try and mitigate these limitations. The multiple measurements of baseline variables and the independent and objective administration of the assessments were some of the mitigation strategies that were used. Future studies can usefully incorporate a control group if class sizes permit.

A further limitation of the study concerns the specific contextual nature of studies using DGBL. The context of the study was in a 3rd year information systems course and used the digital learning game IBM's Innov8 2.0. This also influences the generalisability of the study.

7.4 Conclusion

As a result of the study, we now know that DGBL effects achievement through intrinsic motivation when in close proximity to the assessments. DGBL can appear to decrease perceived competence as it appears to be a feedback mechanism, which should be seen as a positive rather than negative effect. Certain DGBL characteristics such as presence increase intrinsic motivations perceptions. Overall, the study adds further evidence to the growing body of research surrounding the effectiveness of DGBL and its impact on students' motivations and perceptions within a university course.

Table 7.1: Summary of Contributions

Previous Contributions
• DGBL has the potential to increase student motivation and impact learning achievement • The context that DGBL is applied in should inform the type of game being used • DGBL can be used across a range of educational contexts, from primary school to adult education
Contributions from the Study
• DGBL effects learning achievement through intrinsic motivation when in close proximity to the assessments • DGBL can act as a feedback mechanism for students' skill level • An immersive digital game should be used if the objective of the DGBL activity is to affect intrinsic motivation or perceived competence

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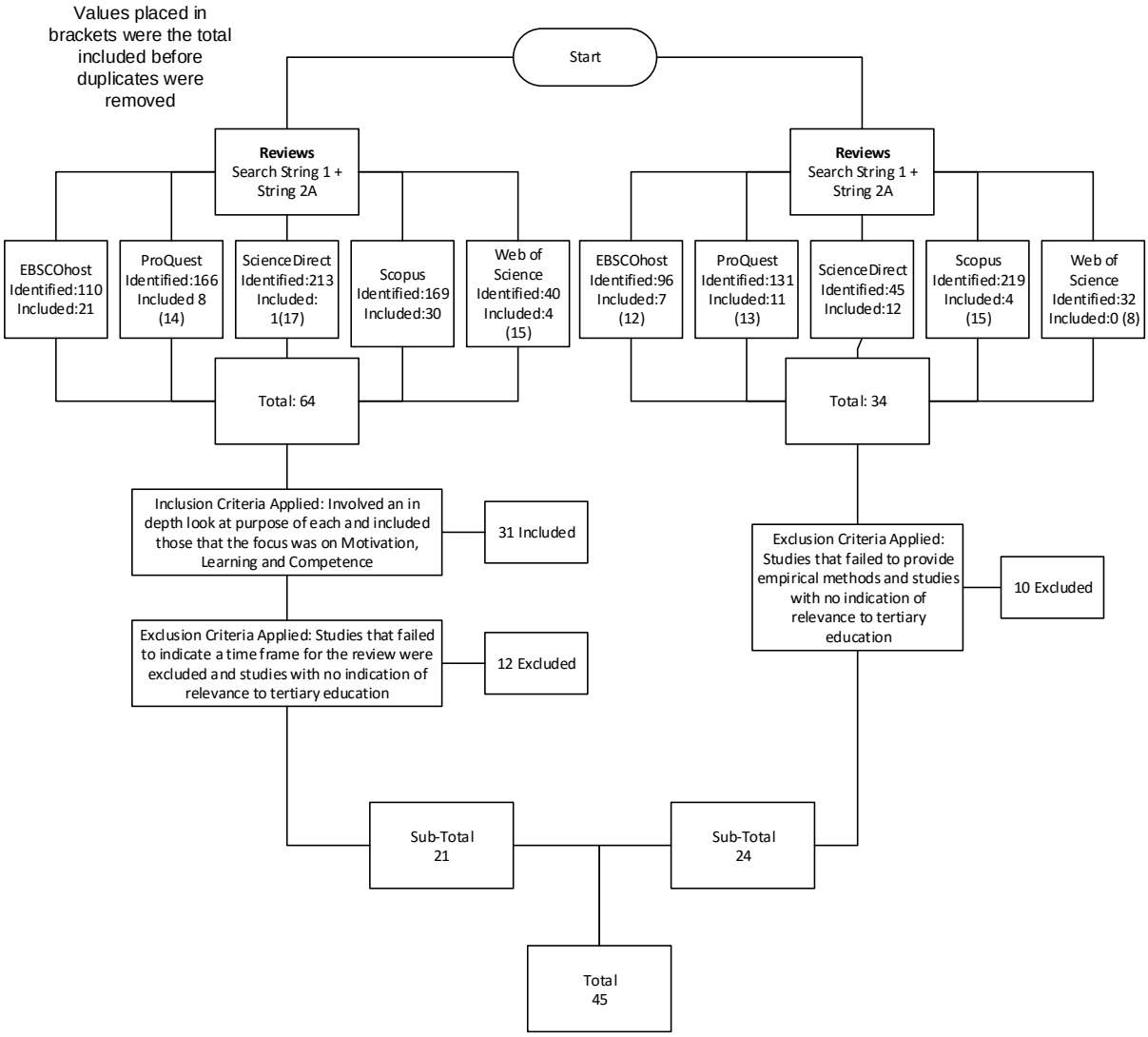
9 APPENDICES

9.1 APPENDIX A

9.1.1 Systematic Review Results and Flow Chart



9.1.2 Participant Information Sheet

Good day

M.Com Dissertation

Researcher: Thomas Grace (011 7178154)

Supervisor: Jason Cohen (011 7178164)

I, Thomas Grace, am an M. Com student in the School of Economic and Business Sciences at the University of the Witwatersrand. I am currently conducting a study titled: *Digital Game-Based Learning: Impacts on Students' Perceptions and Achievements in a Business Process Management Course.* The purpose of this study is to find out the perceptions of students towards Business Process Management (BPM).

I am asking whether you would be prepared to participate in my study. Participation in the study involves answering three online questionnaires. The first questionnaire will be made available during the lab session in week 1 of the BPM module and should take roughly 5 – 10 min to complete. It consists of 11 questions that relate to your perceptions towards BPM and 5 demographic questions, which include your age, gender, and past experience with digital games. The second questionnaire is identical to the first but will not include any demographic questions. It will be made available during your lab session in week 2 of the BPM module. The third questionnaire will be made available during the final lab session in week 3 of the BPM module. It consists of 24 questions regarding your perceptions of BPM and should take 10 – 15 min to complete. Participation also involves matching the survey responses with your grades for BPM.

You are hereby invited to participate in the study. Your participation in the study is voluntary and by submitting your completed questionnaire online you are granting the researcher permission to use your responses and to correlate them with your marks for the BPM course. You may refuse to participate or withdraw from the study at any time with no negative consequence. There will be no monetary gain from participating in the study.

If you consent to participate, you will be asked to complete the above-mentioned questionnaires using the SAKAI e-learning platform. This will allow me to match your responses from each of the questionnaires, as well as match your grades those responses. Once the matching process is complete, your student number will be replaced by a random identifier.

All responses will be treated strictly confidentially. This means that they will not be made available to any other third parties, including the course coordinator. I, and my supervisor, will be the only ones with access to your responses. Your anonymity will also be maintained in the reporting of all results by the researcher and will not be used for any purposes outside of this study. This means that your identities will be concealed in all of the resulting documents pertaining to this study.

If you have any questions or concerns about participating in the study, please contact me or my research supervisor at the numbers listed above.

Yours sincerely
Thomas Grace

9.1.3 Base-Line Questions

For each of the following statements, please indicate how true it is for you, using the following scale:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

		Perceived Competence
PC1	1	I think I am pretty good at business process mapping
PC2	2	I am pretty skilled at business process mapping
PC3	3	I am satisfied with my performance at business process mapping
PC4	4	I think I do pretty well at business process mapping, compared to others
PC5	5	I think I am good at business process mapping
PC6	6	After working at business process mapping for a while, I felt pretty competent.
		Intrinsic Motivation
IM1	7	I think business process mapping is quite enjoyable
IM2	8	I think business process mapping is very interesting
IM3	9	I think business process mapping is fun
IM4	10	While doing business process mapping I often think about how much I enjoy it
IM5	11	I think business process mapping is boring (-)
		Perceived Usefulness
PU1	12	I believe that using digital games to learn could be of some value to me
PU2	13	I think that using digital games to learn could be useful
PU3	14	I think using digital games to learn could be important
PU4	15	I would be willing to use digital games to learn because it could have some value to me
PU5	16	I think that using digital games to learn could be helpful
PU6	17	I believe that using digital games to learn could be beneficial to me
		Control
OSE1	18	I believe that I possess the necessary skills to pursue an IT career

Demographic Questions

1	Please Indicate your gender:	Male	Female	Prefer not to say				
2	Please Indicate your age range:	18-19	20-21	22-23	24+	Prefer Not to Say		
3	Indicate the frequency of your mobile gaming per week i.e. playing a game on a mobile phone or tablet	Never	1 Hour	2 Hours	3 Hours	4 Hours	5 Hours	6 or more Hours
4	Indicate the frequency of your PC gaming per week i.e. playing a game on a PC	Never	1 Hour	2 Hours	3 Hours	4 Hours	5 Hours	6 or more Hours
5	Indicate the frequency of your Console gaming per week i.e. playing a game on a console such as PlayStation of X-box	Never	1 Hour	2 Hours	3 Hours	4 Hours	5 Hours	6 or more Hours

9.1.4 End-line Questions

		Presence (Physical/Emotional/Narrative)
PRES1	1	When playing IBM's Innov8 2.0, I feel transported to another time and place
PRES2	2	Exploring IBM's Innov8 2.0 world feels like taking an actual trip to a new place
PRES3	3	When moving through IBM's Innov8 2.0 world I feel as if I am actually there
PRES4	4	I am not impacted emotionally by events in IBM's Innov8 2.0 (-)
PRES5	5	IBM's Innov8 2.0 was emotionally engaging
PRES6	6	I experience feelings as deeply in IBM's Innov8 2.0 as I have in real life
PRES7	7	When playing IBM's Innov8 2.0 I feel as if I was part of the story
PRES8	8	When I accomplished something in IBM's Innov8 2.0 I experienced genuine pride
PRES9	9	I had reactions to events and characters in IBM's Innov8 2.0 as if they were real
		Perceived Usefulness
PU1	10	I believe that using IBM's Innov8 2.0 to learn was of some value to me
PU2	11	I think that using IBM's Innov8 2.0 to learn is useful
PU3	12	I think using IBM's Innov8 2.0 to learn is important
PU4	13	I would be willing to use IBM's Innov8 2.0 to learn again because it has some value to me
PU5	14	I think that using IBM's Innov8 2.0 to learn is helpful
PU6	15	I believe that using IBM's Innov8 2.0 to learn could be beneficial to me
		Controls
IC1	16	Learning IBM's Innov8 2.0 controls was easy
IC2	17	IBM's Innov8 2.0 controls are intuitive
IC3	18	When I wanted to do something in IBM's Innov8 2.0, it was easy to remember the corresponding control
		Perceived Competence
PC1	19	I think I am pretty good at business process mapping
PC2	20	I am pretty skilled at business process mapping
PC3	21	I am satisfied with my performance at business process mapping

PC4	22	I think I do pretty well at business process mapping, compared to others
PC5	23	I think I am good at business process mapping
PC6	24	After working at business process mapping for a while, I felt pretty competent
		Motivation
IM1	25	I think business process mapping is quite enjoyable
IM2	26	I think business process mapping is very interesting
IM3	27	I think business process mapping is fun
IM4	28	At business process mapping I often think about how much I enjoy it
IM5	29	I think business process mapping is boring (-)
		Controls
OSE1	30	I believe that I poses the necessary skills to pursue an IT career

Additional Questions

1	Did you complete IBM's Innov8 2.0 successfully?	Yes	No	I am not sure
2	Did you play IBM's Innov8 2.0 more than once?	Yes	No	I am not sure
3	What was your final score for Innov8 2.0? (If you played the game more than once then take your highest score)			
4	Did you enjoy playing Innov8 2.0?	Yes	No	I am not sure

9.1.5 Permission Letter from the Registrar

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

OFFICE OF THE REGISTRAR

TO WHOM IT MAY CONCERN

"An evaluation of the impact of Digital Game-based Learning on student perceptions and achievements in Business Process Management"

It is hereby confirmed that the enclosed research material has been distributed in accordance with the University's approval procedures for such a project. Please be advised that it is your right to withdraw from participating in the process if you find the contents intrusive, too time-consuming, or inappropriate. The necessary ethical clearance has been obtained.

Should the University's internal mailing system be the mechanism whereby this questionnaire has been distributed, this notice serves as proof that permission to use it has been granted.

Students conducting surveys must seek permission in advance from Heads of Schools or individual academics concerned should surveys be conducted during teaching time.

Carol Crosley
University Registrar
4th March 2015

Private Bag 3, WITS 2050, South Africa | **T:** +27 11 717 1201/2 | **F:** +27 11 717 1217 | **E:** registrar@wits.ac.za

9.1.6 Ethical Clearance Certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Grace

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H15/02/26**
PROJECT TITLE	Evaluation of the impact of digital game-based learning on students' perceptions and achievements in business process management
INVESTIGATOR(S)	Mr T Grace
SCHOOL/DEPARTMENT	SEBS/
DATE CONSIDERED	20 February 2015
DECISION OF THE COMMITTEE	
EXPIRY DATE	8 March 2017

DATE 9 March 2015 **CHAIRPERSON** (Professor T Milani)

cc: Supervisor : Professor J Cohen

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature **Date** 13/03/2015

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

9.1.7 Assessments

All assessments were removed from the public copy and are available from the researcher by request.

9.2 APPENDIX B

9.2.1 Game Scores for IBM's Innov8 2.0

		Frequency
Score	9800	1
	9876	1
	10166	1
	10179	1
	10254	1
	10418	1
	10502	1
	10596	1
	10629	1
	11258	1
	11283	1
	11444	1
	11460	1
	11489	1
	11580	1
	11593	1
	11677	1
	11881	1
	13104	1
	13174	1
	13450	1
	Total	21

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Game Score	21	3650	9800	13450	11229.19	1055.619

9.2.2 Principal Component Analysis

9.2.2.1 Baseline Survey 1

In order to check for the adequacy of running PCA the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's Test of Sphericity were run. The Kaiser-Meyer-Olkin (KMO) test resulted in a sampling adequacy measure greater than 0.5 and the Bartlett's Test of Sphericity was significant. Individual item KMO tests, or the anti-image correlations, were all above 0.5 as well. This indicates that PCA was suitable.

9.2.2.2 KMO Bartlett Overall

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.730
Bartlett's Test of Sphericity	Approx. Chi-Square	168.927
	df	55
	Sig.	.000

9.2.2.3 KMO Individual Anti Image Correlations

Anti-image Correlation

	B1PC1	B1PC2	B1PC3	B1PC4	B1PC5	B1PC6	B1IM1	B1IM2	B1IM3	B1IM4	B1IM5
B1PC1	.731[a]	-.450	-.229	.009	-.204	-.356	-.269	-.168	-.211	.564	-.466
B1PC2	-.450	.828[a]	-.018	-.272	-.234	.199	.136	.020	.149	-.145	.190
B1PC3	-.229	-.018	.862[a]	-.062	-.086	-.271	-.057	.369	-.256	.037	-.051
B1PC4	.009	-.272	-.062	.883[a]	-.093	-.298	-.269	.143	.133	-.049	.019
B1PC5	-.204	-.234	-.086	-.093	.885[a]	-.341	-.061	.125	-.010	-.360	.104
B1PC6	-.356	.199	-.271	-.298	-.341	.689[a]	.510	-.437	.251	-.232	.389
B1IM1	-.269	.136	-.057	-.269	-.061	.510	.698[a]	-.486	-.227	-.050	.207
B1IM2	-.168	.020	.369	.143	.125	-.437	-.486	.715[a]	-.362	.028	-.400
B1IM3	-.211	.149	-.256	.133	-.010	.251	-.227	-.362	.686[a]	-.571	.439
B1IM4	.564	-.145	.037	-.049	-.360	-.232	-.050	.028	-.571	.554[a]	-.623
B1IM5	-.466	.190	-.051	.019	.104	.389	.207	-.400	.439	-.623	.465[a]

a. Measures of Sampling Adequacy(MSA)

9.2.3 End line Survey

In order to check for the adequacy of running PCA the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's Test of Sphericity were run. The Kaiser-Meyer-Olkin (KMO)

test resulted in a sampling adequacy measure greater than 0.5 and the Bartlett's Test of Sphericity was significant. This indicates that PCA was suitable.

9.2.3.1 KMO Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.582
Bartlett's Test of Sphericity	Approx. Chi-Square	556.172
	df	190
	Sig.	.000

9.2.4 Presence KMO Test

In order to check for the adequacy of running PCA the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's Test of Sphericity were run. The Kaiser-Meyer-Olkin (KMO) test resulted in a sampling adequacy measure greater than 0.5 and the Bartlett's Test of Sphericity was significant. This indicates that PCA was suitable.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.731
Bartlett's Test of Sphericity	Approx. Chi-Square	150.909
	df	36
	Sig.	.000

9.3 RESCORE FORMULA

The following formula was used to transform the scores for the composite scales of intrinsic motivation, perceived competence, perceived usefulness and occupational self-efficacy.

$$X_2 = \frac{(X_1 - Min_1)(Max_2 - Min_2)}{Max_1 - Min_1} + Min_2$$

$$Transformed\ Score = \frac{(Score - 1)(100 - 0)}{7 - 1} + 0$$

$$Transformed\ Score = \frac{(Score - 1)(100)}{6}$$

9.4 NORMALITY TESTS OF THE DIFFERENCES IN THE SCORES FOR THE T-TESTS

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
DIfference_IM_B1_E	.984	19	.978
DIfference_IM_B2_E	.955	13	.681
DIfference_IM_B3_E	.909	11	.239
DIfference_PC_B1_E	.945	19	.325
DIfference_PC_B2_E	.936	13	.408
DIfference_PC_B3_E	.918	11	.306
DIfference_PU_B2_E	.916	13	.222
DIfference_PU_B3_E	.847	11	.039

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

9.5 PLS TABLES

9.5.1 Model with Score 1

9.5.1.1 Factor Loadings

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
BPMTestScoreApril <- Score 1	1.000	1.000	0.000		
EIM1 <- IM	0.930	0.929	0.037	25.097	0.000
EIM2 <- IM	0.933	0.928	0.039	23.894	0.000
EIM3 <- IM	0.924	0.925	0.028	32.765	0.000
EIM4 <- IM	0.882	0.879	0.059	14.943	0.000
EIM5 <- IM	0.749	0.732	0.130	5.778	0.000
EPC1 <- PC	0.952	0.905	0.180	5.295	0.000
EPC2 <- PC	0.936	0.879	0.186	5.024	0.000
EPC3 <- PC	0.786	0.753	0.204	3.852	0.000
EPC4 <- PC	0.944	0.877	0.190	4.969	0.000
EPC5 <- PC	0.961	0.904	0.182	5.275	0.000
EPC6 <- PC	0.755	0.762	0.183	4.131	0.000
EPU1 <- PU	0.908	0.885	0.141	6.423	0.000
EPU2 <- PU	0.969	0.950	0.100	9.660	0.000
EPU3 <- PU	0.922	0.885	0.125	7.396	0.000

EPU4 <- PU	0.941	0.909	0.118	7.966	0.000
EPU5 <- PU	0.928	0.888	0.133	7.000	0.000
EPU6 <- PU	0.907	0.854	0.158	5.736	0.000
Emotinal_Pres <- PRES	0.872	0.865	0.072	12.045	0.000
Narrative_Pres <- PRES	0.604	0.576	0.253	2.386	0.017
Physical_Pres <- PRES	0.820	0.782	0.164	4.990	0.000

9.5.1.2 Cronbachs Alpha

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
IM	0.931	0.927	0.029	31.992	0.000
PC	0.951	0.951	0.013	73.274	0.000
PRES	0.681	0.640	0.190	3.577	0.000
PU	0.969	0.958	0.032	30.735	0.000
Score 1	1.000	1.000			

9.5.1.3 Path Coefficients

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
IM -> Score 1	0.568	0.504	0.312	1.817	0.069
PC -> IM	-0.177	-0.130	0.193	0.916	0.360
PC -> Score 1	0.084	0.044	0.272	0.310	0.756
PRES -> IM	0.945	0.920	0.193	4.893	0.000
PRES -> Score 1	-0.694	-0.605	0.513	1.354	0.176
PU -> IM	-0.195	-0.172	0.224	0.872	0.383
PU -> Score 1	0.146	0.113	0.315	0.464	0.643

9.5.2 Model with Score 2

9.5.2.1 Factor Loadings

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
BPMTestScoreApril <- Score 1	1.000	1.000	0.000		
BPM_Prac <- Score 2	1.000	1.000	0.000		
EIM1 <- IM	0.928	0.923	0.045	20.750	0.000
EIM2 <- IM	0.935	0.929	0.035	26.416	0.000
EIM3 <- IM	0.926	0.929	0.025	36.599	0.000
EIM4 <- IM	0.880	0.877	0.064	13.778	0.000

EIM5 <- IM	0.751	0.734	0.128	5.856	0.000
EPC1 <- PC	0.926	0.845	0.233	3.980	0.000
EPC2 <- PC	0.908	0.823	0.232	3.909	0.000
EPC3 <- PC	0.851	0.755	0.266	3.200	0.001
EPC4 <- PC	0.936	0.831	0.236	3.962	0.000
EPC5 <- PC	0.945	0.850	0.234	4.044	0.000
EPC6 <- PC	0.656	0.666	0.287	2.283	0.022
EPU1 <- PU	0.906	0.883	0.125	7.248	0.000
EPU2 <- PU	0.969	0.950	0.095	10.238	0.000
EPU3 <- PU	0.923	0.883	0.127	7.260	0.000
EPU4 <- PU	0.943	0.913	0.126	7.458	0.000
EPU5 <- PU	0.928	0.886	0.143	6.485	0.000
EPU6 <- PU	0.906	0.849	0.173	5.241	0.000
Emotinal_Pres <- PRES	0.869	0.863	0.073	11.929	0.000
Narrative_Pres <- PRES	0.617	0.571	0.252	2.447	0.014
Physical_Pres <- PRES	0.816	0.785	0.160	5.099	0.000

9.5.2.2 Cronbachs Alpha

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
IM	0.931	0.927	0.030	30.875	0.000
PC	0.951	0.952	0.013	72.727	0.000
PRES	0.681	0.636	0.194	3.511	0.000
PU	0.969	0.959	0.031	31.272	0.000
Score 1	1.000	1.000			
Score 2	1.000	1.000			

9.5.2.3 Path Coefficients

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
IM -> Score 2	0.430	0.342	0.463	0.929	0.353
PC -> IM	-0.133	-0.091	0.214	0.622	0.534
PC -> Score 2	0.236	0.133	0.322	0.734	0.463
PRES -> IM	0.922	0.908	0.192	4.797	0.000
PRES -> Score 2	-0.211	-0.129	0.609	0.347	0.729
PU -> IM	-0.197	-0.183	0.221	0.895	0.371
PU -> Score 2	-0.143	-0.095	0.347	0.412	0.680
Score 1 -> Score 2	-0.014	-0.039	0.317	0.045	0.964

9.5.3 Model with Score 3

9.5.3.1 Factor Loadings

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
BPM_Exam <- Score 3	1.000	1.000	0.000		
EIM1 <- IM	0.932	0.932	0.032	29.128	0.000
EIM2 <- IM	0.935	0.932	0.035	26.341	0.000
EIM3 <- IM	0.922	0.921	0.032	28.796	0.000
EIM4 <- IM	0.879	0.874	0.063	14.030	0.000
EIM5 <- IM	0.750	0.742	0.123	6.101	0.000
EPC1 <- PC	0.946	0.910	0.164	5.763	0.000
EPC2 <- PC	0.927	0.881	0.169	5.493	0.000
EPC3 <- PC	0.798	0.769	0.176	4.536	0.000
EPC4 <- PC	0.949	0.889	0.184	5.165	0.000
EPC5 <- PC	0.964	0.915	0.170	5.673	0.000
EPC6 <- PC	0.743	0.762	0.158	4.701	0.000
EPU1 <- PU	0.905	0.879	0.115	7.851	0.000
EPU2 <- PU	0.969	0.957	0.066	14.626	0.000
EPU3 <- PU	0.922	0.896	0.096	9.577	0.000
EPU4 <- PU	0.942	0.922	0.076	12.478	0.000
EPU5 <- PU	0.929	0.905	0.088	10.544	0.000
EPU6 <- PU	0.908	0.868	0.122	7.441	0.000
Emotinal_Pres <- PRES	0.854	0.831	0.129	6.611	0.000
Narrative_Pres <- PRES	0.620	0.575	0.283	2.191	0.029
Physical_Pres <- PRES	0.834	0.803	0.174	4.806	0.000

9.5.3.2 Cronbachs Alpha

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
IM	0.931	0.928	0.029	32.052	0.000
PC	0.951	0.951	0.013	72.875	0.000
PRES	0.681	0.638	0.193	3.531	0.000
PU	0.969	0.958	0.032	30.544	0.000
Score 3	1.000	1.000			

9.5.3.3 Path Coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
IM -> Score 3	-0.020	0.137	0.439	0.046	0.964

PC -> IM	-0.185	-0.136	0.188	0.981	0.326
PC -> Score 3	-0.130	-0.111	0.341	0.379	0.704
PRES -> IM	0.960	0.936	0.202	4.748	0.000
PRES -> Score 3	-0.095	-0.315	0.538	0.176	0.860
PU -> IM	-0.215	-0.190	0.224	0.959	0.338
PU -> Score 3	-0.018	0.062	0.339	0.052	0.958

9.5.4 Model with Score Total

9.5.4.1 Factor Loadings

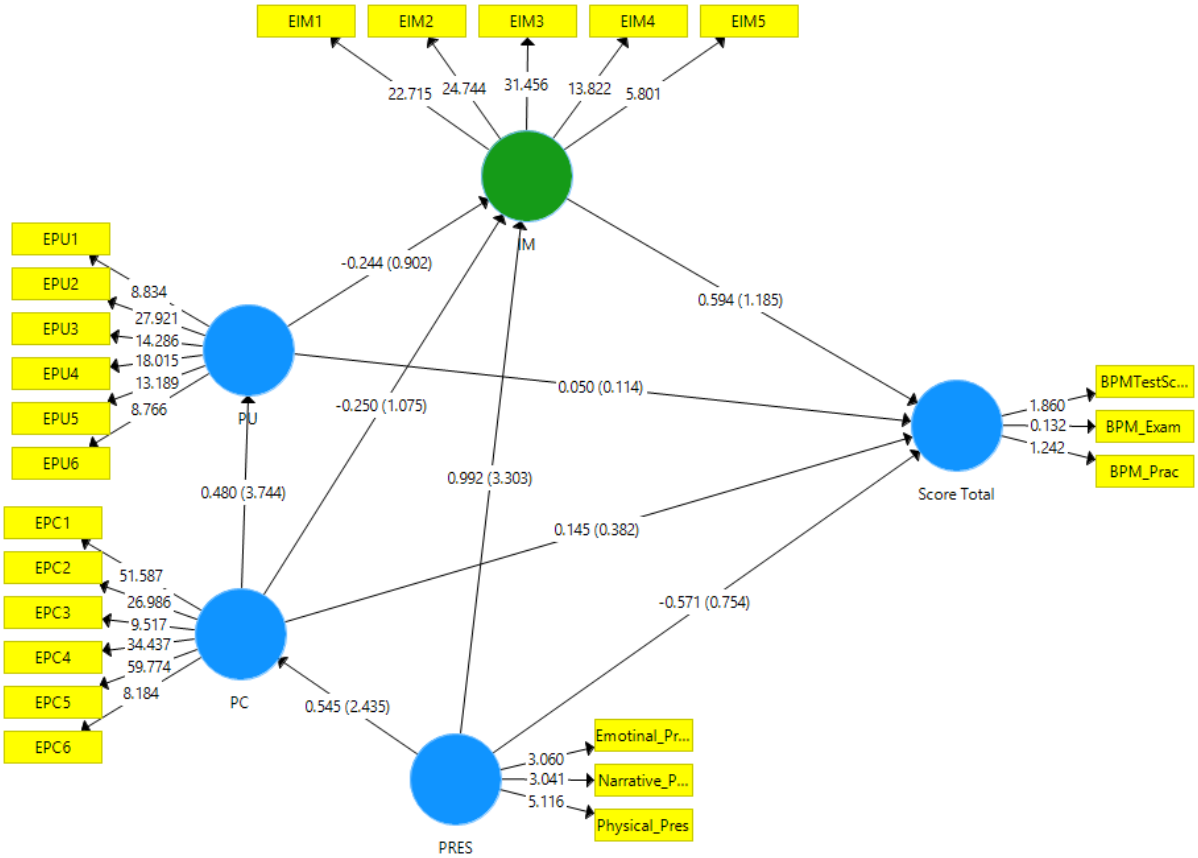
	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
BPMTestScoreApril <- Total Score	0.798	0.527	0.443	1.803	0.071
BPM_Exam <- Total Score	-0.073	0.236	0.583	0.125	0.901
BPM_Prac <- Total Score	0.660	0.284	0.494	1.335	0.182
EIM1 <- IM	0.928	0.925	0.041	22.465	0.000
EIM2 <- IM	0.932	0.929	0.035	26.305	0.000
EIM3 <- IM	0.927	0.928	0.028	33.524	0.000
EIM4 <- IM	0.883	0.880	0.061	14.456	0.000
EIM5 <- IM	0.747	0.737	0.128	5.824	0.000
EPC1 <- PC	0.938	0.835	0.370	2.535	0.011
EPC2 <- PC	0.924	0.812	0.360	2.563	0.010
EPC3 <- PC	0.812	0.688	0.375	2.168	0.030
EPC4 <- PC	0.947	0.810	0.368	2.573	0.010
EPC5 <- PC	0.954	0.835	0.375	2.544	0.011
EPC6 <- PC	0.678	0.704	0.343	1.979	0.048
EPU1 <- PU	0.907	0.870	0.171	5.292	0.000
EPU2 <- PU	0.969	0.944	0.154	6.295	0.000
EPU3 <- PU	0.922	0.883	0.161	5.730	0.000
EPU4 <- PU	0.941	0.909	0.158	5.975	0.000
EPU5 <- PU	0.929	0.888	0.158	5.869	0.000
EPU6 <- PU	0.907	0.852	0.177	5.116	0.000
Emotinal_Pres <- PRES	0.873	0.848	0.097	9.012	0.000
Narrative_Pres <- PRES	0.612	0.583	0.265	2.309	0.021
Physical_Pres <- PRES	0.813	0.788	0.172	4.719	0.000

9.5.4.2 Cronbachs Alpha

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
IM	0.931	0.928	0.029	31.892	0.000
PC	0.951	0.951	0.013	73.566	0.000

PRES	0.681	0.639	0.190	3.592	0.000
PU	0.969	0.958	0.032	30.028	0.000
Total Score	0.053	-0.022	0.423	0.124	0.901

9.5.4.3 Path Coefficients

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
IM -> Total Score	0.680	0.529	0.517	1.316	0.188
PC -> IM	-0.153	-0.132	0.216	0.706	0.480
PC -> Total Score	0.204	-0.069	0.379	0.539	0.590
PRES -> IM	0.933	0.922	0.203	4.596	0.000
PRES -> Total Score	-0.634	-0.532	0.712	0.890	0.374
PU -> IM	-0.192	-0.175	0.224	0.855	0.392
PU -> Total Score	0.022	0.109	0.412	0.053	0.958

9.5.5 Additional Model that includes interactions between PU and PC