MODELLING THE FACTORS THAT INFLUENCE COMPUTER SCIENCE STUDENTS' ATTITUDE TOWARDS SERIOUS GAMES IN CLASS

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Vanderbijlpark

November 2014

DECLARATION

I declare that:

"MODELLING THE FACTORS THAT INFLUENCE COMPUTER SCIENCE STUDENTS' ATTITUDE TOWARDS SERIOUS GAMES IN CLASS"

is my own work, that all the sources used or quoted have been identified and acknowledged by means of complete references, and that this dissertation has not previously been submitted by me for a degree at any other university.

____

M.J. Zeeman

November 2014

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To whom it may concern

This is to confirm that I, the undersigned, have language edited the completed research of M.J. Zeeman for the Master's dissertation entitled: *Modelling the factors that influence computer science students' attitude towards serious games in class*.

The responsibility of implementing the recommended language changes rests with the author of the dissertation.

Yours truly,

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ABSTRACT

KEY WORDS: serious games, programming, computer science, technology acceptance model, education.

Although the software development industry is one of the fastest growing sections in the labour market currently, computer science is one of the subject fields with the least growth in number of enrolments at tertiary institutions. Low enrolment figures and high dropout rates are common in computer science courses. Apart from the fact that programming is a difficult skill to master, irrelevant course material and outdated teaching and learning strategies could be to blame for this phenomenon. When comparing modern technology with which young people engage outside the class room to the stereo typed old fashioned technology they are confronted with inside classrooms, it is discouraging.

Games have been identified as a powerful and effective tool to create an attractive learning environment. Students find the competitive, fast-paced and interactive environment which serious games provide appealing. Progress has recently been made in incorporating digital educational (serious) games into the learning environment. Research on understanding the value that serious games can add to learning in computer science courses is limited. The purpose of this study is to address this issue by investigating the characteristic of serious games and establish the value these can add to learning in the computer science class. The identified characteristics were utilised as external variables in the technology acceptance model (TAM) in order to determine the students' attitude towards the use of serious games in the computer science class. The TAM is a well-known predictor of the users' attitude towards perceived usefulness and perceived ease of use as the internal factors motivating the acceptance of technology. These internal factors can be influenced by external factors which may differ in accordance to the technology being evaluated.

The target population of this study comprised full-time computer science students enrolled at South African registered public higher education institutions (HEIs). For this study, a convenience sample of 547 computer science students was drawn from one traditional university and one university of technology. These two universities were selected by means of a non-probability judgement method. A self-administered questionnaire was hand-delivered to lecturers at each of the two HEIs. The questionnaire requested the participants to indicate on a six-point Likert scale the level of their agreement or disagreement on 41 items, designed to measure their attitude towards the use of serious games in the computer science

class.

Findings from this study suggest that computer science students exhibit a positive attitude towards using serious games in class. Usefulness was identified as the most significant internal variable predictor of attitude, with relevance to classwork, as the most significant external predictor of usefulness. Relevance of serious games to class work emerged as the strongest predictor of ease of use, followed by experienced and perceived enjoyment.

Insights gained from this study will assist educators in designing and planning the implementation of serious games as part of the learning experience in class. Furthermore, educators can gain insights from the factors that students indicated to be the most significant in terms of serious game in class. The proposed model can be used by educators to evaluate the attitude of computer science students towards the implementation of a serious game in class.

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CHAPTER 1
INTRODUCTION AND PROBLEM STATEMENT

1.1 INTRODUCTION

According to the US Bureau of Labour Statistics, occupations in software development is one of the fastest growing sections in the US labour market with a projected growth in computer software design occupations of 45.3 per cent up to the year 2018 (Jackson & Moore, 2012:1). Yet computer science is one of the subject fields with the least growth in the number of enrolments at tertiary institutions. Over the past two decades several institutions worldwide have reported a trend of notable decline in enrolments for computer science (Gomes & Mendes, 2010:113; Heersink & Moskal, 2010:446; Muratet *et al.*, 2011:61). In South Africa the number of enrolments at tertiary institutions is steadily growing. However, the number of enrolments for computer science courses has grown with a disappointing three point four per cent compared to a robust increase of 27.4 per cent in all subjects from 2005 to 2010 (Kirlidog *et al.*, 2011:, unpublished). The fact that low enrolment figures are common in computer science courses despite a technology driven society is a matter of serious concern to educationalists. Kurkovsky (2013:138) blames irrelevant course material and learning content for the state of affairs and for the "ongoing enrolment crisis in computer science".

Peters and Pears (2012:979) summarise views of various authors on possible reasons for a decline in interest in a studying computer science. One of the major problems reported is the perception that programming is a difficult skill to master. This can be due to the fact that within the programming environment, students are required to apply higher order thinking skills which include the ability to solve problems (Kotovsky, 2003:373). Nag *et al.* (2013:146) state that one of the fundamental skills students have to master in today's digital environment is the ability to solve problems. Persistence to attempt to solve problems improves when students are motivated and interactively involved in what they are doing (Stanescu *et al.*, 2011). Furthermore, presenting programming problems within a meaningful context has motivational value and is supportive in assisting students to have a better understanding of what proper solutions should entail (Tan & Rahaman, 2009:153). Solutions to problems in a programming environment are developed and presented in the form of algorithms. In a discussion on how to teach students algorithms in a way that make sense to them, Shabanah and Chen (2009:2) confirm that with difficult concepts such as the algorithms and solution design, knowledge should be conveyed within a meaningful context. Within a challenging and interesting scenario, students become involved and engaged in the concept they need to comprehend. A game testing the speed and other required attributes of a specific algorithm is more effective to encourage students to want to know more about the algorithm than simply requiring students to test the algorithm's attributes for academic purposes as required in a traditional classroom. The traditional classroom does not provide an interactive engaging environment and is often teacher-centred rather than student-centred (Gros, 2007:25).

Requirements pertaining to learning in the twenty first century have changed while education systems have remained the same (Conneely *et al.*, 2012:2). Students are used to digital ways of communicating and learning, and acquiring knowledge via various technologies such as the Internet and social media (Nag *et al.*, 2013:146). The difference between the modern up to date technology they are accustomed to outside the classroom and the stereotypical old-fashioned technology they are confronted with inside classrooms is rather discouraging for students (Husain, 2011:1). According to Prensky and Berry (2001:3), students who grew up in an advanced digital environment think and learn differently in comparison to previous generations. These students are used to a fast paced digital environment and are often are demotivated by the time and effort it takes to become skilled in computer programming. As a result they find it boring to learn how to program (Ali & Smith, 2014:62).

Education needs to adapt to the changing environment, keep students engaged in the classroom and learning relevant to the requirements of the changing world (Kaiser & Wisniewski, 2012:138). Furthermore, the digital world students live in, expects and encourages them to be active participants rather than passive observers (Prensky, 2001b:11). Therefore a change in teaching strategy is required to meet the needs of the new generation of digitally oriented students.

Games have been identified as a powerful and effective learning environment (Wrzesien & Alcañiz Raya, 2010:179). Studies reveal that participatory, sensory-rich environments and experiential or discovery-based learning activities will appeal to today's students because of their constant engagement with technology (Heersink & Moskal, 2010:446; Husain, 2011:1; Shaffer *et al.*, 2005:3). Implementing environments with innovative student-centred learning supported by serious games for example, is vital since old-fashioned education no longer appeals to today's students (Rooney, 2012:1). Heintz and Law (2012:245) recognise the progress that has been made in incorporating digital games into the learning environment.

However, these authors express concern about the lack of research on understanding the aspects of digital educational games which add value to learning. They emphasise the importance of how students perceive games in order to ensure that game play is implemented effectively as part of the learning environment.

A change in teaching strategy by introducing new technology such as serious games involves time and effort to develop and introduce successfully in class. Although the need for change is evident, the positive attitude of potential users plays a major role in the acceptance of technology (Venkatesh & Bala, 2008:274). A commonly known measuring instrument known as the technology acceptance model (TAM) is widely used to test the attitude of potential users towards the acceptance of new technology. The TAM developed by Fred Davis in the late 1980s evaluates a user's internal beliefs, attitude and intentions to behave in a specific way when presented with new technology (Davis, 1989; Lai *et al.*, 2012; Legris *et al.*, 2003; Mathieson, 1991; Teo, 2009). The TAM is used to predict whether the user will accept and make use of the proposed technology (Turner *et al.*, 2010:464). In this study factors that are required to complete a course in computer science successfully are identified based on an extensive literature study. Students' perceptions on how well serious games would address and enhance the learning in the computer science class are evaluated, and an adapted TAM is developed based on responses from participants to the identified factors that influence students' attitude towards games in the computer science class.

1.2 PROBLEM STATEMENT

Kurkovsky (2009b:44) argues that in the changing digital environment the computer science curriculum should continue to be applicable and relevant to reality today. There should be a strong connection between computing and students' everyday involvement with technology. Literature reveals limited empirical evidence supporting the assumption that students in tertiary education will embrace the idea of serious games in class. Most studies focus on serious games in education targeting younger age groups (school children) (Denner *et al.*, 2012; Nag *et al.*, 2013; Yang, 2012). These studies demonstrate largely positive attitudes of younger age groups towards serious games in class. However, students in tertiary education may have different profiles, requirements, prospects and perceptions than younger aged groups. Furthermore, a limited number of studies focus on the application of serious games in computer science. Most studies investigate the use of serious games in other fields of application such as social matters (Lenhart, 2008:6) and language skills (Yusoff, 2010:2). The purpose of this study is to determine the factors that influence the attitude of students towards serious games in the computer science class.

1.3 RESEARCH OBJECTIVES

1.3.1 Primary objective

The primary objective of this research is to identify and model the factors that influence the attitude of students in computer science towards serious games in class.

1.3.2 Theoretical objectives

In order to achieve the primary objective, the following theoretical objectives have been formulated for this study.

- Research the literature to gain a better understanding of the concept of serious games and their current status and role in education.
- Research the literature on the characteristics and potential of serious games to enhance learning in the computer science class.
- Research the current status of computer science and requirements to master computer science and programming skills
- Research the literature on the TAM as an instrument to identify the factors that influence the attitude of students towards the use of serious games in the computer science class.

1.3.3 Empirical objectives

To achieve the primary objective, the following three empirical objectives will be addressed.

- Investigate internal technology acceptance factors that could influence the attitude of computer science students towards the use of serious games in class.
- Investigate external factors that could influence the attitude of computer science students towards the use of serious games in class.
- Propose a model that presents factors that influence the attitude of computer science students towards the use of serious games as a possible teaching approach in a computer science class.

1.4 RESEARCH METHODOLOGY

The study will comprise a literature review and an empirical study.

1.4.1 Literature review

The objective of the literature review will be to identify key issues that could be significant in influencing the attitude of students towards serious games in computer science education. The literature study will be done in order to investigate the use of serious games as a possible teaching and learning approach in the computer science class.

1.4.2 Empirical study

Quantitative research using the survey research method will be conducted during the empirical part of the study. Questionnaires will be used to gather data. The collected data will be analysed and discussed. Factors that could have an influence on the attitude of computer science students towards the use of serious games in class will be modelled.

1.4.3 Target population

The target population for the study is full-time undergraduate computer science students registered at South African higher education institutions (HEIs).

1.4.4 Sampling frame

The sampling frame comprised 23 registered Higher Education Institutions (HEIs) in South Africa listed by Higher Education in South Africa (Higher Education in South Africa, 2013). Two higher education institution campuses in the Gauteng province were selected from the sampling frame as they contain a large number of the South African student population. The two HEI campuses comprise a traditional university and a university of technology. Full-time computer science students enrolled at the two HEIs were selected using convenience sampling.

1.4.5 Sampling method

A non-probability, convenience sample of undergraduate full-time computer science students was drawn from the sampling frame. A structured self-administered approach was followed. Permission was obtained from the managers of the faculties at the institutions and lecturers of the appropriate classes to do the survey. The lecturers on both campuses were contacted and convenient days and times were decided on over a period of one week during the month of October 2013. This time frame was decided on to ensure that all participants had been exposed to at least one year of studying computer science subjects. Exposure to at least one year of studies in the field of computer science would enable students to be in a better position to have an opinion on the use of technology in the computer science class. The lecturers were informed that the completion of the questionnaire was on a voluntary basis only, and that it was anonymous. Full-time undergraduate computer science students were requested, during the scheduled class times, to complete the self-administered questionnaires.

1.4.6 Sampling size

A sample size of 547 students from the two HEIs was considered sufficiently large. For the purpose of this study, 303 full-time undergraduate computer science students from a traditional university and 244 full-time undergraduate computer science students from a university of technology participated. A group of 27 third year full time computer science students from a traditional university was used in the pilot study.

1.4.7 Measuring instrument and data collection

A structured self-administered questionnaire was used to collect data. The questionnaire was compiled based on an extensive literature review on the use of serious games in a teaching and learning approach in computer science classes, factors that enhance learning in the computer science class and factors that motivate users to accept technology such as games in a learning environment. Scales that were compiled, tested and validated by various researchers in the field of acceptance of technology, were adapted and used in this study.

1.4.8 Statistical analysis

The collected data were captured and thereafter analysed using the statistical software package Statistical Package for Social Sciences (SPSS) version 21 for Windows and SAS. The statistical methods used to analyse the empirical data sets were reliability and validity analysis, descriptive analysis, factor analysis, significant tests, correlation and regression.

1.5 ETHICAL CONSIDERATIONS

Permission was obtained from the heads of departments of both universities to conduct this study which involved the participation of full-time undergraduate computer science students who were enrolled at the two afore mentioned universities at the time when the study was conducted. The following ethical principles were adhered to as recommended by the International Development Research Centre (2011).

> Before an individual becomes a subject of research, he or she shall be notified of the purpose, methods and anticipated benefits of the research; his or her right not to participate in the research and to terminate at any point in time; and the confidential nature of the research.

1.6 CHAPTER CLASSIFICATION

The layout of the study is as follows.

Chapter 1 briefly introduces the status of computer science in education, the use and acceptance of technology such as serious games in education and leads to a problem statement with specific objectives.

Chapter 2 explores the literature and provides a detailed discussion on serious games and the role of serious games in education. This discussion is followed by an overview of the status of computer science education and distinctive features in computer science education. The TAM is discussed with reference to its main features, which can be used to predict the acceptance of technology such as serious games in class.

Chapter 3 defines research methodologies and motivates the research approach, methodology and data collection instrument used in this study. It includes the construction of the measuring instrument and specific measuring items with reference to validated TAM measuring items.

Chapter 4 reveals the findings and provides an analysis and interpretation of the empirical findings and the proposed model.

Chapter 5 entails a discussion on conclusions and recommendations.

CHAPTER 2
SERIOUS GAMES AND COMPUTER SCIENCE

2.1 INTRODUCTION

Interactive media is often viewed as a fresh and more engaging approach in teaching than traditional media (Stanescu *et al.*, 2011). Learners find it more fun to interact with content presented in an appealing and interactive format. According to Prensky (2001b:7), digital game-based learning holds potential for people both as children and as adults. Although a number of serious games are available to support the teaching of introductory programming (Kazimoglu *et al.*, 2012:1993), the attitude of users often determines the rate of success when new concepts and technology are implemented in practice (Venkatesh & Bala, 2008:274). In this study, the aim is to investigate the activity of gaming among computer science students and their attitude towards embracing serious games as part of the learning experience in the computer science class.

This chapter explores the literature on which this research is based and is divided into three sections. The first section comprises a thorough discussion on serious games and the progress that has been made in incorporating these games in the classroom. In the second section skills required to master computer programming are discussed. Aspects in computer science, which can be addressed by means of playing serious games, are discussed and also the role serious games play in learning. The TAM is discussed in the third section. This discussion includes an overview of the development of the TAM and application of the model in a variety of fields. Modelling of aspects that influence user motivation towards the use of new technologies such as serious games in education is discussed.

2.2 SERIOUS GAMES

Young people in the present day play more digital games than previous generations (Yusoff, 2010:1). A survey that was conducted from 2007 to 2008 in the US revealed that 97 per cent of young people regularly play computer, web, portable or console games (Lenhart, 2008:1). Initially the amount of time young people spend on playing video games was criticised, but this perception has changed in recent years. The Entertainment Software Association in the US found that during 2010, 64 per cent of the parents of young people regarded the playing of video games to be a positive activity their children engage in (Cheng & Annetta, 2012:204). Recent developments in multimedia technologies such as video and computer games for educational purposes have paved the way for new and exciting ways digital games can be incorporated into education (Girard *et al.*, 2013:207).

2.2.1 Definition and scope of serious games

The concept of games in education was first referred to as serious games by the author of the book titled Serious Games (Ricciardi & De Paolis, 2014:2). The author describes a game as "an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context" (Abt, 1970:6). The author admits, however, that a serious game is not always a contest and that winning is not always the main objective in a serious game. In the educational context, the objective is mainly to motivate, inspire and learn.

To learn is a core objective of education. The aim of games in education is to combine the objective to learn with the entertainment features of the gaming (Azadegan & Riedel, 2012:1; Girard *et al.*, 2013:208; Ricciardi & De Paolis, 2014:2; San Chee *et al.*, 2010:2). However, the serious games concept is ill-defined in literature (Susi *et al.*, 2007:1). One of the most frequently used definitions describes serious games as "interactive digital games with the intention of being used for more than mere entertainment" (Ritterfeld *et al.*, 2009:6) while some researchers describe serious games as "computer games with non-entertainment purposes" (Senevirathne *et al.*, 2011:1; Szczesna *et al.*, 2011:1). Chen and Michael (2005:21) define serious games as "games that do not have entertainment, enjoyment, or fun as their primary purpose". Zyda (2005:26) provides a version of the definition of serious games, which includes a list of various sectors of society that serious games apply to:

> Serious game: a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.

Although entertainment is regarded as a characteristic of serious games, Marsh (2011:61) argues that serious games do not fit into the category of games in the traditional sense of entertainment and fun. The spectrum of computer games shown in Figure 2.1 distinguishes between games played for pure entertainment at one end of the spectrum and realistic games simulating scenarios with the intent to train the game player at the other end (Ricciardi & De Paolis, 2014:2).

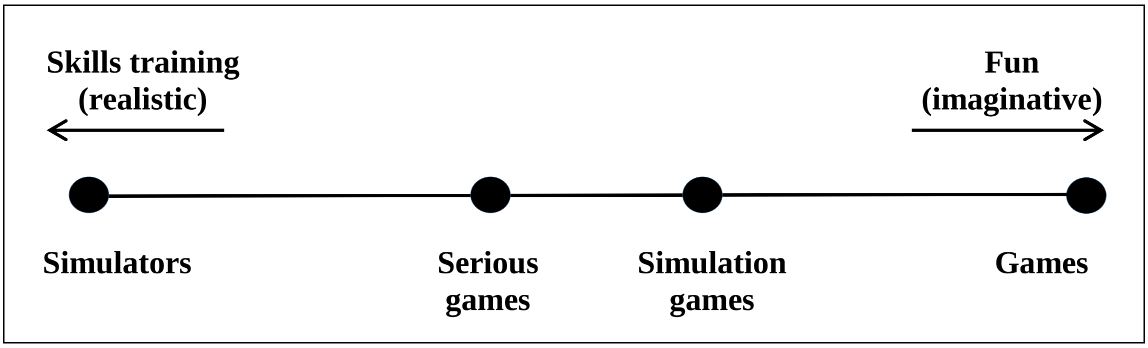


Figure 2.1: The computer game spectrum (Ricciardi & De Paolis, 2014:2)

In a discussion on the difference between video games and serious games, Zyda (2005:25) points out that pedagogy is the differentiating factor (Figure 2.2). Zyda (2005:25) defines video games as "a mental contest, played with a computer according to certain rules for amusement, recreation, or winning at stake". The elements of a video game pertain to a story line, art and software as shown in Figure 2.2. These elements are required in serious games as well, with specific focus on the purpose of learning and conveying knowledge.

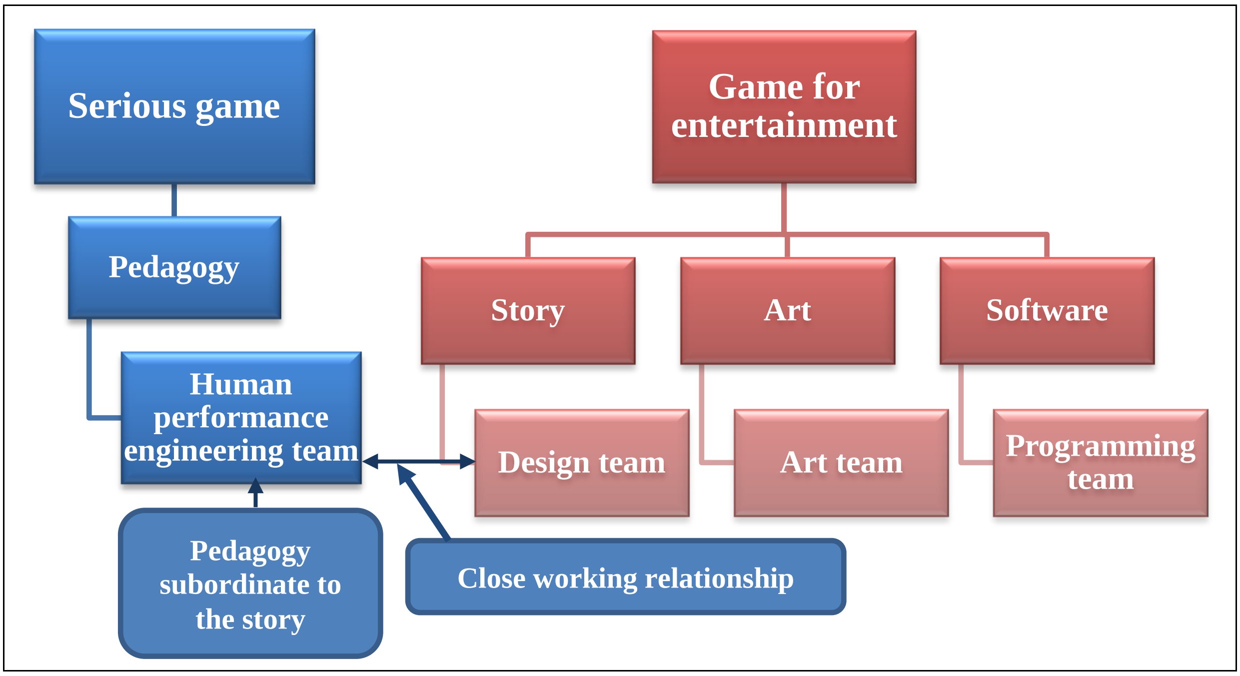


Figure 2.2: From game to serious game (Adapted from Zyda, 2005:26)

Educational activities are an integral part of the serious game play experience, which entails the application of educational principles and pedagogy (Zyda, 2005:26). Experts should be consulted on the subject matter players need to be educated or trained on, while instructional scientists should be involved in the design of the serious game. These experts form part of a human performance engineering team. Experts on story-telling, graphic design and development of software should be involved in planning and designing games, which engage and inspire players to play the game. There should be a close working relationship between these teams as indicated in Figure 2.2. Table 2.1 lists differences between games for entertainment and serious games.

Table 2.1: Differences between entertainment games and serious games (Susi *et al.*, 2007:6)

	Serious games	**Entertainment games**
Task vs. rich experience	Problem solving in focus	Rich experiences preferred
Focus	Important elements of learning	To have fun
Simulations	Assumptions necessary for workable simulations	Simplified simulation processes
Communication	Should reflect natural (i.e. non-perfect) communication	Communication is often perfect

Serious games can contain different levels of gaming elements to the extent where gaming elements can be absent (Marsh, 2011:63). Serious games without gaming elements in the sense of fun and entertainment often deal with complex issues such as drug abuse, health and sexual safety. These issues are addressed mostly in an interactive story-telling way where the player makes decisions that affect the outcomes of specific situations. The ability to simulate the real world in the digital environment contributes to the fact that serious games can move away from a purely game play scenario towards creating an experience in a virtual world. Therefore, Marsh (2011:63) defines serious games as "digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, game play or encounters to inform, influence, for well-being, and/or experience to convey meaning".

2.2.2 Overview and background of serious games

The use of computer games in education has recently gained strong momentum. However, playing games to achieve educational goals is not new (De Grove *et al.*, 2010:107; Flynn & Newbutt, 2006:1; Nag *et al.*, 2013:147). As far back as 1887, a board game known as *Kriegspiel* was used by the German army in military training programs to teach soldiers strategies of war by manoeuvring small battleships on a map to outplay the enemy (Macedonia, 2002:36). In 1929, a flight simulator known as the Blue Box was used initially in an amusement park for entertainment purposes but was taken over by the US army and used to train pilots during World War II. With the release of the first video game − *Spacewar!* − in 1962 (Cheng & Annetta, 2012:203), educationalists realised the potential educational value of video games (Shaffer *et al.*, 2005:3). Various ways of incorporating video games into lesson plans were explored. With the fast developing computer technology and its multimedia features, concepts such as edutainment and game-based learning came to the fore, which emphasised the fact that learning can take place in a fun way. Edutainment is regarded as the first of three generations in the history of the development of computer games in education as categorised by Egenfeldt-Nielsen (2005:2) in Figure 2.3.

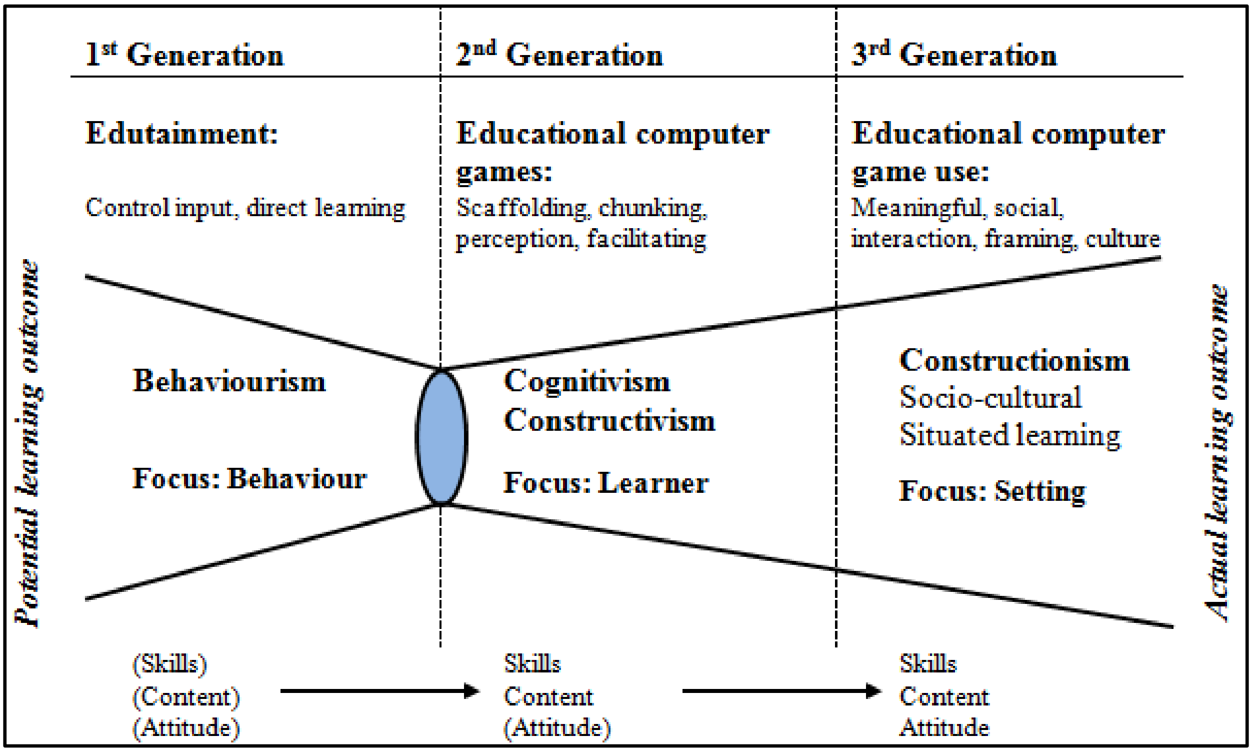
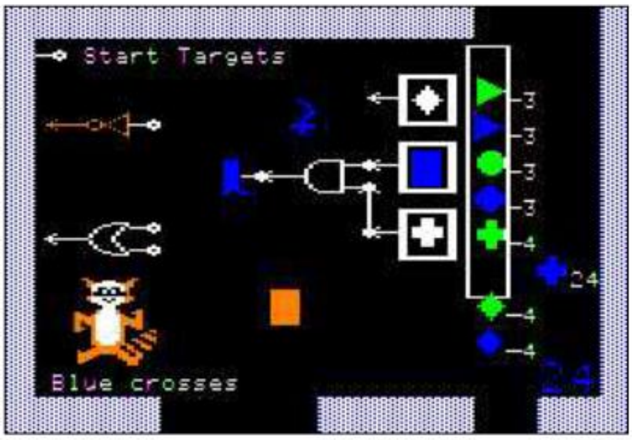


Figure 2.3: Characteristics of different generations of educational game development and applied learning theories (Egenfeldt-Nielsen, 2005:2)

According to Egenfeldt-Nielsen (2005), the three educational generations of game-development namely edutainment, game-based learning and digital contextualised game-based learning, are influenced strongly by technology and the changing profile of the technology-wise generation of learners. The first generation, edutainment, came about in the era of multimedia in the computer industry and entails "any kind of education that also entertains" (Susi *et al.*, 2007:2). Edutainment uses conventional learning theories such as control and direct learning. The content is strictly bounded by a curriculum with young children as the primary target audience (Egenfeldt-Nielsen, 2005:9). Many games categorised as edutainment failed due to these strictly controlled features and boundaries. Figure 2.4

shows images from some of the more successful educational games from the 1980s. *Rocky Boots* teaches children logical thinking skills within the context of an elementary simulated environment (Burbules & Reese, 1984:3). The game *Where in the world is Carmen Sandiego* is an adventurous game about geography while *Oregon Trial* is an adventurous game about social studies.



Rocky Boots (1982)

Where in the world is Carmen Sandiego (1985)

Oregon Trial (1985)

Figure 2.4: Three educational games categorised as edutainment from the 1980s (Egenfeldt-Nielsen, 2005:43)

The games shown in Figure 2.4 were popular during the 1980s. Players were allowed the freedom to explore and learn within the simulated environments these games provided. However, many games from this era contain repetitive exercises focussing on lower order thinking skills and basic facts and concepts (Gros, 2007:25).

According to Van Eck (2006:3), the "drill-and-kill" approach that was followed caused edutainment to be described as boring rather than entertaining. Therefore, edutainment failed to answer the needs of an emerging game-playing, digitally wise generation of learners.

During the next generation of educational game-development, referred to as game-based learning type of games, focus shifted towards the player and the relationship between the player and the game – how players can be motivated and engaged while still achieving the set learning outcomes (Egenfeldt-Nielsen, 2005:80).

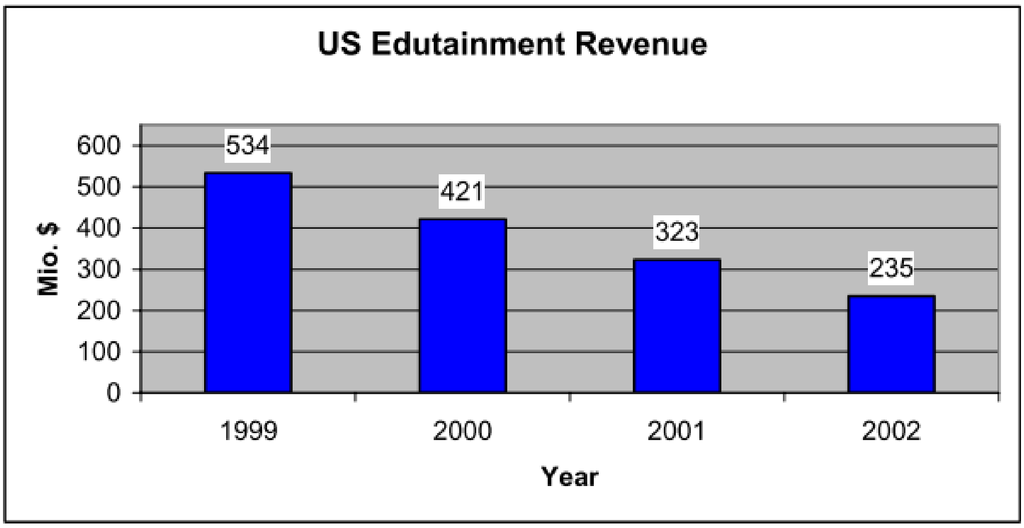


Figure 2.5: Decline in edutainment revenue over the period 1999 to 2002 (Egenfeldt-Nielsen, 2005:80)

During this phase of educational game development, much effort went into stimulation of both intrinsic and extrinsic motivation levels of players. Intrinsic motivation results in players being self-motivated to learn how to play a game and complete challenges the game presents. Extrinsic motivation involves motivation and approval from family and friends to play educational games. Despite efforts to create motivational learner-centred educational games, interest in the edutainment declined quite rapidly with the turn of the century as shown in Figure 2.5, which shows sales figures from the edutainment industry in the US from 1999 to 2002. These sales figures show a steady decline in edutainment revenue. A different approach was required in educational game development. (Gros, 2007:25) argued that more emphasis should be placed on a cognitive approach and on presenting information within the appropriate context to convey required learning goals.

While the educational game industry was not doing well in the early 2000s, a group of game developers were working on games to teach players to attain skills required for the military. Their game, *America's Army*, was released in the year 2002 and was aimed at soldiers from the US military who need to be trained for combat. It is an interactive game simulating a virtual environment matching combat in real life. Soldiers experience combat virtually prior to being exposed to real life warfare (Flynn & Newbutt, 2006:3). Their new, fresh and engaging approach initiated a new way of thinking about games in education (Zyda, 2005:26). This group of game developers officially coined the term serious games (Annetta *et al.*, 2013a:54). Similar games were developed for training health workers on the treatment of seriously ill patients. With this initiative, as well as the release of more advanced software, the third generation in game development was born. Games are placed in context, which enriches the game experience (Egenfeldt-Nielsen, 2005:80). Furthermore, peer-collaboration is promoted and construction of knowledge is enforced in a fun way. A social context of collaboration is promoted where the teacher or instructor takes up the role of facilitator (Gros, 2007:25), which results in a learner-centred teaching strategy. Figure 2.6 shows two popular serious games, which adhere to the aforementioned features of third generation game developers.

Figure 2.6: Concrete experiences from two generation 3 virtual games – images from Grand Theft Auto 3 on the left and Sim City 4 on the right (Egenfeldt-Nielsen, 2005:80)

Third generation digital context-based educational games evolved over the past decade (De Grove *et al.*, 2010:107). The concept of creating a virtual world for the purpose of conveying knowledge and skills was accepted favourably by society. As a result, the Woodrow Wilson Centre for International Scholars in Washington, DC founded the Serious Games Initiative the same year that the game, *America's Army,* was released. The Serious Games Initiative describes its mission as follows:

> The Serious Games Initiative is focused on uses for games in exploring management and leadership challenges facing the public

sector. Part of its overall charter is to help forge productive links between the electronic game industry and projects involving the use of games in education, training, health, and public policy.

Although the educational game industry was not doing well at the turn of the century, the establishment of the serious games concept and the ability to create games in a virtual world turned the situation around. Many companies and educational institutions now believe in the potential of serious games (Annetta *et al.*, 2013b:53). This is evident from the involvement of a game franchise such as *Carmen Sandiego* in the development of serious games to teach subjects such as history and geography in a fun way (Lenhart, 2008:3). The net sales of 442 million US dollars of the technology-based educational game called *Leapfrog* in 2007 emphasise the popularity and success of serious games. In North America and Europe, more than 1.4 billion dollars were spent on subscription to massive multiplayer online role-playing games (MMORPGs) in 2008 (Nag *et al.*, 2013:148). MMORPGs refer to role-playing video games within virtual worlds where large numbers of players interact with one another.

2.2.3 Serious games in education

The youth are comfortable to interact with technology and video games (Heersink & Moskal, 2010:446). They constantly explore and invent creative ways to use technology in their everyday lives (Gros, 2007:23; Kaiser & Wisniewski, 2012:137; Yusoff, 2010:10). However, literature reveals that the educational environment is not keeping up with technology in the classroom (Kaiser & Wisniewski, 2012:137; Kurkovsky, 2009a:92; Shaffer *et al.*, 2005:3). Prensky (2001b) states in chapter one of his book titled "Digital Game-Based learning", that in the training environment trainers and trainees are from two different worlds and that educators are attempting to educate a new generation by using ineffective tools and outdated ways to educate and train (Prensky, 2001b:7). As a result, trainers find it hard to communicate with students and motivate them to participate and experience high levels of frustration. Trainees, on the other hand, describe training as boring. Prensky (2008:40) is of the opinion that students experience the classroom as a dull place in comparison to the technology they engage in outside the classroom. Prensky (2008:42) comments on the contrast between the difference in technology applied inside and outside the classroom with the statement, "When kids come to school, they leave behind the intellectual light of their everyday lives and walk into the darkness of the old-fashioned classroom."

The Kaiser Family Foundation (KFF) found that 92 per cent of young people aged two to seventeen play video games. In the age group eight to eighteen, young people spend nearly two hours per day playing video games (Husain, 2011:1). Playing computer games is a common activity amongst most students (Becker, 2001:22). Annetta *et al.* (2013a:3) interviewed a group of high school students from a science class who admitted that they would neglect their schoolwork in favour of playing computer games. The excessive interest students have in playing computer games inspired the launch of a pilot project in 2005 in the United States to promote CS-STEM (an acronym for Computer Science (CS), Science, Technology, Engineering and Mathematics) education amongst high school students using serious games. As part of the project, a creative gaming platform was developed for education. Teachers were encouraged to use the gaming platform and develop their own subject-based games. These games were used in class to stimulate learners' interest in science. As a direct result of using games as a teaching tool in class, some of the girls showed an increased interest in science subjects such as physics.

The next phase of the project showed promising results in terms of computer programming and creative thinking skills. Students were asked to evaluate some of the games their teachers developed. Although the learners enjoyed playing the games, they were critical and made many valid and useful suggestions to improve the games. It was decided to allow the students to improve the games themselves. In terms of programming and the development of higher order thinking skills, this turn of events was encouraging, since students were now involved at a higher level of learning, namely developing games rather than merely playing the games. Students were totally committed and motivated and willingly spent many hours on improving these educational games. Their subject knowledge improved as well as their programming and problem solving skills.

A similar project was launched in 2009, encouraging high school students to possibly further their studies in astronomy, with positive results (Nag *et al.*, 2013:145). Other similar projects show encouraging results and include a positive impact on the interest in CS-STEM subjects in the United States and even beyond its borders (Annetta *et al.*, 2013a:50).

2.2.4 Educational attributes of serious games

In a serious game an imaginary environment is created where players can gain experience and actively learn by experimentation (Ricciardi & De Paolis, 2014:2). This imaginary world of play allows people to experience the possibility of realising their dreams (Annetta *et al.*, 2013b:56). Therefore, the strong relationship between games and real life is recognised as a key factor of the serious games (Nag *et al.*, 2013:146). Marsh (2011:62) argues that the educative power of serious games lies in the fact that learners can learn by experience in a virtual world. In their discussion on serious games Stanescu *et al.* (2011:2) point out that people relate well to simulations due to the fact that they often create their own ”virtual situations” when they imagine events to take place and play these events out in their minds. Furthermore, simulations reflect the natural way people learn from real-life experiences (Annetta *et al.*, 2009:1093). Serious games add educational values such as motivation, active involvement and the ability to visualise and apply abstraction to the learning environment.

2.2.4.1 Motivational value and interactivity

Several studies reveal that the use of video games in education motivates learners to learn (Annetta *et al.*, 2009:1093; Girard *et al.*, 2013:207; Gros, 2007:23). Lenhart *et al.* (2008:6) report on a study that was done to promote interest in civil society, politics and general community activities amongst the youth in the USA. Video games were used to confront young people with problems and challenging situations to address on issues related to civil society, politics and the community. The study revealed that simulation of civic issues presented in a gaming environment increased interest amongst young people in civil society, politics and the community issues, which they would otherwise describe as boring or too complex to understand. With simulations and interactive virtual environments a new type of learning experience is created which captivates students (Stanescu *et al.*, 2011:2).

The interactive nature of serious games motivates learners to become active learners , which confirms the fact that learners learn by doing (Nag *et al.*, 2013:145; Shaffer *et al.*, 2005:5). Games teach players how to perform tasks while applying knowledge, techniques and rules (Husain, 2011:8). Shaffer *et al*., (2005:7) echo the fact that students “learn by doing” but emphasise that students should be properly guided and that they should be supported by knowledge supplied in order for learning to take place. The game *Full Spectrum Warrior,* which is a US army simulation video game, conveys knowledge about military aspects via virtual soldiers on the player’s squad. Expert knowledge is built into the game. Players apply knowledge gained from the game to plan and execute strategies in an effort to keep virtual soldiers alive. The virtual game *Madison 2200* conveys knowledge and allows the players to apply the knowledge by exercising the skills of virtually planning, developing and managing urban ecologies. This game creates awareness of issues such as waste management, housing, crime and other issues in an urban environment. Students reported that they had not previously been aware of all the pressing matters presented to them in the form of the game.

By interacting with these real life issues virtually, players become more responsible citizens, and aware of urban issues. Furthermore, interactivity as a feature of serious games positively impacts on triggering the interest of ill-motivated students (Ritterfeld *et al.*, 2009:696). Students willingly spend hours on solving problems, discovering information, memorising and applying logical thinking skills within these virtual worlds. However, Annetta *et al*. (2009:1093) point out that the motivational value of games should not be the primary reason for playing games in class. Care should be taken to ensure that specific learning goals are reached as well.

2.2.4.2 Visualisation and abstraction

In the traditional classroom the gap between abstract concepts, words and symbols is often separated from concrete realities (Shaffer *et al.*, 2005:4). Serious games simulate reality and are played in virtual worlds, where learners become part of experiences which simulate reality such as trading, environmental disasters, or any other real life situation. These simulated experiences add meaning to otherwise abstract and almost meaningless concepts students are being taught in traditional classrooms (Gee, 2003:2). Visual representations of complex issues and concepts assist to simplify them and make them easier to understand and to relate to (Lenhart, 2008:3). In the serious game called *Supercharged!*, students are taught physics in a hands-on and visual way. An abstract concept such as gravity, which is traditionally explained in class as an equation on paper, suddenly gets real meaning when the player undertakes flights in different parts of the solar system while experiencing and reacting on different gravitational forces (Shaffer *et al.*, 2005:7). Students become aware of the fact that the knowledge they have attained or are attaining is relevant to everyday life. Knowledge presented meaningfully and in a digital environment they are familiar with, appeals to them and capture their imagination.

2.3 COMPUTER SCIENCE EDUCATION

Since the turn of the century, the importance of computer skills and computer literacy has been emphasised with remarks such as, "to function in society in the 21st century, it is essential for the average citizen to understand at least the principles of computer science" (Tucker *et al.*, 2003:1). and "21st century literacy is defined by 4R's: Reading, 'riting, 'rithmetic and 'rithms, the fourth R being algorithms or basic computational skills" (Nag *et al.*, 2013:146). Remarks such as these emphasise the fact that there is a growing need to redefine our approach towards learning. Communication, leadership, critical thinking and imaginative problem solving skills are listed as essential soft skills that should be included in STEM (Science, Technology, Engineering and Mathematics) education. The demand for twenty-first century skills includes problem solving skills and skills in mastering computer technology.

2.3.1 The current status of computer science education

Even though technology is an important part in almost all spheres of life, literature reveals an alarming decline in interest amongst students in computer science as a field of study (Heersink & Moskal, 2010:446; Muratet *et al.*, 2011:61). More than fifty per cent of students who are enrolled for computer science courses at tertiary institutions in the Latin American countries abandon their studies (Rosas *et al.*, 2014). This is in contrast to the fact that about 5,500 new math and computer-science jobs are available each year in the state of Kentucky alone, according to federal labour data. This phenomenon has also been reported in many studies conducted in other countries such as Australia, France and Tanzania (Corney *et al.*, 2010; Muratet *et al.*, 2011; Tedre *et al.*, 2011).

The Queensland University of Technology (QUT) in Australia, reported an average failure rate of more than thirty per cent since 2003 in their introductory programming course (Corney *et al.*, 2010:63). In 2008, a failure rate of nineteen per cent was reported for this course while an alarming percentage of students dropped out of the course, as shown in Table 2.1. The study reported that more than half of the students who dropped out of the course, dropped out of university completely.

Table 2.2: Attrition rates for the first programming unit at QUT Semester 1, 2008 (Corney *et al.*, 2010)

QUT - Semester 1 : 2008 - Attrition rates	
Reason for attrition	**Rate**
Changed to other course or inactive/on leave	16.2%
Discontinued course enrolment	18.4%
Withdrew from First Programming Unit	19.4%

The situation in South Africa is no different. Figures released annually by the Department of Basic Education in South Africa in the Higher Education Management and Information System (HEMIS) database (HEMIS, 2011), show a concerning low increase in Information

Communication Technology (ICT) enrolments at higher institutions of education. The increase in ICT enrolments, as shown in Figure 2.7, is only 8.7 per cent compared to an overall increase in enrolments for all subjects of about 21.5 per cent for the period from 2005 to 2010 (Kirlidog *et al.*, unpublished). During the same period of time the increase in ICT graduations, as illustrated in Figure 2.8, was only 3.4 per cent compared to an increase of 27.4 per cent for all subjects. These figures indicate that many students who enrol for ICT do not pass the examinations.

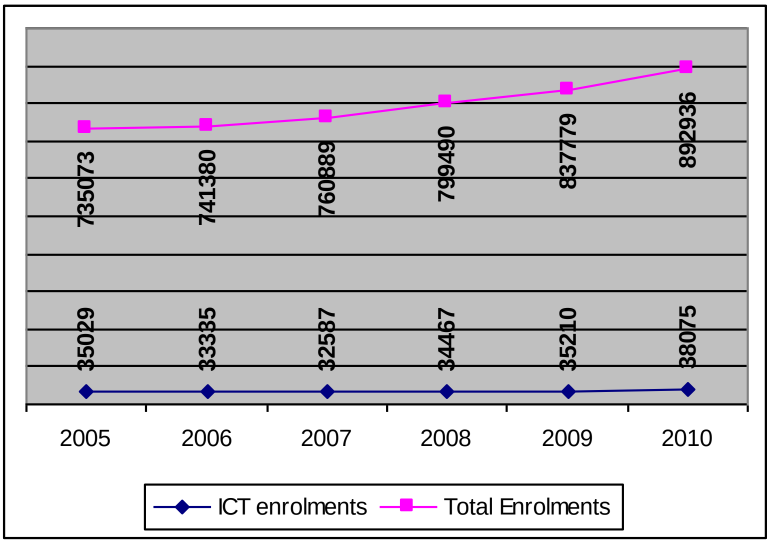


Figure 2.7: ICT enrolments compared to enrolments in all subject matters (Kirlidog *et al.*, unpublished)

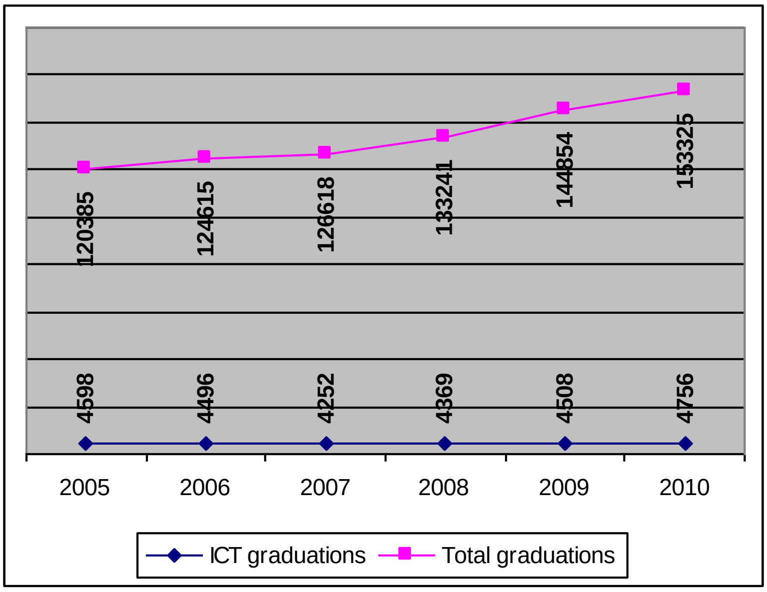


Figure 2.8: ICT graduations compared to graduations in all subject matters (Kirlidog *et al.*, unpublished)

Table 2.3 shows that ICT is one of the subjects with the highest dropout rate at higher education institutions in South Africa, based on the official graduation figures captured in the HEMIS database. The second column in Table 2.3 contains the ratios of graduations to enrolments in ICT subjects. The third column contains the same ratio for all subjects. The last column shows the position of ICT related to all subject matters in terms of dropout rate.

Table 2.3: Severity of dropout problem in ICT and all subjects in South Africa, 2005 to 2010 (Kirlidog *et al.*, unpublished)

Year	Ratio of graduations to enrolments in ICT	Ratio of graduations to enrolments in all CESMs	Rank of ICT among the 20 first order CESMs (from worst (1st) to best)
2005	0.131	0.164	3rd
2006	0.135	0.168	5th
2007	0.130	0.166	3rd
2008	0.127	0.167	1st
2009	0.128	0.173	1st
2010	0.125	0.172	4th

The decline in interest in ICT can be because students often find computer programming a difficult skill to master (Apiola & Tedre, 2012:286; Fesakis & Serafeim, 2009:258; Gomes & Mendes, 2010:113; Robins *et al.*, 2003:137). Therefore, a study was conducted on students' perceptions of the difficulty of IT topics in their IT program at the Tumaini University in Tanzania from 2008 to 2011 (Tedre *et al.*, 2011; Tedre & Kamppuri, 2009). Table 2.4 shows the results of this study. The table lists the averages (on a scale of 1 to 5) of students' perceptions of the difficulty of IT subjects they had enrolled for as part of their computer science course.

Table 2.4: Students' results in IT subjects in 2008 compared to results obtained in 2011, Tumaini University, Tanzania (Tedre *et al*., 2011)

Subject	**Average 2008**	**Average 2011**
Application software	2.20	1.93
Communication skills	2.30	1.65
General IT	2.30	2.35
Operating systems	2.35	2.16
E-Learning	2.35	2.55
Ethics and law	2.35	2.52
Web design	2.40	2.02
Computer hardware	2.47	2.83
Networks	2.55	2.60
HCI	2.65	2.86
Computer security	2.70	2.81
Databases	2.75	2.93
Studying at university	2.75	2.66
Basic CS maths	2.80	2.59
Basic concepts	2.84	2.60
Infrastructure	3.25	3.23
Computer architecture	3.47	2.74
Programming	4.05	3.70
Scale: 1: Very easy; 2: Easy; 3: Average; 4: Hard; 5: Very hard		

Even though students' perceptions of computer programming changed slightly towards the positive side from 2008 to 2011, students indicated in both the surveys (2008 and 2011) that programming was the most difficult topic to master.

Problem solving is strongly associated with computer programming and is regarded as the most important skill to master in computer programming (Apiola & Tedre, 2012:290; Pears *et al.*, 2007:207; Robins *et al.*, 2003:160). In their research Corney *et al.* (2010:63) investigated possible reasons for the high dropout rate of computer science students at QUT in Australia.

Some of the reasons were identified as failure to understand the purpose of programs and their relationship with the computer, the inability to solve problems and a poor conception of programming constructs. Some students indicated that they found the syntax of the programming language used in the course, difficult to use. Although application of a programming language's syntax is important, mastering programming skills revolve around problem solving, logical reasoning and abstraction, all of which require high order thinking skills (Fesakis & Serafeim, 2009:258; Wang & Chen, 2010:39).

Resnick *et al.* (2009:63) express the concern that students are taught programming in a context that does not relate to their interests or experiences. Therefore, students become bored and lose interest in trying to relate programming to the world they live in (Adachi & Willoughby, 2013:1050). Shaffer *et al.* (2005:8) argue that one of the benefits of using serious games is the fact that the learning experience takes place within a meaningful context. Furthermore, the relaxed environment of a game-play experience could reduce anxiety students might experience when confronted with difficult and challenging tasks (Wang & Zhou, 2011:488).

2.3.2 Required teaching strategy for computer science education

Programming is the core of computer science courses. The primary skill to master in computer programming is the ability to solve problems (Robins *et al.*, 2003:160). Motivation, creativity, language parsing, intellectual and reasoning abilities and expertise are some of the aspects involved in the development of problem solving skills (Kotovsky, 2003:373; Robins *et al.*, 2003:140). Green and Ledgard (2011:57) describe programming as a combination of science and art. The science part pertains to the problem solving aspects such as reasoning and critical thinking skills, while the art section involves creativity in terms of interface and program design.

Teaching computer science in an instructivistic way could be at the root of the problem in terms of the high failure rate. In an instructivistic learning environment, learners are passive participants while the teacher feeds them with facts. This teaching style mainly develops the lower order thinking skills – to remember and understand (Apiola & Tedre, 2012:289). In a non-instructivistic learning environment, an interactive environment is created, which is more likely to promote and stimulate higher order thinking skills. Since problem solving is regarded as a higher order thinking skill which requires creativity and innovation, a non-instructive learning environment could be more suitable in the computer programming class.

Wang and Chen (2010:40) state that meaningful teaching strategies and an innovative learning environment are some of the aspects that have been explored and invented in order to teach programming skills over time. In the 1980s, Papert (cited by Tangney *et al.* (2010:54), recommended a change in teaching strategies in computer science from a structured and formal approach to an innovative informal and almost "playful tinkering" fashion, with the introduction of Logo as a teaching tool in computer science. Many other similar initiatives have followed since then.

At the QUT, where the failure rate of the introduction to programming unit exceeded an alarming nineteen per cent in 2008, the teaching strategy was changed by "taking a collaborative approach" and including more "fun stuff" as part of the content of the programming courses (Corney *et al.*, 2010:64). This was accomplished by creating a social informal learning environment and encouraging collaboration by applying the concept of pair programming. Various technologies and a digital environment that students could relate to, such as gaming, graphics and Web development, were implemented as part of teaching tools, strategies and programming projects. The goal was to promote active learning by engaging students in meaningful activities while learning takes place. Within one year, a remarkable improvement was reported as shown in Tables 2.5 and 2.6.

Table 2.5: Comparison between fail/pass rates for 2008 and 2009, QUT (Corney *et al.*, 2010)

QUT : Results for first programming unit		
	Semester 1, 2008	**Semester 1, 2009**
Pass/Fail	**Rate**	**Rate**
Pass	81%	94%
Fail	19%	6%

Table 2.6: Attrition rates - semester 1 at QUT, 2008 and 2009 (Corney *et al.*, 2010:65)

QUT, Attrition Rates during 2008 and 2009		
Reason for attrition	**2008**	**2009**
Changed to other course or inactive/on leave	16.2%	4%
Discontinued course enrolment	18.4%	5%
Withdrew from First Programming Unit	19.4%	6%

The failure rate for the introductory programming unit decreased from 19 per cent to 6 per cent!

As part of the research, students were asked to rate the newly introduced programming projects where different technologies were used and applied. Table 2.7 presents the students' ratings. It is evident that projects with a gaming element and visual components, which included "fun stuff" such as *Turtle Graphics* and *PyGame Animation* were more appealing than less visual and game-related projects such as database manipulation.

Table 2.7: Students' preferred projects (Corney *et al*., 2010:70)

QUT - revised first programming unit: reflection on projects	
Preferred project	**Rate**
PyGame animation	36%
Database manipulation	10%
Turtle graphics	41%
Popularity cloud (HTML production by Python with data from a database)	33%

Their study confirms a statement by Kaiser and Wisniewski (2012:138) that the learning environment has changed. Books and manuals are still significant in education, but interactive ways of learning stimulate higher order thinking skills.

2.3.3 Serious games and computer science

The motivational and engaging nature of games was employed in education even before the era of computers and technology (Kazimoglu *et al.*, 2012:1991). The use of serious games in class has been suggested (Prensky, 2001a:4) for the past decade. Today, games and technology are part of teaching and learning in many modern educational environments (Kaiser & Wisniewski, 2012:58).

2.3.3.1 Motivational features of serious games in computer science

According to Adachi and Willoughby (2013:1050), being bored is one of the aspects that affect the learning experience in class negatively. It has been reported that computer science students often find it boring to learn how to program (Ali & Smith, 2014:62). Prensky (2001) predicts that students who are gamers (belong to the gamer generation) will not accept, attend or engage in boring education. Hence, serious games and interactive teaching strategies will have to emerge.

Studies show that the use of serious games in class motivates learners to participate, get involved and learn (Annetta *et al.*, 2009:76; Barnes *et al.*, 2007:1; Girard *et al.*, 2013:216; Gros, 2007:2; Wrzesien & Alcañiz Raya, 2010:179). In an attempt to counter the decreasing number of enrolments in computer science, a growing number of tertiary institutions have added game design and development courses to their curriculums to attract more students (Coleman *et al.*, 2005:546; Corney *et al.*, 2010:70). In many courses or modules, for example introductory programming courses (Parberry *et al.*, 2005), some or all assignments were replaced with games. A number of game-embedded initiatives have emerged as teaching strategies (Barnes, 2008; Kelleher & Pausch, 2007; Resnick *et al.*, 2009). Research on all these initiatives has reported success in terms of better grades and more motivated students.

Serious games stimulate a brain that has been exposed to repeated fast-moving and multi-sensory input, that otherwise would have been starved by the boring stimuli from text-based teaching methods. Nag *et al*., (2013) state that the competitive nature of games promotes participation by converting learning to an active rather than a passive experience. Furthermore, a sense of individualism is developed in the gaming environment since gamers progress at a self-regulated pace (Adachi & Willoughby, 2013:1050). In their study on the game play habits of Grade 9, 10, 11 and 12 learners reported a higher level of motivation as a contributing factor to play games. The fact that a player has to accomplish success at one level before proceeding to the next level, as well as the progression in terms of level of difficulty, adds a motivational aspect to the game play experience. The interactive and competitive nature of serious games keeps learners interested and motivated to learn and progress.

2.3.3.2 Immersion and the flow experience

Games have the potential to engage players to the extent where they reach a mental state of flow (Ermi & Mäyrä, 2005:92; Tan *et al.*, 2009:4). Zyda (2005:29) states that sensory stimulation of the player's mind is a fundamental part of a game. It creates a sense of presence, which leads to a feeling of immersion and total engagement. Total engagement takes place due to an emotional connectivity (Nag *et al.*, 2013:149). A story- or scenario-based environment has the potential to keep people engaged. It motivates people to stay involved.

In a flow state of mind, players are totally focussed and immersed in what they are doing (Nakamura & Csikszentmihalyi, 2002:89). Tan *et al.* (2009:4) state that problem solving requires intrinsic motivation and deep thinking skills. Intrinsic motivation to stay involved and enjoyment are important results of a flow experience. The circumstances that initiate a flow state of mind include just-manageable tasks and continue with feedback on actions performed, which results in adjusting action based on the feedback. A series of graded challenges accomplished causes the person to experience progression, enjoyment and motivation to continue to try to accomplish the next task. In a state of flow, intense concentration is exercised, and tasks normally regarded as too difficult to accomplish are often achieved (Tan *et al.*, 2009). To be able to perform higher order, expert thinking, requires concentration and cautious practice (Annetta *et al.*, 2013b:55). Serious games in class could be used to create an environment to reach high levels of concentration, which is required, as well as an inner drive to accomplish tasks in class.

Nakamura and Csikzentmihalyi (2002:90) point out that the flow experience is fragile and discontinuous as soon as tasks cannot be accomplished and anxiousness is experienced, or tasks are accomplished with no effort, which results in boredom and loss of interest. Boredom, which is experienced due to lack of concentration, is counteracted by the flow experience (Yusoff, 2010:15). In the zones of proximate flow model shown in Figure 2.9, the flow experiences that a player has when playing a game are presented (Kiili *et al.*, 2012:84). The P1 phase represents the start of the game when the player has no prior experience or knowledge of the game. While practising tasks during this phase, the player gains knowledge and skills and enjoys the games, which results in a state of flow. When the player becomes bored, phase P2 is reached which is a negative experience. Boredom is counteracted by attempting challenges that are more difficult. New challenges are accompanied by a feeling of anxiety represented by P3 in the model. The player has to master new skills or improve on current skills and knowledge in order to experience the state of flow again (P4).

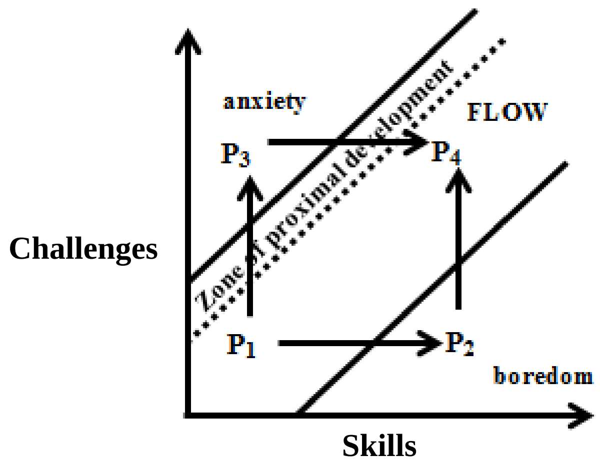


Figure 2.9: Adapted model of the flow experience (Kiili *et al*., 2012:84)

During the state of flow, the player is focused totally on the task and aims to accomplish tasks while time is of no concern. In a state of flow, enjoyment and a feeling of accomplishment is more important than any other reward (Kiili *et al.*, 2012:84).

Research shows higher levels of flow when learners are actively involved by performing tasks than when they are passively listening to lectures (Nakamura & Csikszentmihalyi, 2002:96). In their research on improved ways to teach computational thinking skills, Basawapatna *et al.* (2013b:67) involved 46 schools in the USA to offer their introductory course to programming in the format of a game development course. The teaching strategy deviated from the traditional instructions-first approach. Participants were introduced briefly to basic programming principles and were requested to create as many computer games as projects, using the basic programming principles. During the course of the development of their projects, the flow experiences of five participants were measured and projected onto a zone of proximate flow model. Figure 2.10 shows how the participants enjoyed the game by staying within the flow channel (green area on the chart) and how progression occurred while challenges were completed and skills mastered. The black line in the graph indicates progression when all the challenges are performed exactly as expected. Anxiety (in the red area) occurred when they were confronted with new challenges. The feeling of anxiety motivates students to succeed in performing the new challenge in order to return to the flow zone.

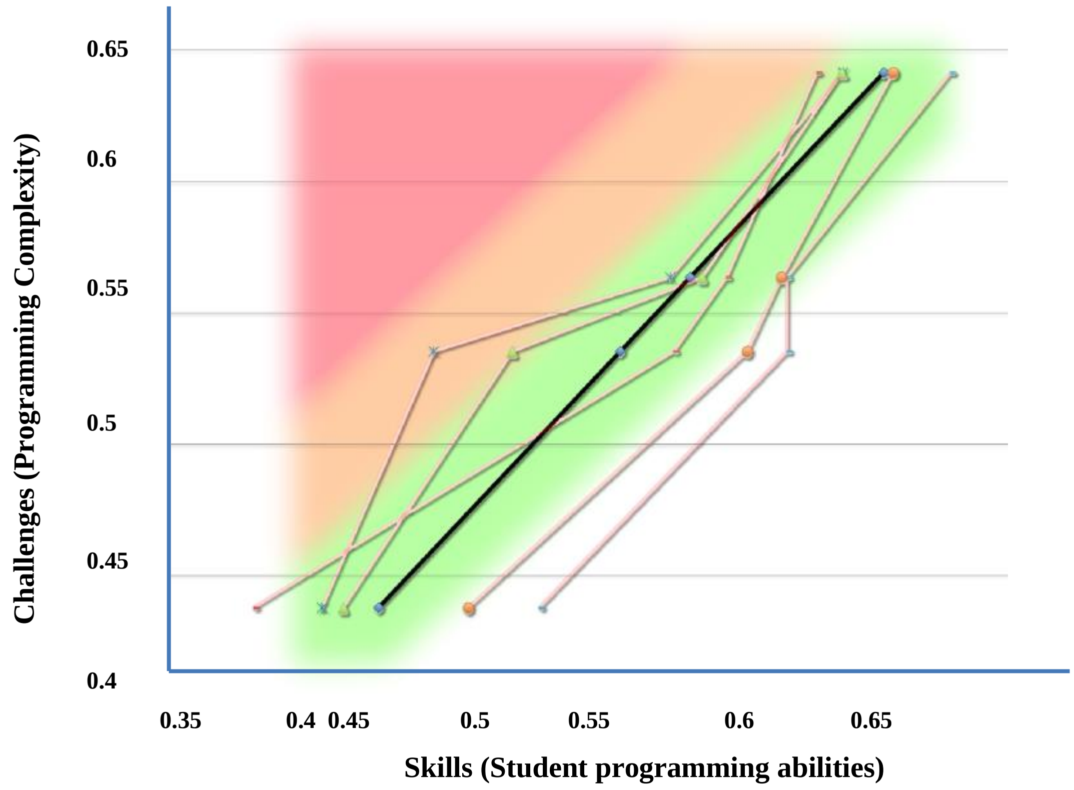


Figure 2.10: Student trajectory data resembling the zone of proximal flow (Basawapatna *et al*., 2013a:67)

Participants obtained the ability to apply problem solving skills across multiple problem areas, while being motivated and engaged in what they were doing. This research confirms that interactive learner-centred learning is more appealing than the traditional knowledge-first and teacher-centred approach when teaching computer programming.

2.3.3.3 Abstract thinking skills

Computer programming is "all about abstraction" (Dann & Cooper, 2009:28). Concrete experiences are required for "building abstract concepts" (Egenfeldt-Nielsen, 2005:146). Building abstract programming concepts is difficult (Wang & Chen, 2010:64). In a game playing environment, interaction with games allows players to build up a rich resource of concrete experiences in a fun way. Players are encouraged to apply their knowledge to solve challenges they are presented with in the game. Concrete experiences contribute towards self-sustainability since concepts are formed based on experiences that can be adapted and applied to different scenarios (Egenfeldt-Nielsen, 2005:146). Robins *et al.* (2003:160) claim that abstract representation of knowledge can only be learned by "practising the operations they are based on". During game-play, abstract representation of knowledge to solve problems in different scenarios often happen spontaneously through experiential learning, as explained by Wang and Chen (2010:40). Experiential learning is based on Kolb's theory, which comprises a four-staged cycle that reflects different learning modes (Egenfeldt-Nielsen, 2005:123). In their study, Wang and Chen (2010) adapted and applied Kolb's theory as illustrated in Figure 2.11.

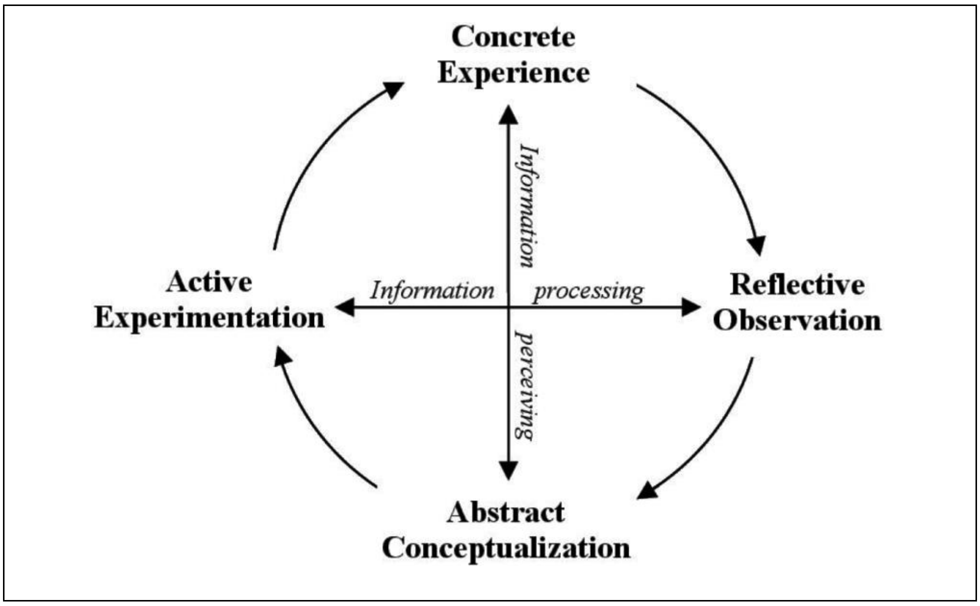


Figure 2.11: The four stages of the cyclic learning process of experiential learning (Wang & Chen, 2010:41)

In the cycle, a concrete experience is followed by a reflective observation during which information is processed in order to conceptualise the experience in an abstract way. During this stage, abstract conceptualisation takes place and abstract knowledge is constructed. The abstract knowledge gained is applied in various different contexts during the active experimentation phase. The newly developed constructs are applied to solve problems in different scenarios. Learners develop the ability to apply knowledge and skills from previous experiences while being confronted with new, often more complex experiences. The cycle starts again while experimenting and discovering new abstract constructs. The four stages of experiential learning can be identified in gaming environments. An active experience takes place while playing the game and information is gathered. The player reflects and processes the knowledge that was gained. The processed knowledge is used to face a new experience or challenge in the game. Thereafter, abstraction and application of abstract knowledge occur, in order to solve new problems in the form of new challenges in different scenarios or levels of the game. Therefore, playing games can be regarded as an experiential learning process that promotes abstract thinking skills. Virtual reality provides the opportunity for experimental learning to take place (Annetta *et al.*, 2009:1093). In programming classes the challenge is how to create concrete experiences in class that lead to abstraction (Dann & Cooper, 2009:28).

Logical and abstract thinking skills are required to survive in the current digital world (Scharf *et al.*, 2012:144). As part of their research in how to apply games to improve logical and abstract thinking skills amongst children, Scharf *et al.* (2012) introduced a group of young children to programming cubes called tangicons as shown in Figure 2.12 and 2.13. In this game, participants are required to observe, analyse and recreate a sequence of events using tangicons. Several versions of the games were developed. Version 1 includes simple tasks using wooden tangicons while version 2.0 of the game comprises more complex tasks and tangicons that are equipped with electronic devices to promote interaction with the player. For example, the tangicons are colour-coded and need to be arranged in pairs according to colours, and stay together as a pair while a sequence of events is recreated. After implementing version 1.0 and 2.0, significant improvement was observed in counting and abstract thinking skills of participants.

Figure 2.12: Tangicons version 2.0 (Scharf *et al*., 2012:145)

Version 3.0 and higher entails computerised versions of the game, which comprise different levels of complexity of problem solving challenges.

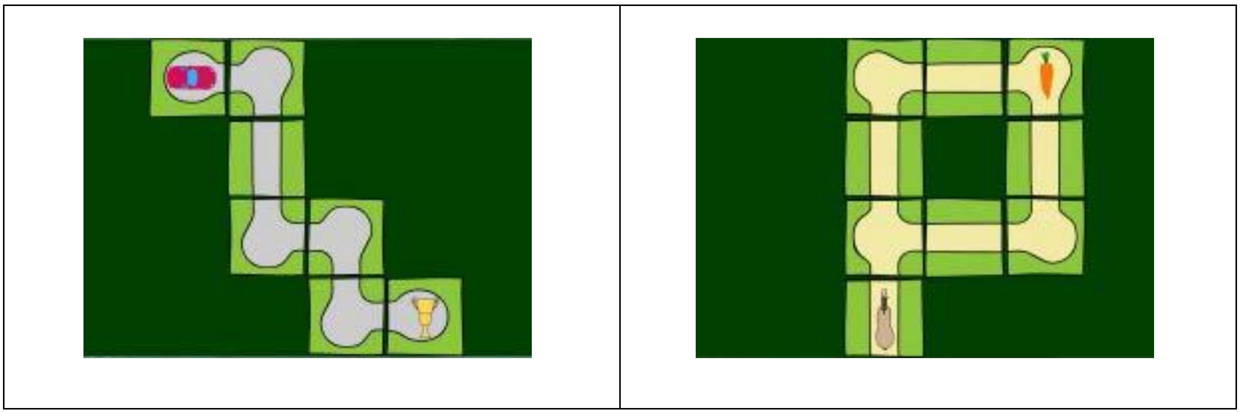


Figure 2.13: Tangicons version 3.0 level 2 and 3 from left to right (Scharf *et al.*, 2012:149)

In their research project, Sherrell *et al.* (2012:78) use robotics to teach learners abstract thinking skills in programming. The basic movements of a robot, such as move forward, turn left, turn right, are supplied in the form of a few methods in a superclass called *BasicRobot*. Learners first use these basic instructions to manipulate the robot to perform simple to complex tasks. Then they are required to apply abstraction by extending from the superclass, and create methods of their own to allow the robot to perform tasks that are more sophisticated. For example, a method called turnAround can be created, which contains a sequence of simple movements. Within the context challenges or tasks to complete, application of abstraction is a natural extension of applying knowledge, which is an essential part of the programming environment.

2.3.3.4 Creative thinking and problem solving skills

The primary goal of education should be to shape the new generation to be creative, systematic thinkers who are comfortable to use programming to contribute towards innovation in the digital world (Resnick *et al.*, 2009:62). Wang and Chen (2012:549) state that creativity entails the production of "original ideas, solutions or insights". Common sense and basic logic are not stimulated by rote learning (Annetta *et al.*, 2013b:55). Learners need to be engaged in cognitive conflict to be able to think creatively.

Jackson *et al.* (2011:86) used the Torrance test of creativity to assess the relationship between creativity and a number of technologies such as Internet use, computer use, cell phone use and playing of video games. Results show that participants who play video games are more creative than those who do not play video games. None of the other technologies that were assessed in this study, *inter alia* the Internet, computer or cell phone usage, showed improved creativity amongst participants. A possible reason could be that that game players are encouraged to become "producers and not just consumers" (Gee, 2003:2). This is because in many games such as *Age of Mythology* and *Tony Hawk*, players can use software supplied with the game to construct new scenarios and set new challenges.

Gamers tend to become "critical consumers of information" (Shaffer *et al.*, 2005:3). In most games players base decisions they make on critically evaluating supplied information since useless and misleading information is supplied deliberately along with meaningful information.

Furthermore, serious games promote a shift towards a non-instructive learning experience (Husain, 2011). A non-instructive approach in learning is based on interactivity and collaboration amongst students. Technology-oriented students can relate to a non-instructive environment, which allows them to explore, to learn by experience and to be creative.

2.3.3.5 Serious games and problem solving skills

When playing games, players learn to generalise and apply knowledge, which leads to mastering problem solving skills (Gee, 2003:3). A recent study that was conducted amongst high school children revealed that strategic video games could contribute towards improved problem solving skills (Adachi & Willoughby, 2013:1050). The participants in this study were in Grade 9, 10, 11 and 12 from eight high schools in Canada. They were asked to report on the type of video games they play and their current ability to solve problems. Positive feedback was received in terms of improved problem solving skills due to playing strategic games. Ventura *et al.* (2013:55) conducted a study amongst 102 undergraduate students enrolled in educational psychology courses at the Florida State University. These students were requested to complete a range of easy, medium and difficult levels of anagrams and riddles. They were allowed up to 120 attempts to solve an anagram or riddle. The participants were asked to report on their perceived ability to persist in solving problems before they commenced. Once they had completed the task, the number of times they had been willing to try to solve an anagram or riddle was used to establish their persistence in problem solving. Participants who play video games regularly were more persistent in trying to solve the anagrams or riddles with which they were presented. According to Newell *et al*. (cited by Grace and Maher (2014:2)) persistence is one of the factors that play a significant role in solving problems.

2.3.3.6 Self-efficacy

Self-efficacy is defined as one's belief in one's ability to perform a particular task (Holden & Rada, 2011:345). Venkatesh and Davis (1996:473), who did research on determinants of ease of use of technology, found that self-efficacy improves when more experience is gained andtechnology is perceived to be used more easily. A strong sense of self-efficacy leads to improved performance and persistence to master difficult skills (Kinnunen & Simon, 2011:20). When tasks are repetitively accomplished successfully, ,learners experience a sense of self-efficacy, which results in enjoyment (Jackson *et al.*, 2012). However, learners perform at their best when the game is challenging and players can experience a sense of accomplishment (Jackson *et al.*, 2012). Programming is a skill students need to master, and repetitive failure creates a weak sense of self-efficacy. Enjoyment is replaced by frustration which could lead to lack of motivation to attempt to complete tasks (Peters & Pears, 2012:979). The challenge is to include, as part of a serious game, tasks which are challenging but still within the ability of participants to accomplish.

2.3.3.7 Collaboration

Communication is an essential skill in the world of science and technology today (Nag *et al.*, 2013:146). Shaffer *et al*. (2005:4) claim that games bring gamers together to compete or to share ideas in discussion forums. While interacting with characters in the game, players collaborate as a community to plan strategies on how to solve challenges (Nag *et al.*, 2013:148). The gaming experience is often turned into a social event. Players with the same interests communicate and share ideas. They share expert knowledge which represents how systems are created and managed in the real world (Gee, 2003:3). Learner performance improves, and their level of involvement in the learning process increases when they do group work. They learn and scaffold one another's ideas (Husain, 2011:5). Preston (2005) regards collaboration as an effective pedagogy for computer programming.

In the gaming environment, different techniques and ways of collaboration can be applied. Some researchers propose the application of a massive multiplayer online role-playing games (MMORPG) (Gros, 2007:28) teaching strategy for the computer science curriculum. Barnes *et al.* (2007) let their students play a collaborative multiplayer online role-playing game that uses programming to meet the game's challenges instead of building games. These challenges include defining the movements of characters in a virtual world (Cooper *et al.*, 2003) or coding movements with specific programming languages (Chen & Morris, 2005).

Barnes *et al.* (2007) believe that this approach can be used to emphasise the positive aspects of games (familiar environment, concrete and engaging experience) which counteract some of the negative experiences that often occur in computer science courses. An inviting, safe and socially stimulating environment with collaborating multiplayer aspects of the role-playing game can be created with serious games in class.

Relatively few video games have been developed and investigated to improve programming and problem solving skills (Adachi & Willoughby, 2013:1042; Kazimoglu *et al.*, 2012:1992). Kazimoglu *et al.* (2012) briefly discuss a number of serious games that are available to support the education of introductory programming. Some of these games are summarised in Table 2.8.

Table 2.8: Games to support teaching introductory programming

Game	Objective of the game
Robocode (2001)	To develop an artificial intelligence (AI) for a tank to fight against other tanks programmed by other players.
Colobot (2007)	Players command different vehicles by writing pseudo codes in an in-game specific programming language (which is similar to C++) in order to complete various tasks. 3D real time game of strategy and adventure for learning programming.
Catacombs (2007)	Game that was specifically developed to teach programming.
Saving Serra (2007)	Game that was specifically developed to teach programming.
Robozzle (2010)	An addictive robot-programming puzzle game.
Elemental (2009)	Game that was specifically developed to teach programming.
LightBot (2008)	Control a robot by giving commands to it.
Prog&Play (2011)	Multiplayer real time strategy (RTS) game.
Program your robot (2012)	To assist a robot and help him to escape from a series of platforms by constructing an escape plan called a solution algorithm.

New technology always runs the risk of being rejected by users. It is therefore important to investigate the level of acceptance of games in an educational environment.

2.4 ATTITUDE OF USERS TOWARDS NEW TECHNOLOGY

Businesses are continuously losing vast amounts of money due to expensive IT systems being rejected by users (Venkatesh & Bala, 2008:274). In an effort to reduce the percentage of IT systems rejected in the workplace, a measuring tool to determine the attitude of potential users of technology known as the TAM was developed. The TAM is used to predict whether users will accept a proposed technology ahead of actually developing and implementing the technology. Since the TAM was developed, it has proved to be a successful indicator of predicting the acceptance of a vast amount of new technologies in different environments. This study investigates the acceptance of serious games in the computer science class.

The development of games is time consuming and expensive, and therefore a model that could predict the possible success rate of implementing games in the computer science class could assist in deciding whether serious games should be part of the computer science curriculum.

2.4.1 Background of the establishment of the TAM

Computers became affordable in the 1970s, and many software systems were developed during this time, which included information systems, financial software systems, training systems, and security systems. However, the failure rate of implementing these systems was high (Legris *et al.*, 2003:192). Upon investigation, it became clear that a large percentage of these systems failed because users rejected these systems (Davis & Venkatesh, 2004:31). Researchers turned their attention to users and their requirements and behaviour in terms of the acceptance of technology in the workplace.

2.4.1.1 The theory of reasoned action (TRA)

The development of the TAM is based on the work of Fishbein and Ajzen (Venkatesh & Davis, 2000:187) in the field of human behaviour in the 1970s which resulted in the establishment of the theory of reasoned action (TRA). The theory states that the intention of an individual to behave in a particular way is influenced by attitude and social pressure towards the intended behaviour (Lai *et al.*, 2012:570). The TRA model in Figure 2.14 shows that the intention of an individual to behave in a specific way (BI) is influenced by the attitude (A) of the individual towards the behaviour and the subjective norm (SN) of the group of people the individual regards as important. Subjective norm is defined as a "person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Fishbein & Ajzen, 1975:302).

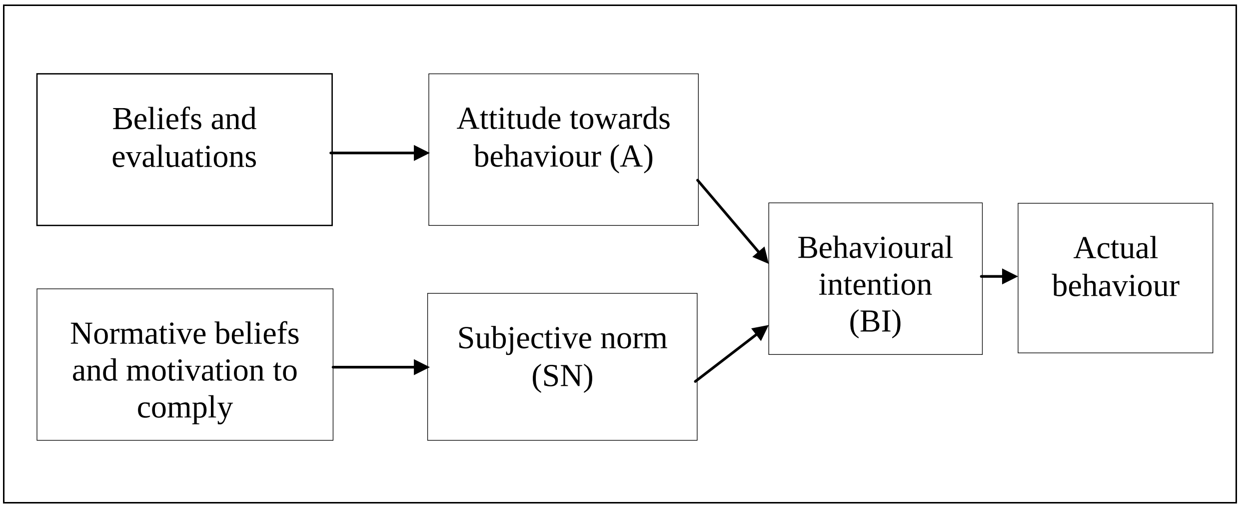


Figure 2.14: The TRA model (Fishbein & Ajzen, 1975:302)

Attitude can be described as "one's positive or negative feelings about performing a behaviour (for example, using technology)" (Teo, 2011:2433). The attitude (A) of the individual towards a behaviour is described as the way the individual himself evaluates a behaviour in terms of the perceived consequences it may hold. Perceived consequences, in turn, are influenced by an individual's internal beliefs.

Fred Davis proposed a model for the possible prediction of the acceptance of technology, better known as the technology acceptance model (TAM), as part of his doctoral thesis (Chuttur, 2009:1). He developed the TAM in an effort to predict to which extent users will accept technology. He argued that a user's internal beliefs, attitude and intentions to behave in a specific way could be evaluated when technology was introduced. The result of the evaluation could be used to predict the behaviour of the user in terms of the acceptance and the actual use of the technology (Turner *et al.*, 2010:464).

2.4.1.2 The technology acceptance model (TAM)

The work of Fishbein and Ajzen (1975) in the field of acceptance of technology led the way to the development of the well-known and widely used technology acceptance model (TAM) (Davis, 1989; Ibrahim & Jaafar, 2011:483; Lai *et al.*, 2012; Legris *et al.*, 2003; Mathieson, 1991; Teo, 2009). Attitude and its relation to actual human behaviour are of particular interest to this study, since the attitude of computer science students towards the use of a specific technology in class is under investigation in this study.

In the 1980s, the business world expressed the need to be able to predict whether planned information systems will be used once they have been developed (Mathieson, 1991:174). Many aspects related to possible reasons why information systems were rejected were investigated. These investigations did not deliver any conclusive and useful results because factors that were identified to have an influence on behaviour were not identified based on solid research on the matter (Davis *et al.,* 1989:983). Therefore, there was a need to establish a better understanding of human behaviour and factors that influence human behaviour. Well-founded research and theories from the field of social psychology on factors that influence human behaviour already existed, based on work that was done by Fishbein and Ajzen (1975). The theory of reasoned action (TRA) is a general model to predict human behaviour within almost any environment has been widely tested as aforementioned.

In his conceptual framework, shown in Figure 2.15, Davis (1986) indicated that factors such as the features and capabilities of a system could motivate a user to use a system. The level of motivation will influence the degree to which the system actually will be used.

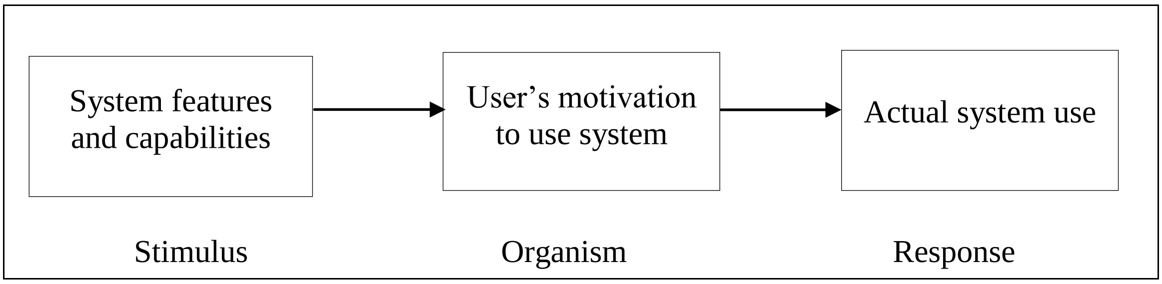


Figure 2.15: Conceptual framework (Davis, 1986:10)

Psychological variables had to be identified to measure users' motivation, for which Davis (1986) relied largely on the factors that were established with the construction of the TRA. In his modelling of the user motivation part of the conceptual framework, a field survey on 100 organisational users was done during which measuring items (or questions) were established and validated. Although other factors such as quality of the system and fun were investigated as well, two distinctive factors or constructs were identified, namely perceived ease of use (PEOU) and perceived usefulness (PU).

Perceived usefulness (PU) is defined as "the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context" and perceived ease of use (PEOU) as "the degree to which the prospective user expects the target system to be free of effort" (Davis *et al.*, 1989:985). The casual links between these two key aspects and users' attitude were investigated, and they were found to have a direct influence on the attitude of users towards computer usage.

The technology acceptance model (TAM) in Figure 2.16 shows that user motivation can be expressed as the level of perceived usefulness, perceived ease of use and the attitude of the user towards use, as well as the relationships between all these components.

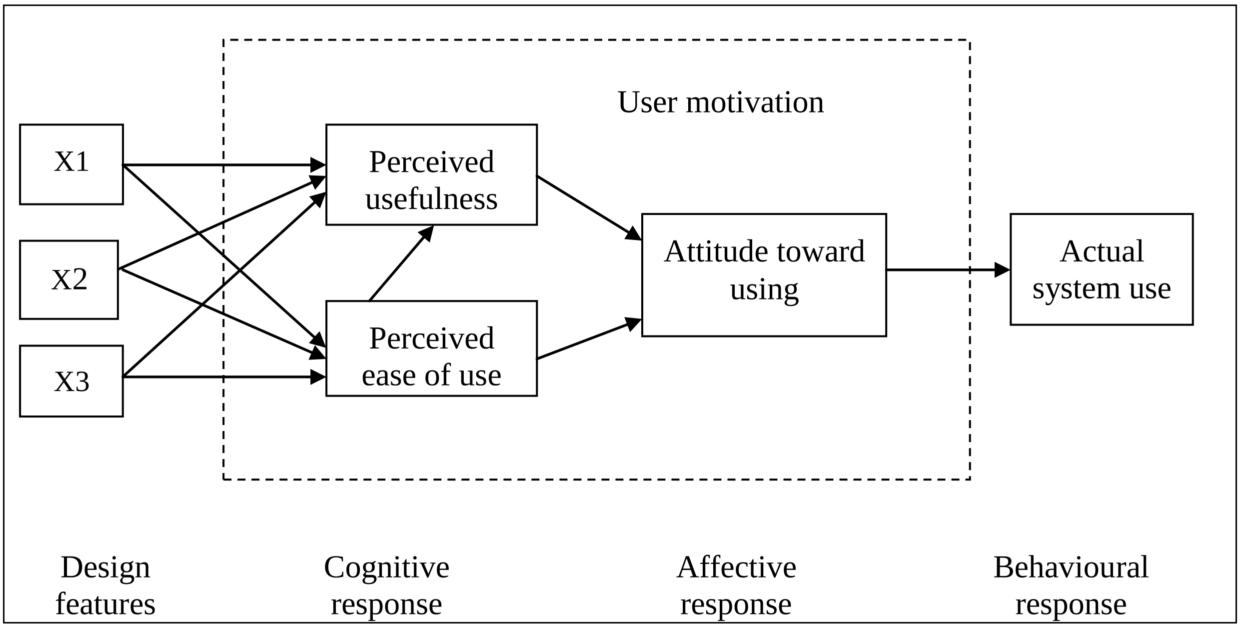


Figure 2.16: Original TAM proposed by Fred Davis (Davis, 1986:24)

The TAM, depicted in Figure 2.16, shows specific relationships between the components that influence user-motivation. Users' attitude towards using technology determines the actual use the technology. The users' attitude towards use of technology, in turn, is influenced by perceived usefulness and ease of use. Furthermore, the usefulness of technology is influenced by how easy the user thinks the system will be to use. Davis's model also includes external variables, X_1, X_2 and X_3, which refer to factors that influence the perception of users on the usefulness of the system and ease of use (Davis & Venkatesh, 1996). The external variables can be aspects such as computer literacy and characteristics of the system.

An adapted version of the TAM compiled by Davis *et al*. (1989:985), which is shown in Figure 2.17, includes intentional behaviour as a determining factor regarding the actual use of technology.

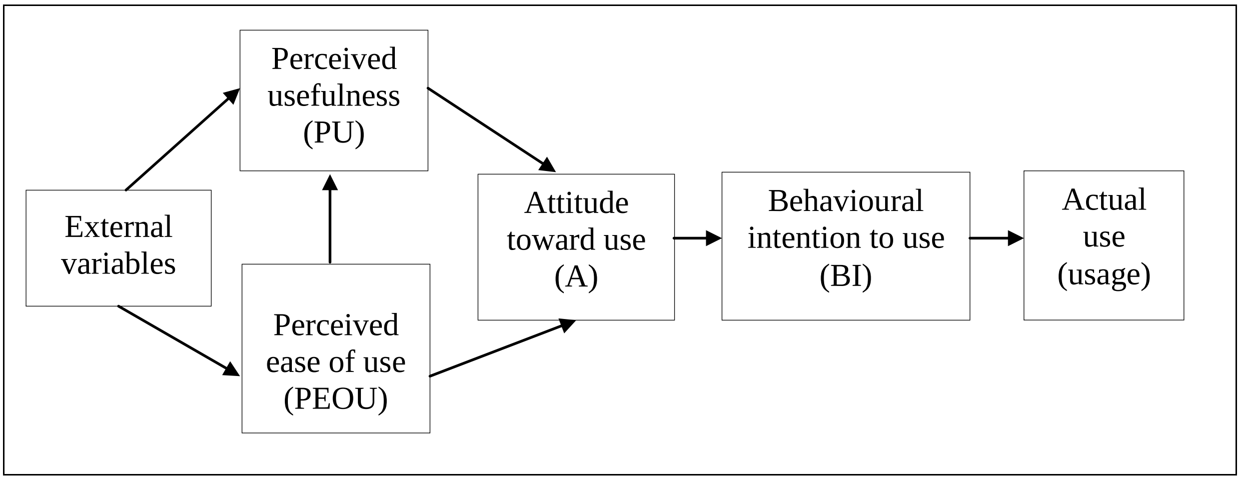


Figure 2.17: The TAM (Davis *et al*., 1989:985)

During his initial study, Davis (1986) identified, validated and used fourteen measuring items per construct, PU as shown in Table 2.9, and PEOU as shown in Table 2.10.

Table 2.9: Perceived usefulness item pools (Davis, 1986:84)

Item #	Item Wording
1	My job would be difficult to perform without electronic mail.
2	Using electronic mail gives me greater control over my work.
3	Using electronic mail improves my job performance.
4	The electronic mail system addresses my job-related needs.
5	Using electronic mail saves me time.
6	Electronic mail enables me to accomplish tasks more quickly.
7	Using electronic mail supports critical aspects of my job.
8	Using electronic mail allows me to accomplish more work than would otherwise be possible.
9	Using electronic mail reduces the time spend on unproductive activities.
10	Using electronic mail enhances my effectiveness on the job.
11	Using electronic mail improves the quality of work I do.
12	Using electronic mail increases my productivity.
13	Using electronic mail makes it easier to do my job.
14	Overall, I find the electronic mail system useful in my job.

Table 2.10: Perceived ease of use item pools (Davis, 1986:85)

Item #	Item Wording
1	I often become confused when I use the electronic mail system.
2	I make errors frequently when using electronic mail.
3	Interacting with the electronic mail system is often frustrating.
4	I need to consult the user manual often when using electronic mail.
5	Interacting with the electronic mail system requires a lot of my mental effort.
6	I find it easy to recover from errors encountered while using electronic mail.
7	The electronic mail system is rigid and inflexible to interact with.
8	I find it easy to get the electronic mail system to do what I want it to do.
9	The electronic mail system often behaves in unexpected ways.
10	I find it cumbersome to use the electronic mail system.
11	My interaction with the electronic mail system is easy for me to understand.
12	It is easy for me to remember how to perform tasks using the electronic mail system.
13	The electronic mail system provides helpful guidance in performing tasks.
14	Overall, I find the electronic mail system easy to use.

2.4.2 Internal and external factors of the TAM

This section will describe the internal and external factors of the TAM.

2.4.2.1 The internal factors of the TAM

Davis *et al*. (1989) focus on the internal factors of the TAM and report on a complete and extensive study that was conducted to compile reliable and valid scales per construct contained in both the TRA and TAM and to compare the significance of the constructs towards the attitude of computer usage. During this study, interviews were conducted with a group of 40 MBA students at the start of their second year of study. During their first year of study they were exposed to the WriteOne word processing software (Davis *et al.*, 1989:990). At the start of their second year, they were interviewed and asked questions related to advantages, disadvantages and possible reasons to use or not to use the WriteOne software in future. Aspects that were mentioned repeatedly during interviews were noted and used to formulate a set of measuring items per construct. The aspects were responses to questions asked. The aspects below are listed in order of most to least frequently mentioned during the interviews.

- I'd save time in creating and editing documents
- I’d find it easier to create and edit documents
- My documents would be of a better quality
- I would not use alternative word processing packages
- I'd experience problems gaining access to the computing centre due to crowdedness
- I'd become dependent on WriteOne
- I would not use WriteOne after I leave the MBA program.

In terms of the TAM, fourteen candidates took part in pre-testing the measuring items, which was scaled down to four items per construct. The items were validated and the reliability was tested. The four ease of use items were:

- Learning to operate WriteOne would be easy for me
- I would find it easy to get WriteOne to do what I want it to do
- It would be easy for me to become skillful at using WriteOne
- I would find WriteOne easy to use.

The four usefulness items were:

- Using WriteOne would improve my performance in the MBA program
- Using WriteOne in the MBA program would increase my productivity
- Using WriteOne would enhance my effectiveness in the MBA program
- I would find WriteOne useful in the MBA program.

These measuring items were used to measure the attitude of 107 full-time MBA students at the University of Michigan towards the use of the word processing program known as WriteOne was evaluated. The students were introduced to the software during the first week of their first semester of their first year of study. A questionnaire that consisted of valid and reliable measuring scales per construct from both the TRA and TAM was used. After a period of fourteen weeks, the same group of students were asked to report on the degree of usage of the same software. The same items and constructs were used to ensure consistency and reliability of the study.

The same items and construct were used in research done by Ajzen and Fishbein who explored human behaviour and acceptance of computer systems (Bandura, 1982; Legris *et al.*, 2003; Mathieson, 1991; Turner *et al.*, 2010). Factors such as cognitive styles, personality variables, political influences and organisational structures are regarded as external variables that indirectly influence a person's behaviour towards the use of technology variables of the TAM

One of the limitations of the TAM pointed out by some researchers is the lack of clarification of ease of use and usefulness of technology and the external factors.

To address these limitations, many adapted versions of TAM were compiled over time. One of the prominent adapted versions of the TAM was compiled by Venkatesh and Davis (Venkatesh & Davis, 2000:188). Their model includes an extensive list of external factors that could influence the perceived usefulness of technology. The factors include aspects such as experience, job relevance and voluntariness. This version of the TAM is known as TAM2. Thereafter, Venkatesh *et al*., (2003) expanded the TAM to include more external factors, such as age and gender.

Venkatesh *et al.* (2003:428) reviewed eight different models of individual users' acceptance of different technologies. In most of these models, the external variables were more clearly defined than the original model and the relationships between the internal variables and the external and internal variables were also redefined. In their review of the TAM, Legris *et al*. (2003:196) analysed 22 studies and compiled a list of the external factors that were considered, including factors such as level of education, prior similar experiences, and participation in training. Regarding external factors, Legris *et al*. (2003:197) state: "Actually, external variables provide a better understanding of what influences PU and PEOU, their presence guide the actions required to influence a greater use."

Venkatesh and Bala (2008:280) developed another variation of the TAM, referred to as TAM3. This version provides a comprehensive list of determinants as external factors that could influence usefulness and ease of use respectively. These include factors such as level of computer anxiety and computer playfulness.

More recent studies on external factors are that of Shih *et al*. (2011), who investigated self-efficiency, subjective norms and facilitating conditions as factors in the acceptance of Lego NXT as technology to enhance teaching and learning among elementary school students, (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) (Im *et al.*, 2011) , who did a study on culture as an external factor that influences the acceptance of Internet banking and the use of MP3 players as technology on citizens of the US and Korea and Wong, *et al.* (2012), who investigated the gender and self-efficiency of teachers in Malaysia.

The TAM was developed originally to predict the acceptance of information systems (Shih *et al.*, 2011:5056). However, it has been used to predict the actual use of technology in a wide range of fields. Each of these research efforts adapted the definitions of PU and PEOU to suit its application. For example, in his study on the factors that influence teachers' intention to use technology, Teo (2011:2433) adapted the definition of PU as follows: "The degree to which a teacher believes that using technology would enhance his or her job performance." He adapted the definition of PEOU as follows: "The degree to which a teacher believes that using technology would be free of effort" (Teo, 2011:2433). Although these definitions and many other variations thereof recorded in the literature differ slightly, the essence of both concepts is quite clear from these quotations.

In this study, PU will be regarded as the degree to which a student believes the use of serious games would enhance his or her performance, and PEOU as the degree to which a student believes that using serious games would be free of effort.

In this study, the aim is to model the external factors that influence the acceptance of serious games as technology in class amongst computer science students in South Africa. The study aims to define PU and PEOU in the context of the computer science student, and also to define some external variables that influence the attitude of students in the South African context towards serious games in the computer science classroom.

2.5 SUMMARY

Technology is part of our everyday lives and is becoming more interactive with users. Programming requires students to apply logical thinking and problem solving skills. Serious games have the potential to be used to teach students these skills in an interactive way. In education, there is a definite trend towards the use of games as a teaching tool.

Students are comfortable with technology as part of many aspects of their lives, but not specifically as part of their learning experience in class. Efforts made to incorporate games into the teaching and learning process have shown some promising results in terms of positive and engaging experiences in class. Financial implications and restructuring lessons are some of the barriers faced in education. Therefore, it is important to have an indication of whether serious games will be accepted in class and add real value to the process of teaching and learning.

Using models to give an indication of the attitude of users to accept technology and the intent of users actually to use the technology could lead to a decrease in the high failure rate of the optimal use of implemented technology. Governments all over the world spend large amounts of money to establish computer technology in educational institutions. Concerns are raised about the possibility of these technologies not being used to their full potential, or not being used at all. The TAM is an important tool to assist in assessing user's attitude towards technology. Therefore, the TAM is used in this study to investigate the attitude of students towards the use of serious games in the computer science class to enhance learning.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

Research takes place when new knowledge is added to a subject or topic (Mouton, 2001:138; Saunders *et al.*, 2009:5). Neuman (2011:9) refers to scientific research as a science "producing knowledge". Saunders *et al*. (2009:3) emphasise the significance of a systematic approach towards the research process and the importance of choices the researcher has to make regarding appropriate research methods and techniques. These choices are influenced by the scientific attitude and philosophy of the researcher (Neuman, 2011:15; Saunders *et al.*, 2009:108).

This chapter discusses different research approaches and methodologies and motivates the approach and methodology used in this study.

The primary objective of this study was to investigate the factors that influence the attitude of computer science students towards serious games in class. This objective was then deconstructed into the following four empirical objectives:

- Determine the attitude of students in computer science towards serious games as part of the teaching and learning resources in computer science classes.
- Determine key factors related to the successful use of serious games as part of the teaching and learning process in computer science classes.
- Gain a better understanding of the perceptions and expectations of the modern computer science student.
- Construct a model indicating the factors that influence the attitude of computer science students towards the use of serious games as a possible teaching approach in a computer science class.

This chapter describes the research methodology used for the collection and the analysis of the data for this study. The first section, Section 3.2, includes a discussion on the research process and paradigms related to the field of information systems (IS) and information technology (IT), and subsequently pertaining to this study. The research approach is described in Section 3.3 while the research strategy that was followed is discussed in Section

3.4. This includes a discussion on survey as research strategy and the sampling strategy that was applied in this study, referring to the target population, sampling frame, sampling method, and the sample size for this study in Section 3.5. The data collection method is discussed in Section 3.6, comprising the questionnaire design, question format and the questionnaire layout. In Section 3.7, the constructs and items concerning the internal and external factors related to the study are motivated. Section 3.8 describes the statistical analysis techniques used in this study, namely reliability analysis, validity analysis, descriptive analysis and tests of significance. A summary is provided in Section 3.9.

The following section describes the research process with specific reference to research paradigms and philosophical assumptions, which ground research paradigms.

3.2 RESEARCH PARADIGM

The research process is driven by a desire to produce valid and truthful knowledge about the aspect under investigation (Mouton, 2009:28). It could be compared to a journey the researcher undertakes with a specific goal, objective or destination in mind. The route and mode of conducting the research journey is determined by the methodology the researcher implements. However, all the aspects comprising the research process or journey such as the research philosophies and motive of the researcher, the objective of the study and methodologies applied should complement each other during the research process. The research onion compiled by Saunders *et al*. (2009) (Figure 3.1) illustrates the research process as interconnected layers. Each layer represents a specific essential part of the research process. Although the research onion was developed for research in the business management field, the visual representation illustrates important components which research in any field of study should comprise in order to be valid.

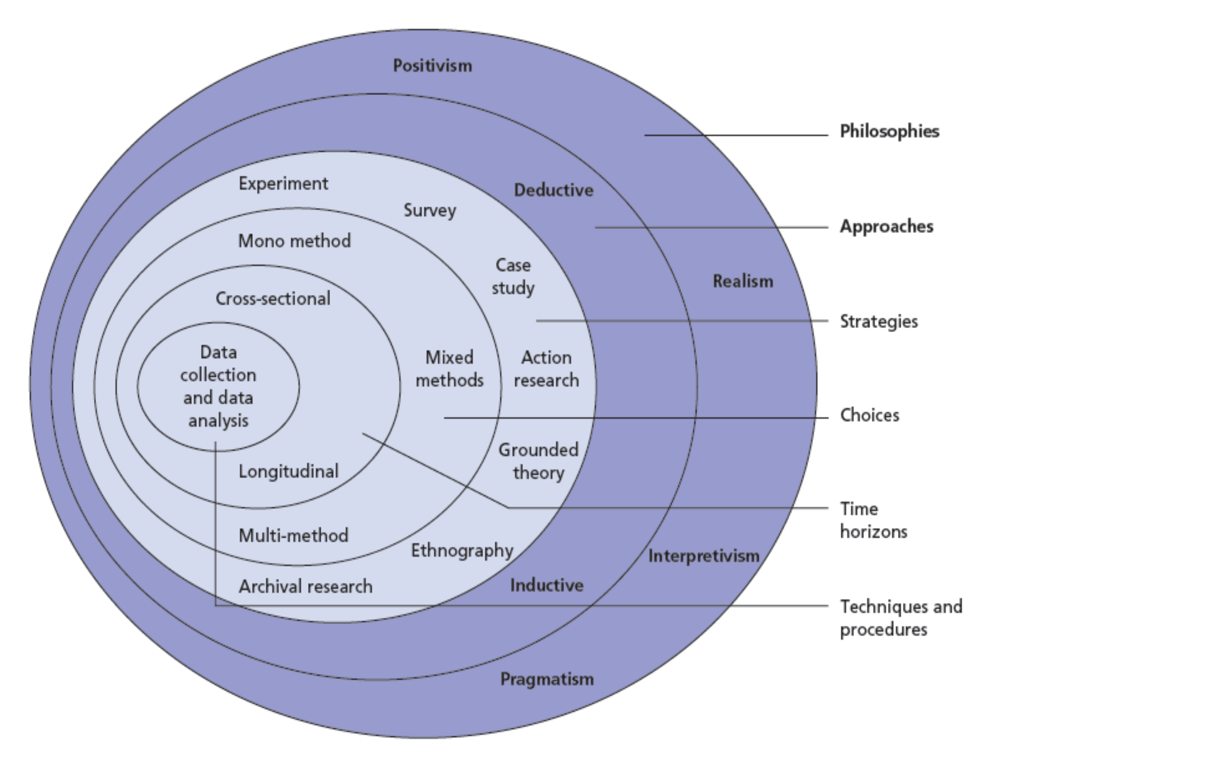


Figure 3.1: The research onion

Source: Saunders *et al.* (2009:138)

The inner layers of the research 'onion' represent strategies, choices, techniques and procedures which are encapsulated and therefore influenced by the researchers' philosophy, scientific attitude and approach towards the research process – the two outer layers in the diagram. Thus, how people view the world influences their research approach and strategy (Saunders *et al.*, 2009:108). Specific research communities follow and accept the same research strategies based on their research philosophy. Research paradigms stem from these scientific communities who think about the nature of the world and reality (ontology) in the same way (Locke *et al.*, 2010:80; Oates, 2006b:282). The outer layers of the research onion illustrate the fact that research philosophies and paradigms determine the methods and techniques used during the research process well.

Positivism, realism, interpretivism and pragmatism are the primary research paradigms applied in the field of business management (Saunders *et al.*, 2009:108). According to Oates (2006b:283), research in the field of information systems (IS) and information technology (IT) mostly stems from the positivism, interpretivism and critical research paradigms. In their paper on design research in the field of IT, Adebesin *et al.* (2011:310) refer to a table (Table 3.1) which was compiled by Vaishnavi and Keuchler (2004). The content of the table describes the philosophical assumptions of four research paradigms. Positivism, interpretivism, critical research/constructivism and design science are listed as research paradigms for IT. Some distinctive features of the philosophical assumptions upon which these four paradigms are grounded in terms, which entail ontology, epistemology, methodology and axiology, are summarised in the table.

Table 3.1: Philosophical assumptions of four research paradigms (Adebesin *et al.*, 2011:310)

	Philosophical assumptions			
Research paradigms	**Ontology**	**Epistemology**	**Methodology**	**Axiology**
Positivist	- Single, stable reality - Law-like	- Objective - Detached observer	- Experimental - Quantitative - Hypothesis testing	- Truth (objective) - Prediction
Interpretive	- Multiple realities - Socially constructed	- Empathetic - Observer subjectivity	- Interactional - Interpretation - Qualitative	- Contextual understanding
Critical/ Constructionist	- Socially constructed reality - Discourse - Power	- Suspicious - Political - Observer constructing Version	- Deconstruction - Textual analysis	- Inquiry is value-bound - Contextual understanding - Researcher's values affect the study
Design	- Multiple contextually situated realities	- Knowing through making - Context-based construction	- Developmental - Impact analysis of artefact on composite system	- Control - Creation - Understanding

Positivism involves objective research based on the laws of the universe (Neuman, 2011:95; Oates, 2006b:284; Saunders *et al.*, 2009:113). Existing theories and facts are studied rather than impressions and subjective views. The researcher is objective and reports on facts and findings without being involved but rather from the perspective of an observer. Interpretivism comprises human involvement and the study of people in their natural environment (Neuman, 2011:293). In IS and IT interpretivism involves explaining social settings and how people, for example, perceive an information or computer system. The researcher is subjectively involved while interacting with people (Neuman, 2011:101). Furthermore findings are based on social aspects and are therefore subject to change over time. Critical research is an extension of interpretivism in the sense that people are studied in relation to their world with the purpose of improving their lives (Kuechler & Vaishnavi, 2011:311; Neuman, 2011:108). For example, social aspects regarding IT can be investigated with the researcher interacting with people. Thereafter, the findings are analysed critically to find solutions in an effort to control and improve the social settings (Oates, 2006a:297). Design science is described as research which is performed in a problem-solving paradigm and therefore involves creating innovations or artefacts (Hevner *et al.*, 2004:76). Man-made artefacts and innovations are developed when design science research is conducted. Artefacts and innovations are reviewed constantly, which could lead to another innovative invention. In this way design science contributes towards constantly changing the world (Vaishnavi & Kuechler, 2004:9). Apart from creating innovations, design science often leads to improvement of innovations. While innovative artefacts are produced, new ideas are formed, concepts defined and practices formulated. Design science supports design theory and include research methods used within the positivist and interpretivist paradigms (Adebesin *et al.*, 2011:312).

In scientific research, the philosophical view of the researcher on reality influences how the researcher reports about facts within a field of knowledge (Adebesin *et al.*, 2011:309). Each research paradigm is characterised by the philosophical views of researchers on aspects of ontology, epistemology, methodology and axiology. Ontology refers to a reflection on "the issue of what exists" or "the fundamental nature of reality" (Neuman, 2011:92). For example, a positivist will reveal facts concerning the as-is world, whereas an interpretivistic view is characterised by a subjective interpretation of the real world. Epistemology reflects on how knowledge is created within the ontological view of the researcher. That is how a researcher thinks about the nature of knowledge or reports the truth about knowledge gained (Mouton, 2009:31; Neuman, 2011:93). Two approaches are recognised in terms of how knowledge is gained, namely an empiricism approach and a rationalism approach (Walliman, 2011:17). Empiricism relies on the senses of the researcher. Following this approach, knowledge is gained by means of inductive reasoning which was established by the ancient Greek key figure Aristotle (348–322 BC). According to Aristotle, knowledge starts with an observation and results in a conclusion based on inductive reasoning (Walliman, 2011:25). Inductive reasoning is a common and often an intuitive activity. However, the number of observations should be large enough to be able to generalise in order to come to a true and valid conclusion. Rationalism relies on the power of the mind. In this instance knowledge is gained by means of deductive reasoning. Plato (427–347 BC), who is associated with deductive reasoning, argued that knowledge is gained by formulating a general statement and refining the statement via logical arguments, which then will then lead to a logical conclusion (Walliman, 2011:18). Deductive reasoning is applied where a theory is formulated and data are collected to either support or reject the theory (Saunders *et al.*, 2009:127). As illustrated by Saunders *et al*. (2009) in the research onion (Figure 3.1), deductive reasoning is associated with positivism and realism. New knowledge is produced deductively by testing pre-existing ideas about reality against empirical data, or inductively by gathering and organising empirical evidence into a higher order of generalisation. The approach followed towards research determines the procedure or method that should be followed. Methodology entails the application of standardised methods and procedures in pursuit of the primary objective to gain truthful knowledge within a specific context (Mouton, 2009:35). Axiology reflects on the values of a researcher in relation to the environment of research (Mouton, 2001:249; Saunders *et al.*, 2009:118).

The research paradigm for this study was positivism, since an objective study was conducted based on a quantitative research methodology. Although triangulation was considered, it was decided to focus on obtaining and analysing quantitative data only in this study for the purpose of modelling the results. According to Olsen (2004:4), triangulation is applied when more than one research approach – usually quantitative research followed by qualitative research – are conducted in order to obtain two or three points of view on the matter at hand. Hussein (2009:3) points out that triangulation can be applied as part of a validation process to increase the accuracy of research results. It is suggested that a qualitative study is conducted to verify the accuracy of the suggested model as part of further research. Based on a thorough literature study on serious games, computer science requirements and the TAM, aspects required to motivate students to enrol for computer science and perform well in computer programming and problem solving skills were identified in relation to skills gamers attain when playing serious games. The identified factors were divided into internal and external factors according to the TAM. Validated constructs were obtained from the literature research and items from the constructs were slightly adapted to evaluate factors that influence the attitude of students towards using serious games as part of the learning environment in the computer science class. A questionnaire was compiled and distributed, and the results obtained were captured. A confirmatory factor analysis was done on measuring items pertaining to factors that were identified as important for this study during the literature review. Students perceive these factors as a valuable part of the teaching and learning experience in the computer science class.

Correlations between factors were determined, which resulted in the construction of a regression model which reflects the internal and external factors that influence the attitude of computer science students towards using serious games as part of the learning environment in class.

3.3 RESEARCH APPROACH

One of the outer layers of the research onion (Figure 3.1) that encapsulates the research strategies and procedures (the inner layers) is the research approach layer. Mouton (2009:74) refers to research approach as “scientific reasoning”. As previously mentioned, an inductive or deductive research approach can be followed (Mouton, 2009:79). Saunders *et al*. (2009:125) refers to the inductive research approach as the “building theory” approach. Although this approach is less structured than the deductive research approach, it allows for human aspects such as feelings and perceptions to be taken into account, other than the pure facts. Collected data are used to understand a problem and to formulate a reasonable explanation or theory. The researcher is involved by making sense of the collected data. This can be done by observing categories or patterns in the collected data. Oates (2009:269) warns against prejudices, and states that researchers who follow this approach should be open minded and “allow the data to speak to you”. Mouton (2009:74) distinguishes between two forms of inductive scientific reasoning based on the aim of the approach, namely inductive generalisation and a retroductive approach. The aim of inductive generalisation is to apply the sample findings to larger populations, thereby substantiating existing beliefs, while the aim of the retroductive approach is to formulate the best and most reasonable explanation of the events based on the data that were collected during the particular study (Mouton, 2009:86).

The deductive research approach is a structured approach during which a theory and hypothesis is developed and tested (Mouton, 2009:80). Since existing theories are used, or the researcher formulates theories, caution has to be taken not to be “too committed to a given theory” (Oates, 2006b:269). If this happens, some valuable information hidden in the data may be overlooked. Some of the characteristics of the deductive research approach are the following (Saunders *et al.*, 2009:127):

- an urge to explain casual relationships between variables
- quantitative data collection mostly takes place
- control measures are put in place to allow the testing of hypotheses
- the highly structured methodology followed ensures reliability
- the researcher is independent of what is being tested which ensures a high level of objectivity
- large enough sample sizes are used to allow generalisation to be applied.

In this study, a deductive research approach was followed. Factors and relationships between factors were identified and tested, which resulted in the formulation theories. A model was compiled based on these theories. In some further studies these theories could be investigated to formulate possible reasons why specific theories and conclusions could be formulated based on the results obtained from this study.

3.4 RESEARCH STRATEGY

A research strategy can be defined as a way of enabling a researcher to reach the objectives of a study and address the research question (Saunders *et al.*, 2009:141). Factors that influence the choice of strategy are the objectives of the study, the research approach and philosophy, the type of data required (quantitative or qualitative) and time and resources available. *"*Our research methods must take account of the nature of the subject matter and the complexity of the real world*"* (Galliers & Land, 1987:901).

3.4.1 Research strategies in the field of computer science

A variety of research strategies are followed in the various computer related fields of study. (Oates, 2009:35) lists the following strategies that are used often when research in the field of IT and IS are conducted:

- **Survey**: Obtain data from large groups of people and analyse the data statistically.
- **Design and creation**: Focus on the development or a phase during the development of new IT products.
- **Experiment**: Investigate an IT product or IT related matter with before and after evaluation in order to prove or disprove hypotheses.
- **Case study**: Investigate one instance of a case or thing in order to understand and know all about the case.
- **Action research**: Take action and then reflect on the results of the action that was taken.
- **Ethnography**: Spend time with a particular group of people in order to understand and get to know their culture for research purposes.

3.4.2 Survey as research strategy

The survey strategy involves obtaining data from large groups of people or events "in a standardised and systematic way" (Oates, 2006b:93). It entails empirical research and is a useful strategy to investigate "relatively uncomplicated facts, thoughts, feelings or behaviours" (Denscombe, 2010:12). Findings can be used to explain or understand relationships between variables and to construct models (Saunders *et al.*, 2009:144). Trends in management information systems (MIS) research methodologies applied in studies published in some of the leading academic MIS journals for the period 1993 to 2003 reveal that survey is the most widely used research strategy in the fields of IS and IT (Palvia *et al.*, 2004:530). Table 3.2 lists the research methodologies that were used, with a brief description of what each methodology entails. Although the majority of the papers published in these journals are US based research, it still is a good indication of the research methodologies suitable for a wide range of IS and IT research topics.

Table 3.2: Trends in MIS research methodologies for the period 1993 to 2003 (Palvia *et al.*, 2004:532)

1	Speculation/commentary	Research that derives from thinly supported arguments or opinions with little or no empirical evidence.
2	Frameworks and conceptual model	Research that intends to develop a framework or a conceptual model.
3	Library research	Research that is based mainly on the review of the existing literature.
4	Literature analysis	Research that critiques, analyses, and extends existing literature and attempts to build new groundwork, e.g., it includes meta- analysis.
5	Case study	Study of a single phenomenon (e.g., an application, a technology, a decision) in an organisation over a logical time frame.
6	Survey	Research that uses predefined and structured questionnaires to capture data from individuals. Normally, the questionnaires are mailed (now, fax and electronic means are also used).
7	Field study	Study of single or multiple and related processes/ phenomena in single or multiple organisations.
8	Field experiment	Research in organisational setting that manipulates and controls the various experimental variables and subjects.
9	Laboratory experiment	Research in a simulated laboratory environment that manipulates and controls the various experimental variables and subjects.
10	Mathematical model	An analytical (e.g., formulaic, econometric or optimisation model) or a descriptive (e.g., simulation) model is developed for the phenomenon under study.

11	Qualitative research	Qualitative research methods are designed to help understand people and the social and cultural contexts within which they live. These methods include ethnography, action research, case research, interpretive studies, and examination of documents and texts.
12	Interview	Research in which information is obtained by asking respondents questions directly. The questions may be loosely defined, and the responses may be open-ended.
13	Secondary data	A study that utilises existing organisational and business data, e.g., financial and accounting reports, archival data, published statistics.
14	Content analysis	A method of analysis in which text (notes) are examined systematically by identifying and grouping themes and coding, classifying and developing categories.

The graph in Figure 3.2 shows the trend in seven of the research methodologies that were applied by the researchers whose papers were published by these MIS journals for the period 1993 to 2003.

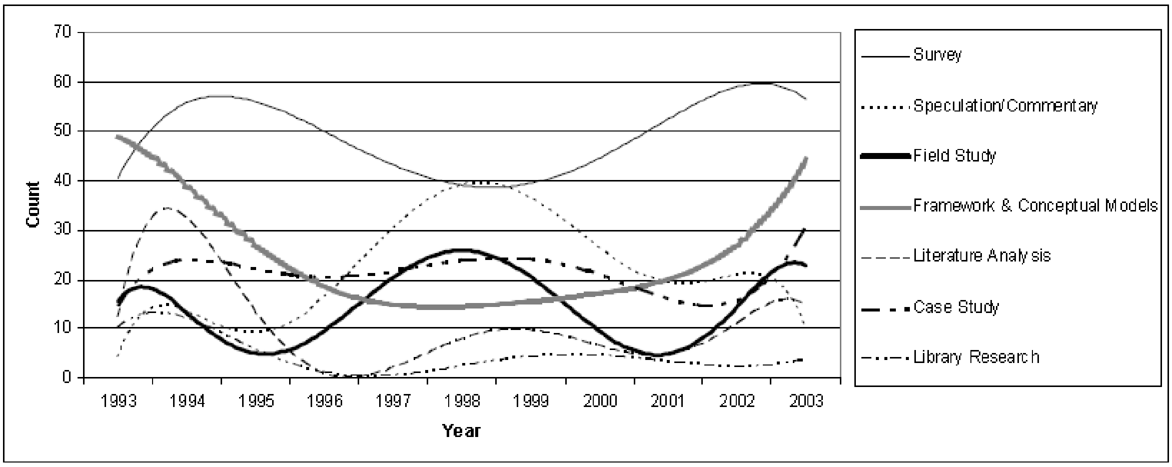


Figure 3.2: Most frequently used research methodologies in papers published in academic MIS journals for the period 1993 to 2003 (Palvia *et al.*, 2004:532)

Some of the advantages of conducting a survey are the relatively low cost, exclusion of any personal influence, flexibility, convenience for respondents, the large geographical area that can be covered, and relatively quick and easy administration (Lazar *et al.*, 2010:101; Walliman, 2011:97). Furthermore, once the data have been collected, they can be statistically analysed which adds a specific level of credibility to the findings (Fowler, 2009:1; Oates, 2006b:104). However, the lack of depth in data, and the fact that research findings rely on figures and numbers only, are some of the concerns raised related to the survey research strategy (Lazar *et al.*, 2010:101; Oates, 2006b:105). Consequently, surveys are not well suited for in-depth research on complex issues, since it is usually not possible to ask respondents follow-up questions. Therefore, detailed data can be overlooked (Oates, 2006b:220). Another drawback associated with surveys is the fact that the researcher has to rely on respondents' cooperation and goodwill, which can slow down the research process (Saunders *et al.*, 2009:144).

Generalisation is possible when a survey is conducted, which means the researcher can get an overview of the opinion of a population on a specific matter without having to collect data from the entire population. For this purpose, sampling strategies are applied.

3.5 SAMPLING STRATEGY

A census is conducted when information is collected about an entire population (Fowler, 2009:4; Walliman, 2011:98). Due to lack of funds, time and other resources it is usually impossible for researchers to obtain information from all possible instances within a particular study. Therefore, researchers usually work with a sample taken from a well-defined group of objects, which could be people, or any other object or topic. This group of objects or topics is regarded as a population within the research environment, also known as a research population (Denscombe, 2010:23; Neuman, 2011:244). Sampling is concerned with the selection of a subset or sample of items from within a research population.

Working with sample results is a more manageable and affordable process, and it is less time-consuming in terms of collecting and capturing data (Denscombe, 2010:23; Saunders *et al.*, 2009:212). It is argued that sampling provides results that are more accurate because more effort can go into proper piloting and obtaining valid information. The overall quality of the process is more reliable using a sample than when trying to collect and process large volumes of data (Saunders *et al.*, 2009:213; Swanepoel *et al.*, 2011:11). A target population should be identified to be able to identify a sampling frame and conduct a sampling process.

3.5.1 Target population

A target population is the complete group of elements from which the data must be collected in order to conduct a research project.

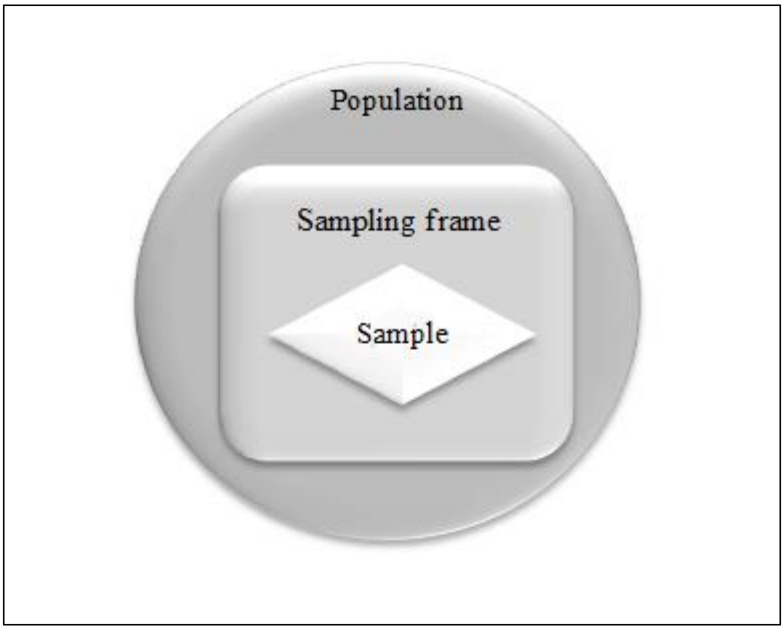


Figure 3.3: Sampling frame in relation to population and sample (Walliman, 2011:94)

The specific group that is used within the target population is known as the sampling frame. A sample is a sub-set taken from the sampling frame.

A population in general terms is an abstract concept and has to be related to a survey or specific study as a research population (Denscombe, 2010:23). The boundaries of a research population need to be defined clearly. The population is identified based on a combination of aspects such as geography, demographics and other related aspects (Neuman, 2011:245). A target population is a specific collection of elements or group of cases to be studied within a specific research population (Neuman, 2011:246). To identify the target population correctly is of great importance, as a vaguely defined population will provide inaccurate results. (Walliman, 2011:95). For this study, the population was defined as full-time students enrolled for a qualification in computer science at registered public South African Higher Education Institutions (HEIs) during 2013.

3.5.2 Method of sampling

The researcher applies a method of sampling in order to draw a sample from the target population. Generalised results are obtained from the sample (Neuman, 2011:246). In order to ensure that findings are reliable and representative of the population, it is important to find a sample (or subset) that represents the population as closely as possible. Sampling methods can be divided mainly into probability sampling techniques and non-probability sampling techniques (Denscombe, 2010:24-27; Saunders *et al.*, 2009:213; Walliman, 2011:96). Each of these categories contains a selection of specific sampling methods, which are applicable to specific sets of data and required results.

When probability sampling is applied a sample is drawn from the population based on the principle of randomisation or chance (Denscombe, 2010:24). During non-probability, sampling elements are chosen arbitrarily and thus there is no way to estimate the probability of any element being included in the sample. Generalisation cannot be applied due to the fact that sample elements included are dependent on the judgement of the researcher or accident (Walliman, 2011:96). Therefore, it cannot be assumed that the sample is representative of the population. The sampling methods are presented in Figure 3.4

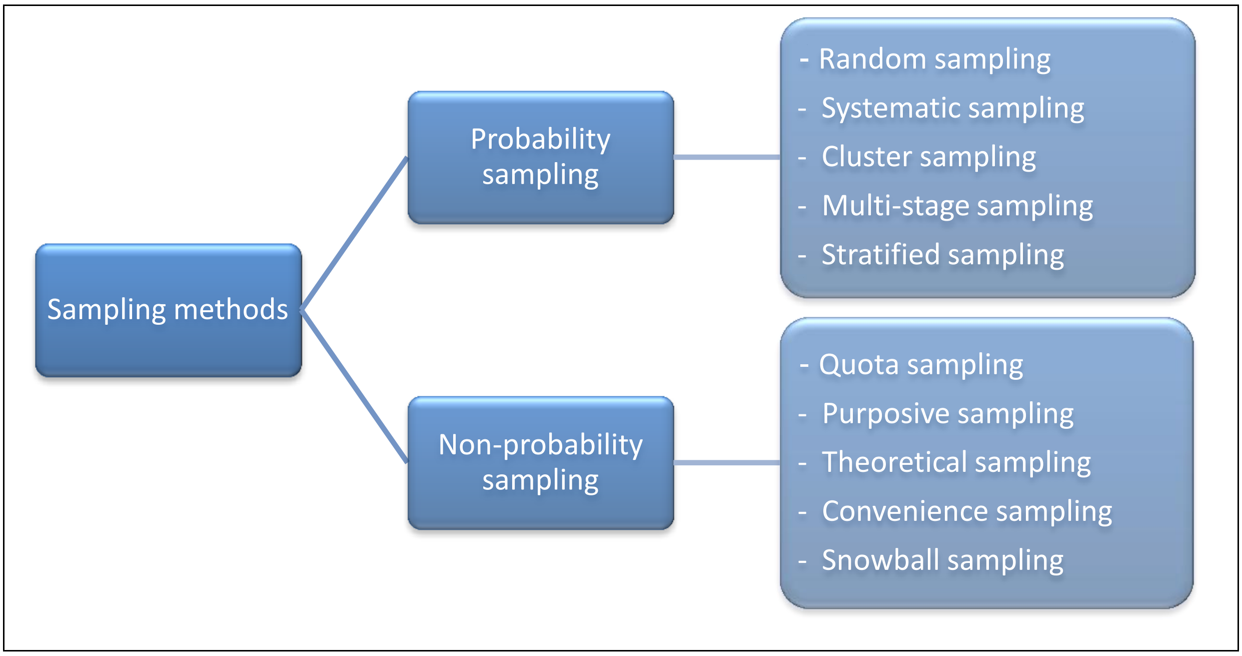


Figure 3.4: Probability and non-probability sampling methods

Results obtained from probability sampling methods are more representative of a whole population since the sample elements are selected randomly (Denscombe, 2010:25; Walliman, 2011:96). The complete subset of elements from which a sample is drawn from is referred to as the sampling frame (Gray, 2013:148; Walliman, 2011:94).

3.5.2.1 Sampling frame

The sampling frame comprises a set list of the population units from which the researcher will identify the sample (Mouton, 2009:135; Neuman, 2011:246; Walliman, 2011:94). A telephone directory is an example of such a list. The sample frame should be well chosen in order to ensure accurate and valid sampling.

The sample frame should be well defined and complete in order to ensure that it is a valid representation of the population. Some of the features of a good sampling frame are relevance to the research topic, representation of all relevant items, exclusion of all irrelevant items, and ensuring that the items included in the sampling frame are up-to-date (Denscombe, 2010:27). Generalisation cannot take place if the sample frame does not represent the population properly. The sampling frame for this study consisted of the 23 public registered South African HEIs, comprising eleven (11) universities, six (6) comprehensive universities and six (6) universities of technology as published by Higher Education in South Africa (2013) as listed in Table 3.3.

Table 3.3: Registered South African public HEIs (Higher Education in South Africa, 2011)

Name of University	Location
Cape Peninsula University of Technology	Western Cape
Central University of Technology	Free State
Durban University of Technology	KwaZulu-Natal
Mangosuthu University of Technology	KwaZulu-Natal
Nelson Mandela Metropolitan University	Eastern Cape and Western Cape
North-West University	North-West and Gauteng
Rhodes University	Eastern Cape
Tshwane University of Technology	Gauteng, Mpumalanga, Limpopo and North-West
University of Cape Town	Western Cape
University of Fort Hare	Eastern Cape
University of the Free State	Free State
University of KwaZulu-Natal	KwaZulu-Natal
University of Johannesburg	Gauteng
University of Limpopo	Limpopo and Gauteng
University of Pretoria	Gauteng
University of South Africa	All provinces
Stellenbosch University	Western Cape
University of Venda for Science and Technology	Limpopo
University of the Western Cape	Western Cape
University of the Witwatersrand	Gauteng
University of Zululand	KwaZulu-Natal
Vaal University of Technology	Gauteng, North-West, Mpumalanga and Northern Cape
Walter Sisulu University	Eastern Cape

3.5.2.2 Sample size

The size of the sample that is drawn from the sample frame depends on the types of analyses that will be done, the integrity of the data and the size of the population that the data represent (Denscombe, 2010:41). Statisticians recommend a minimum sample size of thirty (30) to provide useful results. Data of high integrity that are collected from the sample size are more likely to represent the characteristics of the population represented accurately. The researcher should keep in mind that "providing they are not biased, samples of larger absolute size are more likely to be representative of the population they were drawn from than smaller samples" (Saunders *et al.*, 2009:218). A level of 95 per cent certainty that the target population is represented by the sample is normally acceptable.

From the aforementioned list of the 23 registered institutions, one sample, which included two HEIs in the Gauteng province, was selected. These two HEIs comprise a traditional university and a university of technology. Given time and cost constraints, a convenience sample of these two HEIs was chosen because of the geographic proximity, thus making the research more manageable. One group of participants, namely full-time undergraduate registered students, was selected by means of convenience sampling. For the purpose of this study, a non-probability convenience sample of 547 students was taken from the sampling frame.

Data collection is an integral part of the research process. The sampling strategy often determines the method of data collection (Fowler, 2009:70).

3.6 DATA COLLECTION STRATEGY

Data within the research paradigm can be described as "findings and results which, if meaningful, become information" (Gray, 2013:575). Sensible data related to a study or research problem have to be collected and processed to provide useful information. There should be consistency between the research problem and objectives, the research strategy and the methods of data collection (Saunders *et al.*, 2009:323). The particular problem being analysed and the factors associated with the study determine the nature of the data which will be collected.

The sampling strategy often requires a specific method of data collection (Fowler, 2009:70). If sampling is done from a mailing list, a questionnaire will probably be distributed and collected via email. If a telephone directory is used to do sampling, initial contact with participants will probably be via telephone calls even though the actual collection of data could be done using a different data collection strategy.

To be able to collect data that are useful and valid, the researcher has to know exactly what information is required (Denscombe, 2010:12). Furthermore, data should be collected in a format and the spirit of research, which makes statistical analysis of data possible with the purpose of discovering knowledge (Denscombe, 2010:155). For example, a data collection tool such as a questionnaire should not be misused for the marketing of products. The circumstances suitable for the collection of reliable data include an open social climate, which allows participants to be honest when answering questions. Participants must be of a literacy level, which will enable them to be able to read and understand the questions asked. Data should also be obtained directly from the source to ensure reliability. The data collection method should not exclude participants who belong to the target population which is relevant to the study. For example, if a mailing list is used, all members of the target population should be on the mailing list and have Internet access (Fowler, 2009:71).

The organisation and scheduling of the data collection process should be well administered (Denscombe, 2010:157). In this study, a face-to-face group administration data collection strategy was followed since the respondents were computer science students enrolled for computer science at the Vaal campus of the North-West University and computer science students at the Vaal University of Technology. In these environments, the survey could be conducted within a specific period of time. This caused the response rate to be high and eliminated the waiting time for respondents to return the completed questionnaires.

3.6.1 Survey strategy using a questionnaire

The two prominent features of the survey strategy are questions compiled and asked by the researcher on the one hand, and answers provided by the participants on the other hand (Fowler, 2009:11). Researchers often conduct surveys on the feelings, opinions, behaviour, beliefs or attitudes of large groups of people using written questionnaires as a measuring instrument (Neuman, 2011:48, Walliman, 2011:98). Lazar *et al*. (2010:100) describe a survey as a set of "well-defined and well-written set of questions to which an individual is asked to respond". The method of conducting a survey and collecting data can be postal, telephonic, the Internet, group administration, observation, documents and interviews (Fowler, 2009:69; Denscombe, 2010:13-19). Questions can be presented as part of a structured or telephonic interview, an online or paper-based questionnaire or even observation (Saunders *et al.*

2009:360).

3.6.2 Questionnaire design

Resources such as time and cost involved in compiling, printing, distributing and collecting questionnaires do not permit the process to be repeated more than once; therefore, the design of the questionnaire should be well planned (Denscombe, 2010:157). General guidelines for compiling a questionnaire suitable for research purposes entail (Denscombe, 2010:162):

- Relevance: Identify and use only the questions that are absolutely necessary Guard against including questions on issues irrelevant to the study. Be cautious not to include duplicate questions.
- Procedure: Ensure that the procedure of responding is simple and not time consuming.
- Pilot test: Run a pilot test to get feedback on aspects such as the time it took to complete the questionnaire and the reliability of responses to the questions.

The design of a questionnaire could affect the response rate and, therefore, the reliability of results.

3.6.2.1 Questionnaire layout

A good layout of the questionnaire can result in an improved response rate (Gray, 2013:354). A general layout presented in the format of a booklet is recommended, even though stapled sheets are acceptable in the case of a low budget. A questionnaire should provide some background information from an ethical and practical point of view. Background information should include a brief explanation on the research topic and the purpose of the survey, the sponsor or institution or individual undertaking the research, a confidentiality clause, information stating that participation is voluntary and a note of gratitude for taking part in the survey at the end of the questionnaire (Denscombe, 2010:160). The researcher should never assume participants know the procedure to follow when answering the questions (Gray 2013:355). Instructions on how to complete the questionnaire are important and can be provided in the format of an example or a set of specific instructions. Questionnaires must be identified uniquely. Therefore, each questionnaire should contain a serial number.

The type of data collected using a written questionnaire can be categorised as either facts, which require no form of judgement or opinions which include attitudes, beliefs, views, etcetera. Although questionnaires generally contain questions on both these types of data the researcher should state clearly what type of data are required (Denscombe, 2010:157). Therefore, questionnaires often consist of different sections to accommodate these two categories of data.

For the purpose of this study, the questionnaire was divided into two sections, namely Section A, which contains questions on demographic information about the participants as well as their past and current level of engagement with serious games. Section B required of participants to express their attitudes and opinions towards the use of serious games in the computer science class in order to obtain information pertaining to the research topic and objectives of the study.

Fowler (2009:111) states that multiple questions on the same subjective state should be asked in different ways and combined into a scale. This strategy is useful to even out extreme responses and improve the validity of the process. For this purpose, two sub-scales were used in Section B, each comprising of constructs adopted from validated measuring instruments. The first sub-scale contains constructs to investigate the internal factors of the TAM while the constructs contained in the second sub-scale investigates the external factors related to the attitude of computer science students towards the use of games in class.

3.6.2.2 Question format

Questions can be formulated as either closed or open questions (Fowler, 2009:101; Gray, 2013:348; Walliman, 2011:97). Open questions provide for respondents to formulate answers themselves. Answers to open questions reflect the actual view of respondents but these answers are often not suitable for analytical purposes. If the researcher requires ordinal data, closed questions are more suitable. Closed questions provide the respondent with sets of pre-designed answers (Gray, 2013: 349). Provided answers have the advantage of obtaining more reliable responses since the possibility of misinterpretation of questions is limited (Fowler, 2009:101). Questions are easy to answer and quick and easy to code (Walliman, 2011:96). The captured data are ready to be analysed if the categories of possible answers are planned well. List questions, category questions, ranking questions and scale questions are some of the closed type of questions, which can be formulated (Gray, 2013:349). In list questions, a list of responses is provided. Respondents are requested to select one or many items from the list. Category questions are used when only one response is required. Categories are provided and the respondent is requested to select one of the provided categories. Ranking questions are used when respondents are required to rank responses. When ranking questions are formulated, categories must be clearly formulated and a category must be provided to catch response not covered by the provided categories. Also, guard against providing too many categories which could result in a complex list of responses to choose from. Scale questions are used when the respondent is required to rate a variable. Scale questions are common and will be discussed in the next paragraph.

Fowler (2009:88) states that the wording of questions is a key aspect to the reliability of answers respondents provide. Questions should be brief, simple and straightforward and in order for respondents to interpret the questions the same (Denscombe, 2010:155). Well-selected words should be used to avoid varying interpretations of the questions. When questions are phrased, words that are simple and universally interpreted in the same way should be used (Fowler, 2009:92). The style of questions may vary throughout a questionnaire. Denscombe (2010:161) recommends that instructions should be provided for sections where the style of questions differs from the previous set of questions.

3.6.2.3 Rating questions

Rating questions, also referred to as scale questions (Gray, 2013:350), are often used to evaluate attitudes or opinions on a matter (Saunders *et al*. 2010:378). An itemised rating scale such as the Likert scale is used to represent appropriate categories, which reflect the indicators of an attitude or opinion. These categories can be supplied by means of brief descriptions or by assigning numerical values to each category. The participant rates an object by selecting the most appropriate category (Saunders *et al*. 2010:378). Two of the most commonly used itemised rating scales are the semantic differential scale and the Likert scale.

- **Semantic differential scale:** In a semantic differential scale, two contrasting or opposite adjectives are place at the opposite ends of a scale (Saunders *et al*. 2010:380). Participants select a position on the scale, which best represents their feelings on the matter they are required to evaluate. An example of a semantic rating scale is shown below.

> Place an x on the line to show how you feel about using serious games in the computer science class.
>
> Positive __|__|__|__|__|__|__|__|__|__ Negative

Gray (2013:351) refers to this type of scale as a continuum scale. The author mentions that using a continuum scale could pose problems when data analysis is done - specifically when responses need to be consolidated into less number of categories, for example from 10 categories to three (yes, not sure and no).

- **Likert scale:** The Likert scale is named after psychologist Rensis Likert and is the most widely used scale in survey research. When using the Likert scale, participants are requested to indicate the level to which they agree or disagree on an agree-disagree rating scale. The rating scale usually is numbered where the most positive statement will have the highest score and the most negative statement will have the lowest score. The Likert scale can be modified to consist of a five, six or seven point scale. A six-point scale has the advantage of forcing the participant to choose between a negative or positive answer, as a midpoint indicates uncertainty of the participant.

For the purpose of this study, a Likert scale was implemented as the measuring instrument. In Section B of the questionnaire of this study, a six-point Likert scale was employed to measure the respondents' rate of agreement or disagreement with each specific item. Each of these statements were unified with numerical values, ranging from strongly disagree (1) to strongly agree (6).

An example of a Likert questionnaire item that was used in the questionnaire is as follows:

		Strongly Disagree	**Disagree**	**Disagree Somewhat**	**Agree Somewhat**	**Agree**	**Strongly Agree**
B1	I like the idea of playing (serious) games as part of the learning process in class.	1	2	3	4	5	6

3.6.3 Quality of the measuring instrument

Truthful knowledge is developed by conducting an in depth and systematic process of research (Neuman, 2011:9). Gray (2013:155) states that research tools must be valid and reliable. Valid research is ensured by using measuring instruments that "measure what it was intended to measure". Furthermore, it must be possible to generalise results obtained from using the measuring instrument to the population

3.6.3.1 Validity

Validity refers in general to "the condition of being true" (Locke *et al.*, 2010:81). In terms of research, validity indicates how truthful results are. Methods of data collection and the measuring instrument are some of the aspects, which can have an influence on the integrity of a study. Validity of questions entails research to identify the best set of questions to measure each variable (Fowler, 2009:112). Multiple questions on the same subjective state, asked in different ways, are combined into a scale (Fowler, 2009:111). This strategy is useful to even out extreme responses and improve the validity of the process.

3.6.3.2 Reliability

Reliability of a measuring instrument such as a questionnaire has to do with the level of consistency that is maintained (Locke *et al.,* 2010:85). The reliability of surveys is measured by analysing the consistency of responses. That means a response pattern should emerge from participant's responses, which represents the view of the general population. For example, the response to a question is considered to be reliable if the majority of participants show either a negative or positive result. If the response to a question does not show a general consensus amongst participants, the result is not reliable which means the question cannot be used to obtain reliable results.

To ensure validity and reliability measuring instruments, which have been well tested over time in different studies, are often used. For this study, measuring instruments that were used and validated during previous research on the TAM were used. The TAM evaluates a set of factors regarded as the internal variables (Lee *et al.*, 2003:756) and a set of factors regarded as external variables, which contribute towards the predicting of the attitude towards and intention of the use of technology.

3.6.4 Questionnaire administration

The response rate of participants is often problematic when a questionnaire is used (Fowler, 2009:70). The respondent's level of interest in the research topic, ease of contact and ease of response are some of the factors that ensure a good response rate. Group-administered surveys have a high response rate, for example normally all the students in class would fill a questionnaire if asked to do so (Fowler, 2009:75). In this study, a group-administered survey was conducted.

Structured questionnaires are employed typically when using survey methods for systematic and structured data gathering (Walliman, 2011:97). The method of data collection that was used to conduct research for this study was the survey method, where a standardised self-administered questionnaire was utilised as research instrument. Permission to deliver the self-administered questionnaires was solicited telephonically from lecturers of full time computer science students at each of the two HEIs. Thereafter, the questionnaires were hand-delivered by the researcher to the contacted staff members residing at the two HEIs, who then distributed the questionnaires to their students for completion after class. The task of the staff members distributing the questionnaire was made easy by using a structured questionnaire. The questionnaires were collected after a period of one week.

A detailed discussion on the motivation of the questionnaire and the validity of sub-scales, constructs and items follows in the next section.

3.7 MOTIVATION OF THE MEASURING INSTRUMENT FOR THIS STUDY

A questionnaire was developed to determine the attitude of students towards the use of serious games in the computer science classroom. The perception students may have about the use of technologies as part of the learning experience in class may have an impact on their attitude towards the use of serious games in the classroom. Attitude can be defined as the person's positive or negative feelings about a behaviour (Ajzen, 1991:201; Teo, 2011:2433). In this study, the attitude towards playing games as part of the learning process in the computer science class was investigated. Attitude towards the use of technology as part of the learning experience in class is important since it has a direct influence on whether the user will accept the technology and regard it as useful to improve his or her performance (Davis & Venkatesh, 1996).

3.7.1 Motivation for internal TAM variables used

When Davis (1989) first introduced the TAM, many researchers conducted studies to confirm the validity and reliability of the TAM constructs and measuring items. Results of studies conducted by Adams *et al*. (1992), Hendrickson *et al*. (1996) and Szajna (cited by Lee *et al.*, 2003:756) all confirmed that the original TAM measuring instruments are valid and reliable and could be used to predict the attitude of future users towards the use of the technology successfully, and subsequently, the actual use of the technology. Lee *et al.*, (2003:756) analysed 101 studies that were conducted on using the measuring items of the original TAM.

These studies evaluated the acceptance of a range of different technologies within the information system (IS) environment. Table 3.4 comprises a summary of the number of studies that found relationships between the constructs perceived usefulness (PU), perceived ease of use (PEOU), behavioural intention (BI) and actual behaviour (B) to be significant, not significant or not applicable. These constructs evaluate the internal TAM variables.

Table 3.4: Evaluated relationships between the original internal TAM variables (Lee *et al*., 2003:760)

Level of significance	**Relationships between major TAM variables**			
	PEOU → PU	**PU → BI or B**	**PEOU→ BI or B**	**BI → B**
Significant	69	74	58	13
Non-significant	13	10	24	2
Not applicable	19	17	19	86
Total	101	101	101	101

As shown in Table 3.4, 69 out of the 101 studies that were reviewed by Lee *et al.,* (2003) found the relationship between PEOU and PU to be significant while 13 studies found this relationship not to be significant. The phrase, Not Applicable in the second last row in Table 3.4 refers to the number of studies where relationships between the internal TAM variables were not tested for significance. In 19 out of the 101 studies, the relationship between PEOU and PU was not tested for significance. Many of the studies that were reviewed evaluated the relationship between PU and either behaviour intention (BI) or behaviour (B). Lee *et al.,* (2003:760) summarised the results of these relationships using the heading PU → BI or B. Similarly the results of relationship between PEOU and BI and B respectively was summarised using the heading PEOU → BI or B. A large number of studies (74) found the relationship between PU and BI or B to be significant, while 10 studies indicated that the relationship was not significant. Fifty-eight studies found the relationship between PEOU and either BI or B to be significant while 24 indicated that the relationship as not being significant. A limited number of studies were conducted on the relationship between BI and B, of which 13 found the relationship to be significant and two not significant.

The revised version of the original TAM, TAM2 (Figure 3.7) does not include attitude as an internal TAM variable. However, the original TAM includes attitude (A) as an internal variable (Davis, 1989). Davis and Venkatesh (1996) state that grouped items from the original TAM can be used for predicting the acceptance of technology. Since this study analyses the attitude of students towards the use of a technology in class, attitude (A) was included as an internal TAM variable along with perceived ease of use (PEOU), perceived usefulness (PU) and behaviour intention (BI). These TAM variables are the constructs used in the first subscale for this study as shown in Table 3.5 along with authors who validated and used these constructs in studies they conducted on the acceptance of technology.

Table 3.5: Internal TAM factors as construct of the first sub-scale of this study

Constructs	**Authors**
Perceived usefulness (PU)	Davis, 1989; Davis & Venkatesh, 1996; Saade & Bahli, 2005; Turner *et al*., 2010
Perceived ease of use (PEOU)	Davis, 1989; Davis & Venkatesh, 1996; Saade & Bahli, 2005; Lee *et al*., 2005; Turner *et al*., 2010; Teo, 2011
Behavioural intention (BI)	Davis, 1989; Lee *et al*., 2005; Saade & Bahli, 2005; Teo:2011
Attitude (A)	Fishbein & Ajzen, 1975; Lee *et al*., 2005; Teo, 2011

Measuring items used in this study are listed in Table 3.6 together with the authors from whom these measuring items were borrowed. Measuring items from these studies were used for this study. These were formulated to evaluate serious games as the technology under investigation. Some of the measuring items were adjusted slightly for the purpose of this study. Based on feedback received from participants who were involved in the pilot study, the reading time was reported to be too long. As a result, some of the measuring items were formulated differently from that of the original TAM in order to reduce the amount of reading and ensure clarity. Table 3.6 provides a summary of the constructs and measuring items that were used to measure the internal variables of the TAM in this study and authors these measuring items were adopted from.

Table 3.6: Constructs and measuring items for measuring internal variables

Internal TAM variables		
Constructs		**Authors**
Perceived usefulness (PU)		
I think playing games as part of the learning experience in class will...		
B8	improve my performance in the course.	Davis, 1989; Davis & Venkatesh, 1996; Saade & Bahli, 2005; Turner *et al*., 2010
B9	be to the advantage of my learning experience in class.	
B10	cause me to be more productive and do more class related work.	
B13	be useful to enhance learning in class.	
Perceived ease of use(PEOU)		
It would be easy for me to ...		
B14	Learn how to play a game.	Davis, 1989; Davis & Venkatesh, 1996; Lee *et al*., 2005; Saade & Bahli, 2005; Turner *et al*., 2010; Teo, 2011
B15	Interact with a game.	
B16	Be in control of the game to do what I want it to do.	
B17	Follow instructions and navigate through the stages of a game.	
B18	Become skilful at playing games.	
Behavioural intention to use (BI)		
B3	I would like to attend classes where games related to class work are played.	Davis, 1989; Lee *et al*., 2005; Saade & Bahli, 2005; Teo, 2011
B4	I intend to play games related to class work if it is available.	
B5	Given that I have access to class related games, I predict that I would use it.	
Attitude(A)		
B1	I like the idea of playing (serious) games as part of the learning process in class.	Fishbein & Ajzen, 1975; Lee *et al*., 2005; Teo, 2011
B2	I think it is wise to use games to enhance learning in class.	
B20	Playing games as part of the learning experience in class will be very pleasant	

Aspects such as hardware and software requirements and capabilities of these technologies often influence a user's perception of the usefulness of technology, and how easy it will be to use the proposed technology (Venkatesh & Davis, 2000:186). Therefore, external TAM variable are discussed in the next section.

3.7.2 Motivation for the use of external TAM variables

The influence of external factors on the intention to behave in a specific way in has been recognised in the Theory of Reasoning (Fishbein & Ajzen, 1975). As discussed in Chapter 2, the TAM was based on upon the Theory of Reasoning (Davis, 1986:15). Figure 3.5 shows beliefs and evaluations influence as variables, which has an impact on attitude towards behaviour.

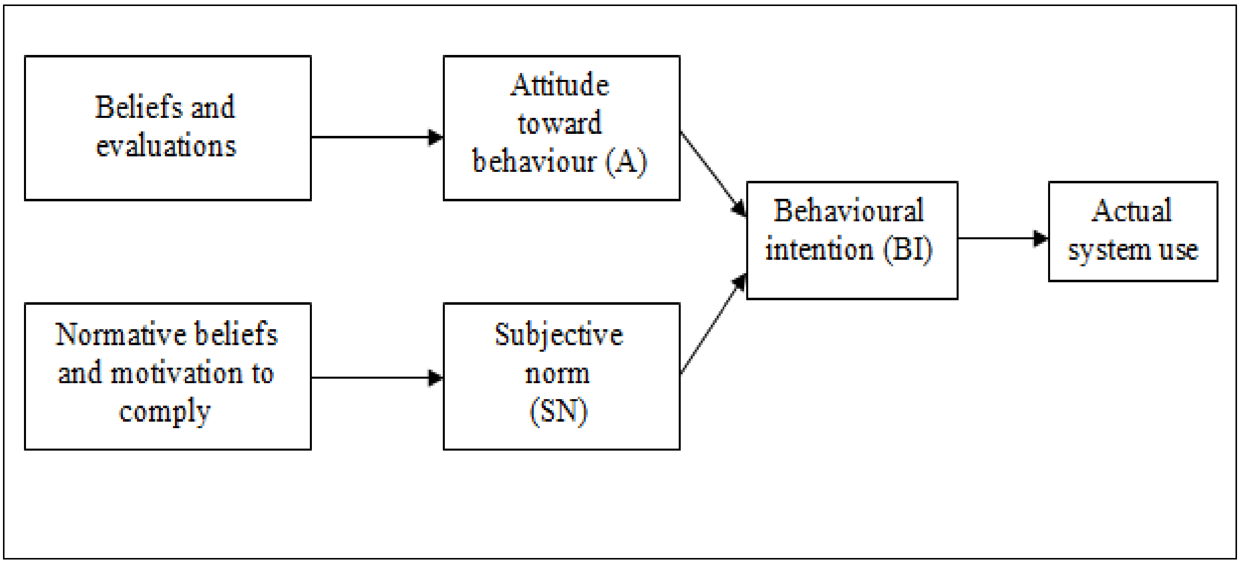


Figure 3.5: Theory of reasoned action (Davis *et al.*, 1989:984)

Furthermore, normative beliefs, and motivation to comply, influence subjective norms, while subjective norms influence intentional behaviour (Davis *et al.*, 1989:984). The existence of secondary factors, which influence internal factors influencing intentional behaviour, was acknowledged by Davis when he constructed the original TAM (Davis, 1986:24). The external factors are indicated by variables X1, X2 and X3 in the original TAM - Figure 3.6.

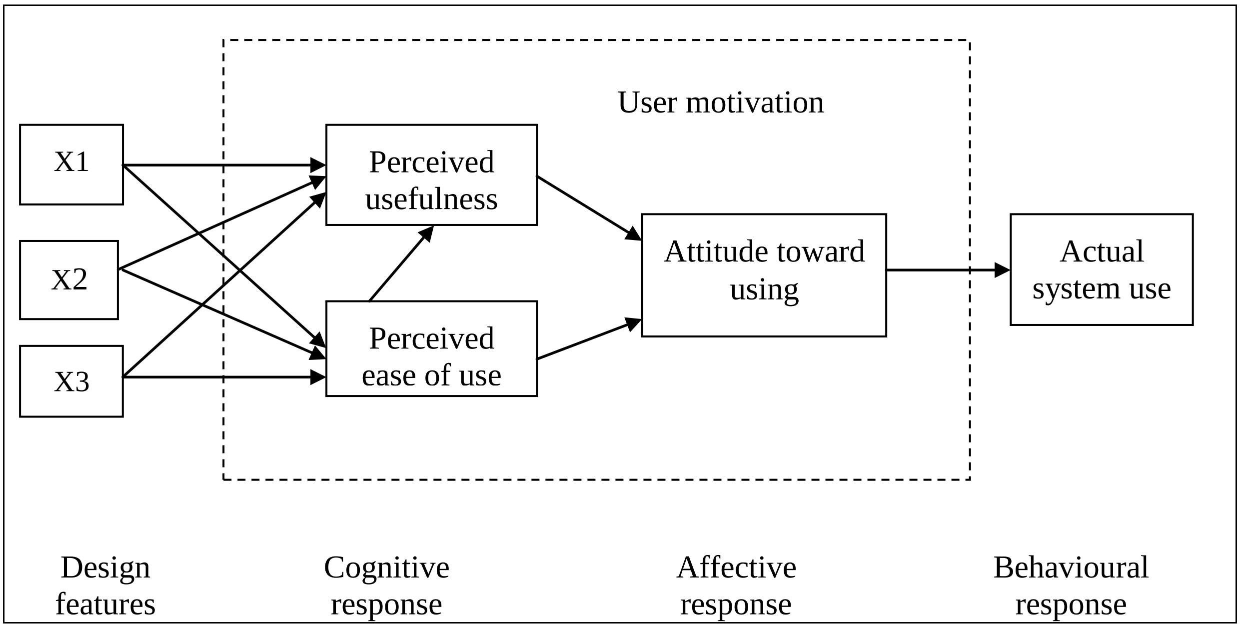


Figure 3.6: The original TAM (Davis, 1986:24)

In the original TAM, Davis (1986:24) describes the variables X1, X2 and X3 (Figure 3.6) as design features of the system that users intend to use. He states that variables X1, X2 and X3 in the proposed TAM "fall into the category of external variables within the Fishbein paradigm" (Davis, 1986:24). In a follow-up study, Davis *et al.* (1989:984) describe the external TAM variables as, "uncontrollable environmental variables and controllable interventions on user behaviour". Factors such as self-efficacy, training, documentation and user support are listed as some of the external TAM variables. Design characteristics of the system, training, a sense of self-efficacy of users, and how involved users are in the design of a system, are aspects that can be added to the list of external variables (Davis & Venkatesh, 1996:20). The TAM2 (Figure 3.7) that was proposed and developed by Venkatesh and Davis (2000) lists voluntariness, experience, subjective norm, image, job relevance, output quality and result demonstrability as external variables that were applicable to the study they conducted on the acceptance of information systems in the workplace (Venkatesh & Davis, 2000:188).

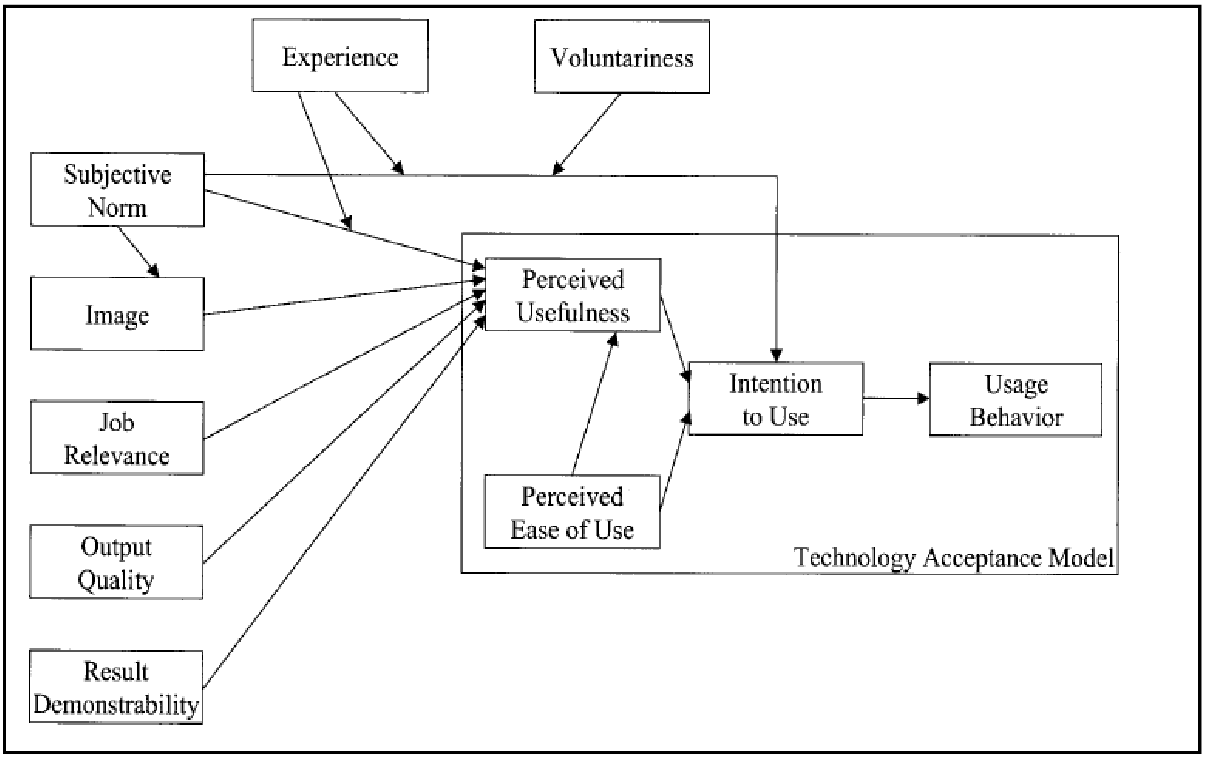


Figure 3.7: Proposed TAM2 − Extension of the TAM (Venkatesh & Davis, 2000:188)

Since the development of the original TAM (Davis, 1986) many studies have been conducted on a variety of external TAM variables (Chow *et al.*, 2012; Compeau & Higgins, 1995; Davis *et al.*, 1989; Hartwick & Barki, 1994; Lee *et al.*, 2005; Lu *et al.*, 2008; Mathieson, 1991; Moon & Kim, 2001; Saadé & Bahli, 2005; Venkatesh & Davis, 2000). The external TAM variables that were used in all of these studies depended upon the technologies that were evaluated as well as the type of user and environment within which these technologies were intended to be used. For each of these studies, validated measuring items were slightly adapted to relate to each specific technology that was evaluated.

The aim of this study is to identify and model aspects that influence the attitude of students' acceptance of serious games as a technology to be used as part of the learning experience in the computer science class. Validated constructs and measuring items for the influence of external TAM variables on attitudes towards the acceptance of technology from previous studies were evaluated carefully against factors that influence motivation and performance of students in computer science based on a thorough literature study on these aspects. Relevant external variables were identified. In the next section, these variables are motivated in the discussion of each construct that is used in this study. The measuring items used to evaluate each construct have been adapted to evaluate the attitude of students towards using serious games in the computer science class. These adapted measuring items were used to compile the second sub-scale for this study.

3.7.2.1 Subjective norm (SN) as a construct

According to the TRA the intention to perform a behaviour is determined by a person's attitude towards performing the behaviour as well as subjective norms or beliefs (Davis *et al.*, 1989:983; Othman & Lam, 2012:1291). While attitude reflects a person's own positive or negative feelings about whether a behaviour should be performed or not, subjective norm (SN) is described as a "person's perception that most people who are important to him think he should or should not perform the behaviour" (Fishbein & Ajzen, 1975:302). Subjective norm can cause people to perform behaviours, which they themselves do not approve of in order to adhere to the opinion of people from their social environment whose opinion they value (Venkatesh & Davis, 2000:187). Davis (1986) based his original study on the attitude towards acceptance of technology on the TRA model (Figure 3.6), which represents factors that determine conscious intended behaviour; subjective norm was not emphasised in his study due to the fact that people often feel obligated to comply with behaviour in some instances, due to the fact that it is expected of them to do so. They are in many circumstances confronted with consequences they may face if they do not comply. In these circumstances, a specific behaviour is often mandatory (Davis, 1986:17). In follow-up studies, Davis *et al*. (1989:984) established that behaviour may be mandatory in some instances, but in the computer-usage environment, acceptance of technology is often voluntary rather than mandatory. With more studies at the time revealing that social aspects play a significant role in intended behaviour in the acceptance of technology, Venkatesh and Davis (2000) concluded that subjective norm indeed has a significant influence on user acceptance. Potential users of technology accept and react upon the opinion of people they relate to in terms of usefulness of technology and do not necessarily accept the technology due to pressure or being instructed to do so. Therefore, the relationship between subjective norm and perceived usefulness from the original TAM was found to be significant.

From the study conducted by Venkatesh and Davis (2000) an extended TAM, TAM2 (Figure 3.7), was developed which includes subjective norm as an external influencing factor on user acceptance of technology. According to the literature, mixed results were reported on the significance of the influence of subjective norm on intended behaviour. Some researchers found subjective norm to have no significant influence (Davis *et al.*, 1989; Mathieson, 1991) while the others (Hartwick & Barki, 1994; Lu *et al.*, 2008; Taylor & Todd, 1995) found subjective norm to have a significant influence on behavioural intention.

Table 3.7: Measuring items for subjective norm as a construct

Construct 5 – Subjective norm (SN)		**Authors**
B6	People who are important to me will think it is a good idea to play games as part of learning in class.	Mathieson, 1991; Hartwick & Barki, 1994; Taylor & Todd, 1995; Venkatesh & Davis, 2000; Lee *et al*., 2005; Lu *et.al*., 2008
B7	People who influence my behaviour will think it is a good idea to play games as part of learning in class.	

Even though many aspects regarding normative beliefs are still unclear and should be researched, subjective norms should be part of the TRA model according to Fishbein and Ajzen (1975:304). Since students value the opinion of their peers and people around them, subjective norm has been included as a construct as shown in Table 3.7.

3.7.2.2 Relevance (R) as a construct

The theory of work motivation states that being motivated to perform a task is based on a process of matching process of performing the task against goals to be reached (Bandura, cited by Venkatesh & Davis, 2000:191). The decision to perform a task is made during a cognitive matching process, which involves a compatibility test. A profitability test is done during which a decision of acceptance is measured against whether it will add value to the process at hand or objective that has been set (Venkatesh & Davis, 2000:189). The matching process contributes towards a question of relevance to the job. Due to the significant influence job relevance had on perceived usefulness in their study, Venkatesh & Davis (2000) added relevance to the list of external factors in TAM2 (Figure 3.7). A number of studies confirm relevance to be an external variable of significance in the acceptance of technology. However, the descriptive used to refer to the aspect of relevance may vary depending on the specific technology and users (Hartwick & Barki, 1994; Vessey, 1991).

Hartwick and Barki (1994) describe the concept of relevance as "personal importance" while Vessey (1991) and use the phrase "cognitive fit" to describe relevance. For the purpose of this study, the borrowed validated measuring items were adapted to measure the perceived relevance of the use of serious games in the computer science class.

Table 3.8: Measuring items used to measure Relevance (R) as a construct

Relevance (R)		Authors
I think playing games as part of the learning experience in class will...		
B11	improve my logical thinking skills.	Venkatesh & Davis, 2000
B12	improve my problem solving skills.	

3.7.2.3 Perceived enjoyment (Enjoy)

Potential users may have a perceived idea to what extent they may enjoy using technology (Venkatesh & Bala, 2008:279). Perceived levels of enjoyment may influence their attitude towards using the technology. The fun and entertainment aspects of the use of serious games could be used in the computer science class as intrinsic motivation to become absorbed into programming (Wang & Chen, 2010). The enjoyment related to playing serious games and the subsequent flow experience could have a positive influence on learning in class. This is often referred to as the flow experience (Nakamura & Csikszentmihalyi, 2002). Jackson *et al.* (2012) state that even the idea of fantasy that an experience can be enjoyable could be sufficient for students to show an interest in learning content. Therefore, this construct was included in the subscale.

Table 3.9: Measuring items for perceived enjoyment (Enjoy) as a construct

Perceived enjoyment (Enjoy)		Authors
Playing games as part of the learning experience in class will be ...		
B19	enjoyable for me.	Ghani,1995; Moon & Kim, 2001; Koufaris, 2002; Saade & Bahli, 2005; Lee *et al*., 2005; Lu *et al*., 2008
B21	fun.	
B22	frustrating.	
B23	boring.	

3.7.2.4 Self-efficacy (SE)

Davis *et al*. (1989:987) argue that a sense of self-efficacy triggers a users' inborn drive towards competence. Many aspects related to the design of the system such as icons, menus and feedback could influence the user's perceived ease of use. The easier a user perceives a system is to use, the stronger the sense of self-efficacy, which in turn motivates the user to interact with the system. Motivation feeds on a process of continuous self-evaluation against internal sub-goals (Bandura, 1982:134). When sub-goals are met, internal satisfaction is experienced and interest is sparked, which motivates the user to set new internal sub-goals and persist in his or her effort to accomplish tasks that are more complex. A person's motivation and behaviour will be influenced by the confidence a person has in his or her ability to perform a task (Chow *et al*., 2012:1137; Holden & Rada, 2011:347). A strong sense of self-efficacy could have a positive impact on the attitude of computer science students towards the use of games in class. Therefore, self-efficacy has been included as a construct in this study. Several validated measuring items were borrowed from previous studies, and formulated in terms of the playing of serious games in the computer science class.

Table 3.10: Measuring items for self-efficacy (SE) as a construct

Self-efficacy(SE)		**Authors**
I will be able to play a serious game related to class work if ...		
B24	there is someone around to tell me what to do.	Compuae & Higgens, 1995; Holden & Rada, 2011; Chow *et al*., 2012; Lai *et al*., 2012
B25	I have watched someone else play the game before trying it myself.	
B26	I have only the instructions on how to play the game for reference.	
B27	I have never played a game like it before.	
B28	I can call someone for help if I get stuck.	
B29	someone else help me get started.	
B30	I have a lot of time to complete the class work for which the game is provided.	
B31	I have only the built-in help facility for assistance	
B32	someone shows me how to play the game first.	
B33	I have played similar games before to do the same class work.	

3.7.2.5 Temporal dissociation (TD)

Fun and entertainment has the ability to involve people totally in the activity they perform to such an extent that they lose track of time and spend more time on the activity than they anticipate. This is described as a flow experience. The flow theory describes a state in which ‘‘people are so involved in an activity that nothing else seems to matter” (Lu *et al*., 2008:31). Csikszentmihalyi and Csikszentmihalyi (1991) define the flow experience as “a state of concentration so focused that it amounts to absolute absorption in an activity”. The authors relate happiness to experiencing moments of flow. When a person takes up a challenge he or she is absorbed totally in the task at hand and performs at the peak of their ability in order to succeed. The flow experience occurs when the task or challenge is accomplished successfully. Total concentration and absorption, as well as individual effort and creativity, are required to have a flow experience. Repetitive flow experiences result in a feeling of mastering the task and enjoyment.

The theory of flow has been adopted from the field of psychology and applied in research related to the acceptance new technology such as instant messaging (Lu *et al*., 2008) and personal computers (Finneran & Zhang, 2005). Lu *et al.* (2008) used the play of online games as an example of people who experience a state of flow while playing games. In their study, the acceptance of the use of instant messaging amongst Chinese people was investigated. The study showed that fun and entertainment are intrinsic motivation for a user to become totally absorbed in the use of technology (Lu *et al*., 2008:30). The attitude of users towards the acceptance of technology involves both an extrinsic and intrinsic motivation. Although extrinsic motivation has been emphasised in research that was conducted on user behaviour in information systems when the TAM was first compiled (Venkatesh *et al.*, 2003), the important role of intrinsic motivation in user acceptance has been realised and investigated over the past decade (Agarwal & Karahanna, 2000). Lu *et al*. (2008) describes intrinsic motivation as the desire to engage in an activity for no other reason than the process of performing it (Lu *et al*., 2008:31). The TAM evaluates users’ extrinsic motivation to accept technology since it evaluates the desire of users to accept a technology or perform a task because a specific outcome will be reached.

Davis (1986:139) notes that there are two elements to consider when motivation to behave in a specific way is discussed. Extrinsic motivation relates to being rewarded in some way while intrinsic motivation does not relate to any specific reward. (Malone, 1981:335) states that elements such as fantasy, curiosity or challenging aspects, which are typically part of the gaming environment, could cause users to be intrinsically motivated to interact with computer systems. “People seem to engage in the activities for their own sake and not because they lead to an extrinsic reward” (Deci as cited by Davis, 1989:139).

Table 3.11: Measuring items for temporal dissociation (TD) as a construct

Temporal dissociation (TD)		Authors
B34	Sometimes I lose track of time when I am playing a serious game	Moon & Kim, 2001; Saade & Bahli, 2005
B35	Time flies when I am playing a game	
B36	Most times when I start playing a game, I end up spending more time playing the game than I had planned.	

3.7.2.6 Focused immersion (FI)

A state of flow is associated with people who become totally absorbed in what they are doing (Lu *et al.*, 2009:30). An example of users who play games online is used to explain that people block out the surrounding environment when they experience focused immersion while in a state of flow. In their study on creating a zone of proximal flow, as discussed in paragraph 2.3.2.2, Basawapatna *et al.* (2013a:68) found that learning computational thinking skills takes place more effectively when students are totally engaged in an interactive game play environment. Students can perform challenging tasks within a zone of proximal flow. Quality user engagement is associated with focused attention (Mccay-Peet *et al.*, 2012:541; Novak *et al.*, 2000)

Table 3.12: Measuring items for focused immersion (FI) as a construct

Focused immersion (FI)		Authors
B37	When I am playing a game, I am able to block out most other distractions.	Huang, 2003; Saade & Bahli, 2005; Li & Browne, 2006; Lu *et al.*, 2008
B38	While playing game, I am absorbed in what I am doing.	

3.7.2.7 Experienced enjoyment (ExpEnjoy)

People who are ignorant and less experienced in using technology will be influenced to a larger extent to behave in a specific way by people close to them, than people who have experience in using the technology (Venkatesh & Davis, 2000:190). In their model (Figure 3.7) Venkatesh and Davis (2000) include experience in the use of a specific technology as an external variable. The model indicates that experience has an influence on perceived usefulness and, therefore, intention to use. As discussed in Chapter 2, being familiar with technology could influence the perceived ease of use positively and, therefore, the attitude of the users towards the use of technology. In this study, experience was investigated in relation to TAM constructs and subjective norm.

Table 3.13: Measuring items for experienced enjoyment when playing serious games as a construct

Experienced enjoyment (ExpEnjoy)		**Authors**
B39	I have fun when interacting with games.	Lu *et al.*, 2009
B40	Playing games bores me.	
B41	I enjoy playing games.	

The final questionnaire comprised 50 items. The first section, Section A, which consisted of eight items, obtained the participant's demographical information and two items obtained information about the participant's experience in playing computer games. The second section, Section B, determined the internal and external factors that influence the participant's attitude towards the acceptance of serious games as technology in the computer science class. Section B comprises 41 items. The cover letter, which explains the purpose of the research study, and questionnaire items, formed part of the four-page questionnaire.

The complete measuring instrument has been added to this document as Appendix A

3.8 STATISTICAL METHODS

The properties of a set of data needs to be explored once the data have been collected, captured, grouped and graphical presented as descriptive data (Swanepoel *et al.*, 2011:55). Statistical analysis is done on the data set in order to discover or confirm hidden properties and patterns of a set of data.

3.8.1 Statistical concepts

Nominal data are the lowest level of quantitative data (Denscombe, 2010:243). The data are collected by counting things and categorising them, for example, the number of males and females, graduates and under graduates. This type of data allows little room for statistical manipulation.

Ordinal data are also based on counting things but candidates are required to respond in terms of ordered and ranked categories, which are the one lower or higher than the other one, or less or more than the other one (Denscombe, 2010:243). Numbers are allocated to the categories of such a quantitative scale, for example for the categories of the Likert scale – strongly agree may be represented by one, agree by two, and so on.

Discrete data can only be a finite whole number, for example the number of people or number of students per class.

Continuous data can theoretically take any value, which means the data are not provided in neat, clear, whole numbers (Denscombe, 2010:244). Examples are a person's height or weight. The researcher can determine the level of accuracy.

The mean is one of the most popular statistics used in practice. It is obtained by calculating the sum of all the observations and dividing the answer by the number of observations. The mean of a set of numbers is referred to typically, as the average of a set of values (Denscombe, 2010:248).

Median is the middle value or mid-point of a range of data values (Denscombe, 2010:249). That means fifty per cent of the data values will be lower than the median and the other fifty per cent higher than the median. The median is not affected by extreme values and can be used well with a low number of values.

Mode is the value that occurs most frequently in a data set. Outliers or extreme values do not affect the mode (Denscombe, 2010:250).

Standard deviation (SD) describes, "the extent to which data values differ from the mean" (Saunders *et al*., 2009:445) or "the average amount of variability in a set of scores" (Oates, 2009:257).

To be able to compare the relative spread of data between distributions of different magnitudes, the coefficient of variation has to be calculated. The distribution with the largest coefficient of variation has the largest relative spread of data.

3.8.2 Relationships in data

Significant testing is the term used for testing the probability (p-value) that a relationship between variables occurs only by chance (Heckard & Utts, 2012:456). The test is done by first assuming that there is no relationship – the null hypothesis (*H_0*). If the significant test produces a probability (p) of greater than one in 20 ($p > 0.05$) the probability of the null hypothesis of the relationship occurring by chance stands. If the significant test produces a probability (p) of less than one in 20 ($p < 0.05$), the probability of the relationship occurring by chance does not stand and the relationship is regarded as statistically significant. If this is the case, the null hypothesis (H_0) is rejected. The size of the sample is important because the significance test will be insensitive with a small sample. On the other hand, if the sample is very large, the significance test will be overly sensitive.

The chi-square test is used to test, "whether two variables are associated to a significant level" (Oates, 2009:259). It is a comparison of what is observed in the data and what could be expected by chance. The null hypothesis would be that there is no difference. That is, what is observed in the data are what is expected. A probability of 0.05 or smaller means it is 95 per cent certain that the relationship between the two variables does not occur by chance alone.

T-tests are used to compare two groups of data to assess the likelihood of being different. The test compares the difference between the means of the two groups.

Independent group's t-test is used, which requires the samples to be independent. If the result of the test is less than 0.05 it means the probability of any difference between the two groups occurring by chance alone is low. It is 95 per cent certain that any difference between the two groups is statistically significant. The sample size of the groups can be small and can be different for the two groups.

The paired t-test is used to compare two sets of data for the same group for example before an event and after an event took place. It is calculated and interpreted in the same way as the independent group's t-test.

Correlation is a number that indicates the strength and direction of a straight-line relationship between two quantitative variables (Heckard & Utts, 2012:82). The letter r represents correlation, which often is referred to as Pearson correlation coefficient. The coefficients are always between -1 and +1. The sign only has meaning in terms of the direction of the relationship and not the strength. If the sign is positive, it implies that if one variable increases, the one variable will increase as well. This is referred to as a positive association. A negative sign is an indication of a negative association, which means that if one variable increases, the other variable will decrease. The squared value of the correlation (r^2) always delivers a value between zero and one. This means the strength of the relationship is provided but information about the direction is lost. r^2 explains the percentage a specific variable contributes towards the variation amongst observations or responses.

Regression can be used to determine the relationship between variables or to predict a y-value when a x-value is known (Heckard & Utts, 2012:89). A regression model describes the relationship between a response variable (referred to as the y-variable or dependant variable) and one or more explanatory variables (referred to as the x variable(s) or independent variable(s)) (Heckard & Utts, 2012:549).

3.9 SUMMARY

The research methodology implemented for the empirical part of this study was discussed in this chapter. The research design and approach, the sampling strategy as well as the measuring instrument were discussed. The pre-testing and administration of the data collection process and some statistical procedures followed were discussed.

The following chapter presents the findings of the empirical part of this study. This includes the tabulation, interpretation and discussion of the pilot and the main study's results, as well as the results regarding the demographic information, descriptive analyses, and correlations analysis between factors. The chapter concludes with the construction of a regression model, which reflects the internal and external factors that influence the attitude of computer science students towards using serious games as part of the learning environment in class.

With Chapter 4 as foundation, conclusions and recommendations for this study will be outlined in the final chapter.

CHAPTER 4
ANALYSIS AND INTERPRETATION OF EMPIRICAL FINDINGS

4.1 INTRODUCTION

This chapter consists of a discussion of the analysis and interpretation of the empirical findings of the study's pilot and main survey. Section 4.2 reports on the pilot test and the resulting amendments to the questionnaire. The preliminary data analysis, including the coding and tabulation of the data, are discussed in Section 4.3, while Section 4.4 contains a discussion on the descriptive analysis of the data, including the demographical information of the participants, the reliability and validity of the scale, the confirmatory factor analysis of the scale and descriptive statistics. The proposed model is discussed Section 4.5.

For the purpose of conducting the data analysis, SPSS version 21 for Microsoft Windows and SAS were used. The data analysis was conducted in two stages. Analysing the results of the pilot testing of the questionnaire was the first stage and the second stage involved analysing the results found within the main survey's data sets.

4.2 PILOT TESTING

Conducting a survey is a costly and time-consuming exercise. Therefore, care should be taken to ensure that the measuring instrument is reliable and valid. Pre-testing the measuring instrument prior to conducting the survey is an important step towards ensuring that the collected data are valid and reliable (Denscombe, 2010:159). Reliability refers to consistency in the responses to questions (Saunders *et al.*, 2009:156). A reliable measuring instrument delivers similar results when used a second time to measure the same variables. Validity refers to the credibility and authenticity of the research instrument (Gomm, 2008:13,34). A measuring instrument, construct or item is valid if it tests what it is supposed to test. The face value of the measuring instrument, including the design and layout, as well as the content in relation to the purpose of the study are among aspects that need to be evaluated as part of validating the measuring instrument (Maree *et al.*, 2007:216). Pre-testing a questionnaire is a standard measure that is employed to ensure a good response rate and valid and reliable data (Saunders *et al.*, 2009:362; Walliman, 2011:98). Participants who are excluded from the sample take part in pre-testing and assist in modifying and improving elements of the measuring instrument. During pre-testing aspects such as poorly worded, ambiguous and irrelevant questions, as well as a poor sequence of questions are eliminated (Gray, 2013:227).

For this study, the questionnaire was subjected to a pre-test procedure, which was followed by a pilot test. One experienced researcher and four academic staff members participated in the pre-testing procedure. Participants were asked to comment on the structure and design of the questionnaire by means of notes or verbal feedback. Based on their recommendations, some questions were formulated differently to improve on the clarity thereof. For example, question B13 stated:

B13	Playing serious games as part of the learning experience in the computer science class will not be useful to enhance learning in the computer science class.

Feedback from participants indicated that question B13 could be misinterpreted because the question is asked in the negative by using the word not. The comment was confirmed by the literature (Maree *et al.*, 2007:160; Neuman, 2011:317). Maree *et al.* (2007:160) recommend that the word not be avoided when a Likert-type response scale is used, since it can lead to double negatives when a respondent disagrees to a negative statement. This could lead to confusion on how to respond. Therefore, question B13 was re-phrased as follows:

B13	Playing serious games as part of the learning experience in the computer science class will be useful to enhance learning in the computer science class.

Other minor changes pertained to spacing and improved phrasing of statements and questions were suggested, and applied where applicable.

Once the pre-test was completed, the questionnaire was pilot tested in order to establish the reliability of the sub-scales within the questionnaire. The pilot testing of the questionnaire was conducted on a convenience sample of 40 full-time undergraduate students who did not form part of the sampling frame of the main study.

Participants of the pilot group were concerned about the amount of time it took to complete the questionnaire. According to Maree *et al.* (2007:159) the time adults should spend on completing a questionnaire should not exceed 20 minutes. Participants spent 30 to 40 minutes on the completion of the questionnaire. Gray (2013:363) states that lengthy questionnaires may have an effect on the response rate to a questionnaire. If the response rate is low, results obtained are not regarded as representative of the target population (Maree *et al.*, 2007:13). If generalisations are applied when the response rate was low, it poses a threat to the external validity of the study. It was decided to revise the questionnaire.

The phrasing of the questions was identified as the reason why extensive reading was required. Key concepts such as the phrase “the computer science class” were repeated in many of the questions. It was decided to add information to the introductory cover letter instead of repeating specific phrases in each individual question. Therefore, the definition of a serious game and a clear explanation of the purpose of the use of serious games in the computer science class were formulated and added to the information in the cover letter. The phrase “as part of the learning experience in the computer science class” was removed in a number of questions. Instead, introductory sentences containing this phrase were formulated for sets of questions where applicable. Questions were rephrased in such a way that they did not influence the meaning of the question.

Below is an example of a selection of questions from the questionnaire that were used in the pilot study and identified to be rephrased for the main study:

B19	Playing serious games as part of the learning experience in the computer science class will be enjoyable for me.	1	2	3	4	5	6
B20	Playing serious games as part of the learning experience in the computer science class will be very pleasant.	1	2	3	4	5	6
B21	Playing serious games as part of the learning experience in the computer Science class will be fun.	1	2	3	4	5	6
B22	Playing serious games as part of the learning experience in the Computer science class will be frustrating.	1	2	3	4	5	6
B23	Playing serious games as part of the learning experience in the computer science class will be boring.	1	2	3	4	5	6

The questions listed above were rephrased as follows using an introductory sentence:

Playing serious games as part of the learning experience in the computer science class will be ...

B19	enjoyable for me.	1	2	3	4	5	6
B20	very pleasant.	1	2	3	4	5	6
B21	fun.	1	2	3	4	5	6
B22	frustrating.	1	2	3	4	5	6
B23	boring.	1	2	3	4	5	6

As a result of the formulation of introductory sentences, the questions were regrouped.

Internal consistency of responses to questions is another critical aspect that was tested when the pilot study was conducted. Saunders *et al*. (2009: 374) describes internal consistency as the correlation between responses from participants to all the questions or sub-sets of questions contained in a questionnaire. A high level of consistency in responses to a question confirms that the question is well formulated and will be interpreted in the same way by the majority of participants. If so, it can be assumed that the measuring item is reliable and data that are collected using the question is valid (Gomm, 2008:45).

The most frequently used statistical techniques to measure internal consistency is Cronbach's alpha (Maree *et al.*, 2007:216). Gray (2013:363) describes Cronbach's alpha is a reliability coefficient that uses a scale from 0.00 (unreliable) to 1.00 (reliable) to determine the extent of consistency of all the measuring items contained in a questionnaire both globally and individually. Table 4.1 contains the Cronbach's alpha reliability coefficient pertaining to the two sub-scales found within the pilot test for this study.

Table 4.1: Summary of the pilot test results

Items	Number of items	Cronbach's alpha
Internal and external technology acceptance scale	41	0.952
Sub-scale:		
Internal technology acceptance factors	15	0.938
Construct 1 – Perceived usefulness (PU)	4	0.905
Construct 2 – Perceived ease of use (PEOU)	4	0.938
Construct 3 – Behavioural intention (BI)	3	0.805
Construct 4 – Attitude (A)	4	0.844
Items	**Number of items**	**Cronbach's alpha**
Sub-scale:		
External technology acceptance factors	26	0.900
Construct 5 – Subjective norm (SN)	2	*
Construct 6 – Relevance (R)	2	*
Construct 7 –Perceived enjoyment (Enjoy)	4	0.882
Construct 8 – Self-efficacy (SE)	10	0.831
Construct 9 – Temporal dissociation (TD)	3	0.865
Construct 10 – Focussed immersion (FI)	2	*
Construct 11 – Experienced enjoyment (ExpEnjoy)	3	0.863
* Minimum of 3 items required to calculate		

The six-point Likert scale used in the questionnaire returned a Cronbach alpha value for the entire scale of 0.952, which is above the recommended level of 0.60 (Gomm, 2008:46; Maree *et al.*, 2007:216). The average inter-item correlation of 0.344 for the entire scale falls within the recommended range of 0.15 and 0.5 (Clark & Watson, 1995:316). The internal technology acceptance sub-scale (15 items) returned a Cronbach alpha value of 0.938, which exceeds the recommended level of 0.60 and suggests that the sub-scale is reliable (Gomm, 2008:46). The average inter-item correlation of the internal technology acceptance scale (15 items) of 0.484 falls within the recommended range of 0.15 and 0.5 as well. The internal technology acceptance sub-scale was found to be reliable, subsequently none of the items included in the internal technology acceptance subscale were changed. The external technology acceptance sub-scale (26 items) delivered a Cronbach alpha value of 0.900. The average inter-item correlation for the external technology acceptance sub-scale was estimated at 0.294, within the recommended range and therefore the sub-scale was found to be reliable.

Therefore, the 15 items from the internal technology acceptance sub-scale, together with the 26 items from the external technology acceptance sub-scale, were used to prepare the main survey questionnaire. Table 4.2 outlines the descriptions of the variables included in the sub-scales to be used in the main study.

Table 4.2: Description of items and constructs

Sub-scale: Internal technology acceptance factors		
Code	**Items**	**Constructs**
B1	I like the idea of playing games as part of the learning process in class.	**Construct** 1: **Attitude (A)**
B2	I think it is wise to use games to enhance learning in class.	
B20	Playing games as part of the learning experience in class will be very pleasant.	
B3	I would like to attend classes where games related to class work are played.	**Construct 2: Behavioural intention (BI)**
B4	I intend to play games related to class work if they are available.	
B5	Given that I have access to class related games, I predict that I would use it.	
	I think playing games as part of the learning experience in class will...	**Construct 3: Perceived usefulness (PU)**
B8	improve my performance in the course.	
B9	be to the advantage of my learning experience in class.	
B10	cause me to be more productive and do more class related work.	
B13	be useful to enhance learning in class.	

Table 4.2: Description of items and constructs (continued…)

Sub-scale: External technology acceptance factors		
	It would be easy for me to ...	
B14	learn how to play a game.	**Construct 4: Perceived ease of use (PEOU)**
B15	interact with a game.	
B16	be in control of the game to do what I want it to do.	
B17	follow instructions and navigate through the stages of a game.	
B18	become skilful at playing games.	
B6	People who are <u>important to me</u> will think it is a good idea to play games as part of learning in class.	**Construct 5: Subjective norms (SN)**
B7	People who <u>influence my behaviour</u> will think it is a good idea to play games as part of learning in class.	
I think playing games as part of the learning experience in class will...		**Construct 6: Relevance (R)**
B11	improve my logical thinking skills.	
B12	improve my problem solving skills.	
Playing games as part of the learning experience in class will be...		**Construct 7: Perceived enjoyment (Enjoy)**
B19	**enjoyable for me**	
B21	**fun**	
B22	**frustrating**	
B23	**boring**	
I will be able to play a serious game related to computer science as part of class work if ...		**Construct 8: Self-efficacy (SE)**
B24	there is no one around to tell me what to do.	
B25	I watched someone else play the game before trying it myself.	
B26	I only have instructions on how to play the game for reference	
B27	I have never played a game like it before	
B28	I can call someone for help if I get stuck.	

Table 4.2: Description of items and constructs (continued…)

B29	someone else helps me get started	
B30	I have a lot of time to complete the class work for which the game is provided.	
B31	I have only the built-in help facility for assistance	
B32	someone shows me how to play the game first.	
B33	I have played similar games before to do the same class work.	
B34	Sometimes I lose track of time when I am playing a serious game.	**Construct 9: Temporal dissociation (TD)**
B35	Most times when I start playing a serious game, I end up spending more time playing the game than I had planned.	
B36	Time flies when I am playing a serious game.	
B37	When I am playing a serious game, I am able to block out most other distractions	**Construct 10: Focussed immersion (FI)**
B38	While playing a serious game, I am absorbed in what I am doing.	
B39	I have fun when interacting with serious games.	**Construct 11: Experienced enjoyment (ExpEnjoy)**
B40	Playing serious games bores me.	
B41	I enjoy playing serious games.	

Apart from the constructs listed in Table 4.2, questions A8 and A9 were included in Section A to provide background on gaming experience of the target group. In Section B of the questionnaire, the pilot study contained 26 questions. Data collected from these questions were analysed statistically. The following section describes the process of preliminary data analysis that was followed pertaining to this study.

4.3 PRELIMINARY DATA ANALYSIS

It is recommended that a preliminary data analysis be conducted before the data set is analysed. The preliminary analysis comprises coding, data gathering and tabulation. The following three sections provide an overview of the coding, data gathering process and tabulation employed in this study.

4.3.1 Coding

Coding is the process of allocating unique numbers to collected data items (Gray, 2013:455). Saunders *et al.* (2009:385) recommend a coding schema to be developed and incorporated into the questionnaire prior to collecting data. For this study, coding of the measuring items was done partially prior to conducting the survey. The coding is shown in Table 4.3 for Section A and Table 4.5 for Section B. Section A comprises eight questions on demographical information and two questions on prior experience in the playing of computer games. The measuring items were coded prior to collecting data but options provided within each of the measuring items were coded during data capturing and not as part of the design of the questionnaire. This was done to avoid possible confusion and also to avoid subconsciously influencing participants' responses.

Table 4.3: Coding information Section A

Section A: Demographical data and game play experience			
Question	**Topic**	**Number of options**	**Code**
Question 1	Institution	2	A1
Question 2.1	Country of origin	2	A2.1
Question 2.2	Province of origin	10	A2.2
Question 3	Nationality	6	A3
Question 4	Mother tongue language	13	A4
Question 5	Gender	2	A5
Question 6	Age in years	0	A6
Question 7	Current year of study	6	A7
Question 8	Frequency of playing computer games	6	A8
Question 9	At what age did you start playing computer games?		A9

Section B comprises 41 items on factors that influence the acceptance of serious games in the computer science class. Table 4.4 shows how the questions contained in Section B that were used for statistical analysis were coded partially prior to collecting data.

Table 4.4: Coding information Section B

Internal and external technology acceptance factors		
Section B: Internal technology acceptance factors sub-scale		
Item	**Construct measured**	**Code**
Item 1	**Attitude**	B1
Item 2	**Attitude**	B2
Item 3	**Attitude**	B20
Item 4	**Behavioural intention**	B3
Item 5	**Behavioural intention**	B4
Item 6	**Behavioural intention**	B5
Item 7	**Perceived usefulness**	B8
Item 8	**Perceived usefulness**	B9
Item 9	**Perceived usefulness**	B10
Item 10	**Perceived usefulness**	B13
Item 11	**Perceived ease of use**	B14
Item 12	**Perceived ease of use**	B15
Item 13	**Perceived ease of use**	B16
Item 14	**Perceived ease of use**	B17
Item 15	**Perceived ease of use**	B18
Item 16	**Subjective norms**	B6
Item 17	**Subjective norms**	B7
Item 18	**Relevance**	B11
Item 19	**Relevance**	B12
Item 20	**Perceived enjoyment**	B19
Item 21	**Perceived enjoyment**	B21
Item 22	**Perceived enjoyment**	B22
Item 23	**Perceived enjoyment**	B23
Item 24	**Self-efficacy**	B24

Table 4.4: Coding information Section B (continued…)

Item	Construct measured	Code
Internal and external technology acceptance factors		
Section B: Internal technology acceptance factors sub-scale		
Item	**Construct measured**	**Code**
Item 25	**Self-efficacy**	B25
Item 26	**Self-efficacy**	B26
Item 27	**Self-efficacy**	B27
Item 28	**Self-efficacy**	B28
Item 29	**Self-efficacy**	B29
Item 30	**Self-efficacy**	B30
Item 31	**Self-efficacy**	B31
Item 32	**Self-efficacy**	B32
Item 33	**Self-efficacy**	B33
Item 34	**Temporal dissociation**	B34
Item 35	**Temporal dissociation**	B35
Item 36	**Temporal dissociation**	B36
Item 37	**Focussed immersion**	B37
Item 38	**Focussed immersion**	B38
Item 39	**Experienced enjoyment**	B39
Item 40	**Experienced enjoyment**	B40
Item 41	**Experienced enjoyment**	B41

Options provided with question in Section B according to a six-point Likert scale were coded during the process of data capturing using a numbering system from the one representing strongly disagree, to the six representing strongly agree, as shown in Table 4.5.

Table 4.5: Example of coding of the Likert scale options for Section B

	Strongly disagree	Disagree	Disagree somewhat	Agree somewhat	Agree	Strongly agree
Code	**1**	**2**	**3**	**4**	**5**	**6**

Each questionnaire was assigned a unique number. A table in the form of a matrix was used to represent the items (columns and possible options) and individual completed questionnaires (rows). The following section pertains to the data gathering process.

4.3.2 Data gathering process

Once permission from lecturers at the two institutions was obtained to distribute the questionnaire, 580 self-administered questionnaires were hand-delivered to the participating lecturers at the two selected HEI campuses who distributed the questionnaires to students, either during class time or after class. A total of 569 completed questionnaires were returned, which shows a 98% per cent response rate. Of the 569 completed questionnaires, 22 were discarded due to incomplete or invalid responses. The remaining 547 questionnaires indicated an actual response rate of 94 per cent. The traditional university returned 303 valid questionnaires and the university of technology returned 244 valid questionnaires. The tabulation of the data obtained by this questionnaire is discussed in the succeeding section.

4.3.3 Tabulation

Gathered data should be represented in a format that is easy to read, which is normally in table format (Saunders *et al.*, 2009:439). During tabulation, raw data are organised and summarised in a format that shows the number of responses in each response category in a way that will be helpful to the study's objectives. Table 4.6 presents the frequencies obtained from the total sample for Section B of the questionnaire and two questions from Section A, which aimed at measuring internal technology acceptance factors (PU, PEOU, BI and A) and external technology acceptance factors (SN, R, Enjoy, SE, TD, FI, ExpEnjoy). These were identified as factors that could influence a student's attitude towards the play of serious games in the computer science class.

Table 4.6: Frequency table of responses

Code	Strongly disagree	Disagree	Disagree somewhat	Agree somewhat	Agree	Strongly agree
	1	**2**	**3**	**4**	**5**	**6**
B1	18	23	18	106	184	198
B2	13	18	24	105	183	204
B3	11	15	29	90	185	217
B4	9	20	20	94	192	212
B5	9	5	29	105	215	184
B6	21	40	75	180	147	84
B7	16	26	51	172	175	107
B8	6	25	26	100	180	210
B9	6	18	23	98	202	200
B10	10	18	33	95	187	204
B11	7	11	10	70	170	279
B12	7	15	14	87	218	206
B13	5	13	19	107	221	182
B14	2	7	21	88	177	252
B15	1	10	11	82	196	247
B16	2	8	22	98	211	206
B17	2	4	17	66	212	246
B18	3	6	10	66	185	277
B19	6	10	21	67	180	263
B20	5	11	32	79	189	231
B21	6	11	25	56	172	277
B22	200	143	75	60	40	29
B23	246	138	70	33	38	22
B24	38	66	59	141	159	84
B25	33	49	51	145	180	89

Table 4.6: Frequency table of responses (continued…)

Code	Strongly disagree	Disagree	Disagree somewhat	Agree somewhat	Agree	Strongly agree
	1	**2**	**3**	**4**	**5**	**6**
B26	9	28	53	136	201	120
B27	61	64	94	133	130	65
B28	21	26	48	120	196	136
B29	39	61	65	115	177	90
B30	13	17	43	143	203	128
B31	15	39	62	160	197	74
B32	25	41	68	122	194	97
B33	29	47	63	136	175	97
B34	15	30	41	88	169	199
B35	6	22	25	77	152	260
B36	7	14	21	70	167	262
B37	4	17	38	93	184	206
B38	3	15	23	101	181	267
B39	3	7	15	69	175	266
B40	316	119	32	27	32	16
B41	4	9	5	51	127	346

Statistical analysis software will be used to process the tabulated data. Section 4.4 reports on the descriptive statistics computed related to this study.

4.4 DESCRIPTIVE ANALYSIS

Descriptive statistics “describe numerical data” (Neuman, 2011:386). It entails the description of basic patterns in data that were obtained from a sample. The identified basic patterns are used to determine and describe characteristics of the specific sample. Maree *et al*. (2007:19) list three ways in which descriptive statistics are expressed, namely by means of the central tendency or the mean, dispersion or how data are spread around the mean and the shape of the distribution or skewness and kurtosis. An overview of the descriptive statistics of this study's sample is set out below. First, the demographical information of the sample is discussed, followed by a discussion concerning the reliability and validity of the research instrument, and a discussion on the internal and external factors that influence the participants' attitudes towards acceptance of serious games in the computer science class. Lastly, the factors are modelled into a serious games acceptance model, which is applicable to computer science classes.

4.4.1 Demographical information

Demographical information describes the characteristics of participants who took part in the survey (Mouton, 2009:145). These variables include aspects such as gender, nationality and age. Mouton (2009:146) explains that demographic information is required in order to place the data collected in context. The author uses the example of firing guns at a target to explain the meaning of data within a specific context. Shots fired may be clustered in one location. A conclusion that the shots were accurate is invalid. The clustered shots must be evaluated within the context of the target and how close they are to the centre of the target. In the same way, demographic information adds to viewing the data collected in context and, therefore, adds to reliable and valid research results.

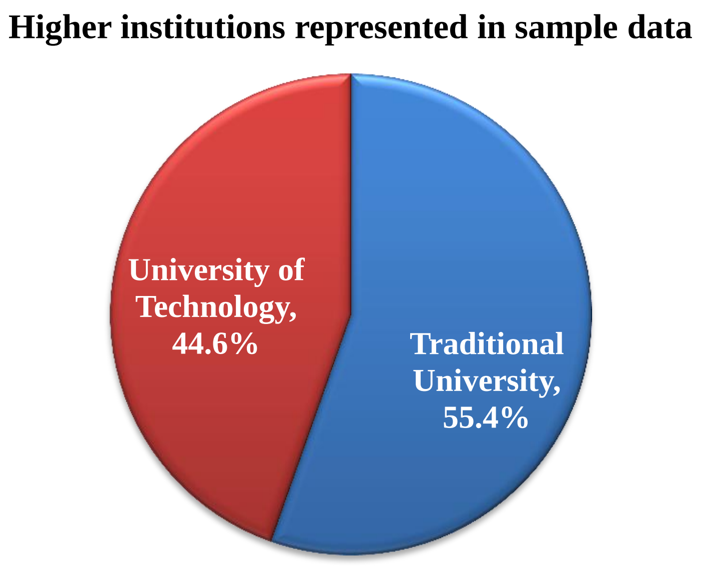
Section A of the questionnaire for this study pertains to the demographical information of the selected sample. It includes following aspects:

- higher education institution
- country of origin
- province of origin
- nationality
- mother tongue language
- gender
- age
- year of study.

Table 4.7 presents a summary of the distribution of the participants between the two higher education institutions.

Table 4.7: Higher education institutions

Higher education institutions	Frequency *F*	Percentage %
Traditional university	303	55.4
University of technology	244	44.6
N	547	100.0

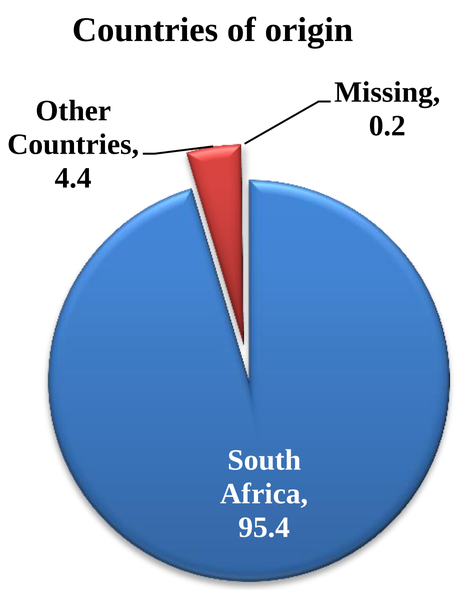


The total sample (N) of participants who partook in this study is one sample group made up of participants from two HEIs. Table 4.8 illustrates the results from the number of questionnaires obtained from each HEI, which reveals that 55.4 per cent of the total sample (N) of the participants came from a traditional university, while 44.6 per cent of the participants came from a university of technology.

The distribution of the participants amongst South Africa and other countries is shown in Table 4.8. One participant did not indicate his/her country of origin.

Table 4.8: Country of origin

Country of origin	Frequency *f*	Percentage %
South Africa	522	95.4
Other countries	24	4.4
Missing	1	0.2
N	547	100.0

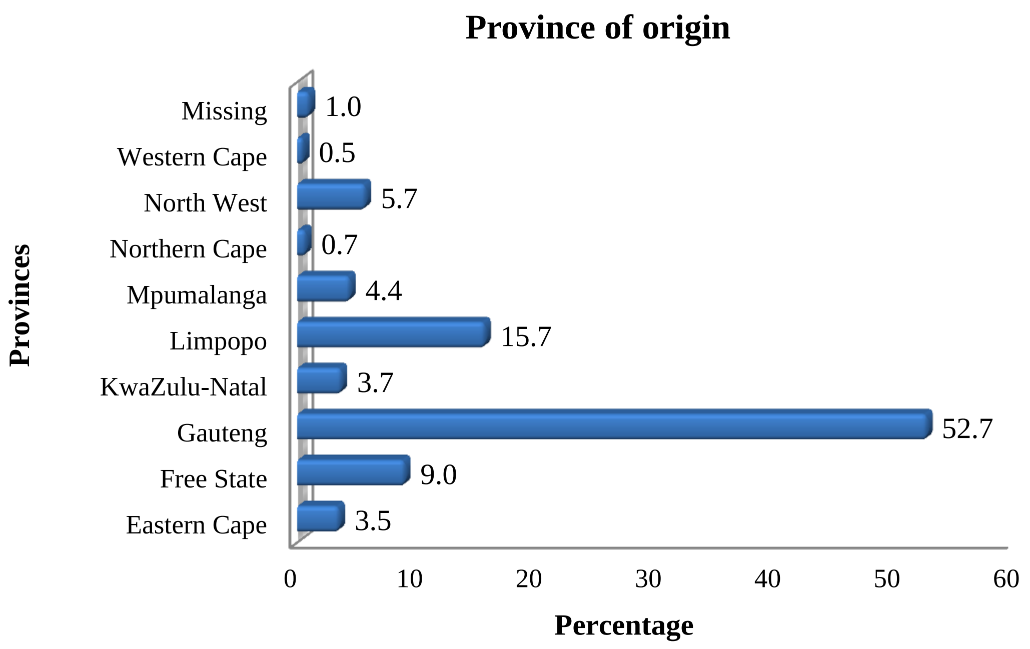


A figure of 95.4 per cent as shown in Table 4.8 indicates that the majority of participants who partook in this study are from South Africa while a mere 4.4 per cent of the participants are from other countries.

Table 4.9 illustrates the distribution information relating the participants' province of origin

Table 4.9: Province of origin

Province	Frequency *f*	Percentage %
Eastern Cape	19	3.5
Free State	49	9.0
Gauteng	288	52.7
KwaZulu-Natal	20	3.7
Limpopo	86	15.7
Mpumalanga	24	4.4
Northern Cape	5	0.9
North West	31	5.7
Western Cape	20	3.7
Other		
Missing	5	0.9
N	547	100.0

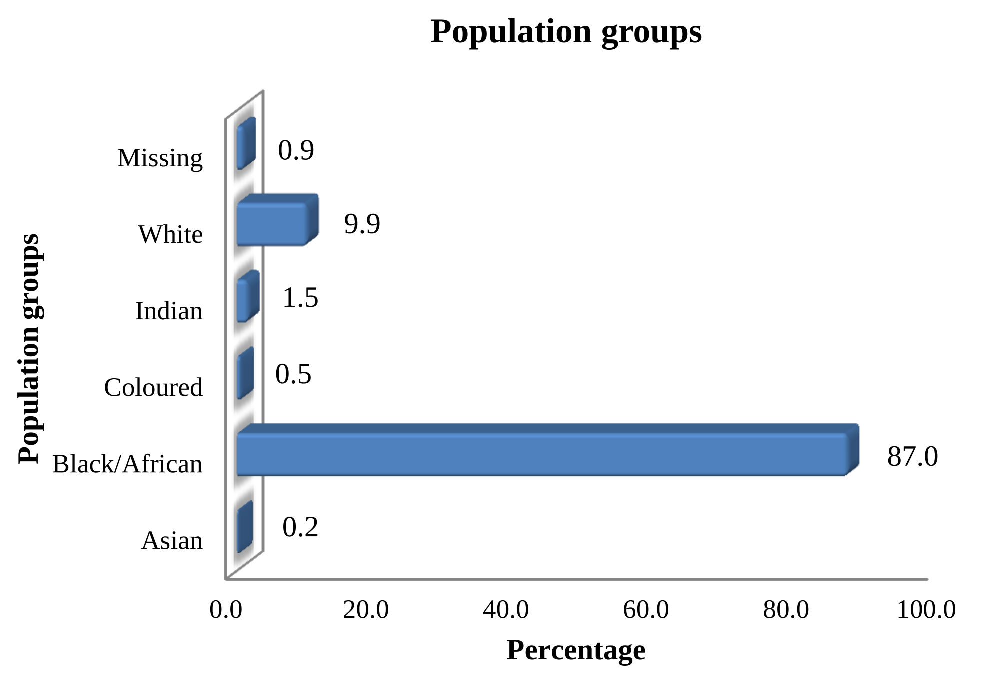


The majority of the participants are from the Gauteng province, representing 52.7 per cent of the sample. The Limpopo province is represented by 15.7 per cent, while the Free State is represented by 9.0 per cent of the sample. North West, Mpumalanga and KwaZulu-Natal represented 5.7, 4.4 and 3.7 per cent of the sample respectively. The Eastern Cape represented 3.5 per cent of the sample, while the Northern Cape represented 0.7 per cent of the sample, closely followed by the participants from the Western Cape, with 0.5 per cent. Four participants did not complete this question on the classification data, thus signifying one per cent of the responses.

Table 4.10 presents a summary of the representation of populations groups within the sample of participants.

Table 4.10: Population groups

Population group	Frequency *f*	Percentage %
Asian	1	0.2
Black/African	476	87.0
Coloured	3	0.5
Indian	8	1.5
White	54	9.9
Missing	5	0.9
N	547	100.0

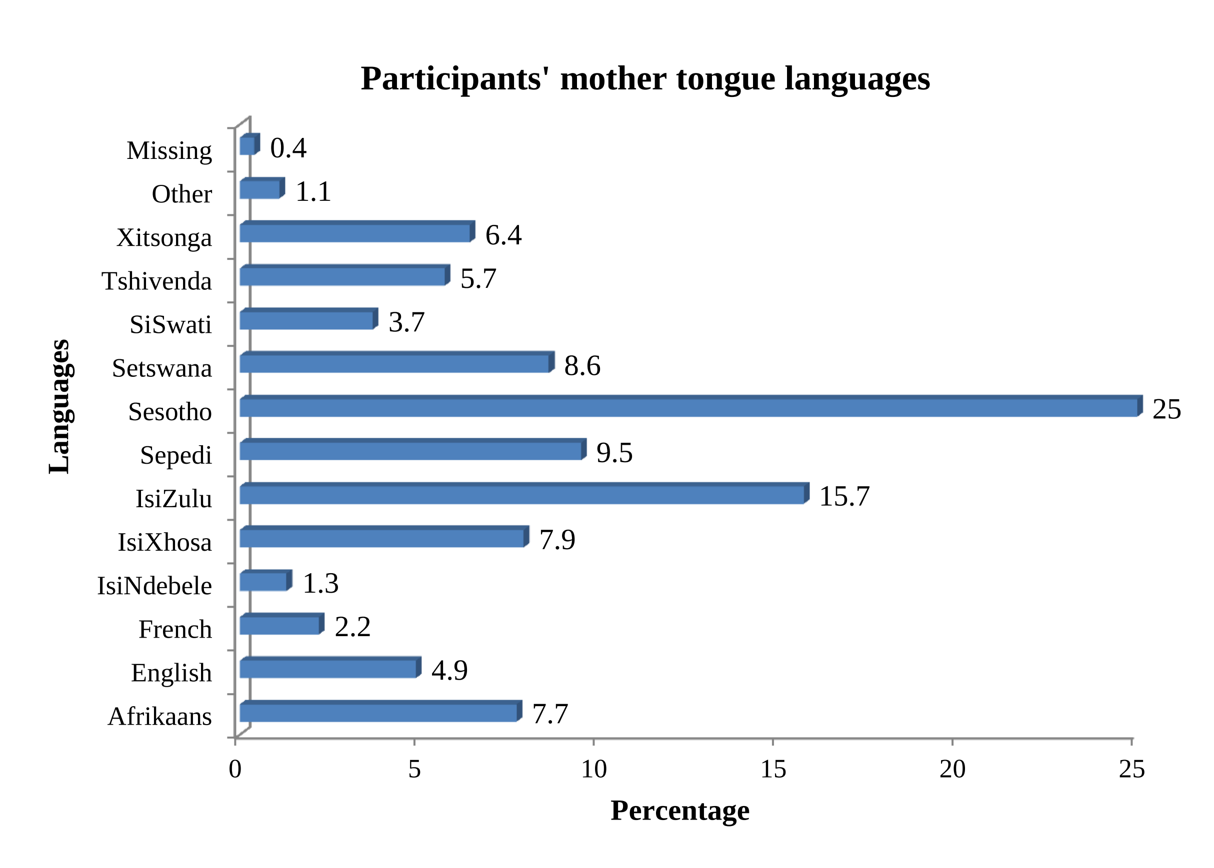


The majority of participants were black Africans with 87.0 per cent followed by whites with 9.9 per cent. The Indian population was represented with 1.5 per cent, followed by coloureds with 0.5 per cent and the Asian population group with 0.2 per cent. A total of five participants did not indicate to which population group they belong.

A summary on the participants' mother tongue languages is illustrated in Table 4.11

Table 4.11: Mother tongue language

Mother tongue language	Frequency *f*	Percentage %
Afrikaans	42	7.7
English	27	4.9
French	12	2.2
IsiNdebele	7	1.3
IsiXhosa	43	7.9
IsiZulu	86	15.7
Sepedi	52	9.5
Sesotho	137	25.0
Setswana	47	8.6
SeSwati	20	3.7
Tshivenda	31	5.7
Xitsonga	35	6.4
Other	6	1.1
Missing	2	0.4
N	547	100.0



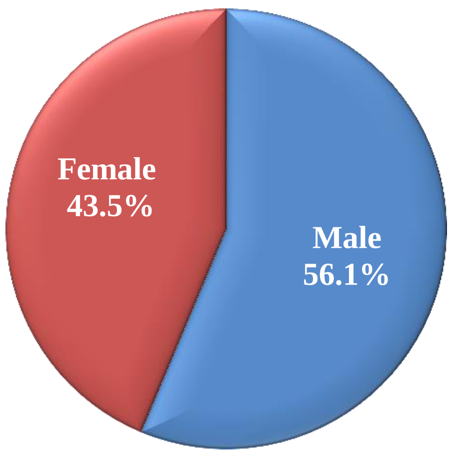
The majority of the participants were Sesotho speaking, as indicated by 25.0 per cent in Table 4.11. The participants speaking IsiZulu, with a value of 15.7 per cent, followed this. From the sample, 9.5 per cent of the participants indicated that they are Sepedi speaking, 8.6 per cent Setswana speaking and 7.9 per cent speak IsiXhosa. Furthermore, 7.7 per cent indicated that they speak Afrikaans, 6.4 per cent speak Xitsonga, 5.7 per cent speak Tshivenda, 4.9 per cent speaks English, 3.7 per cent speak SiSwati, 2.2 per cent speak French and 1.3 per cent speak IsiNdebele.

Table 4.12 provides a summary of the representation of gender sample (N) of the participants.

Table 4.12: Gender profile

Gender	Frequency *f*	Percentage %
Male	307	56.1
Female	238	43.5
Missing	2	0.4
N	547	100.0

Participants' gender representation



The gender differences of the sample suggest that 43.5 per cent of the participants were female and 56.1 per cent of the participants were male, thereby indicating that the majority of the participants were males.

The age of participants ranges from 18 years of age up to 40 with the majority being in the range of 19 to 23 years old as reflected in Table 4.13.

Table 4.13: Age of members of the sample

Age (in years)	Frequency *f*	Percentage %
18	10	1.8
19	66	12.1
20	101	18.5
21	130	23.8
22	99	18.1
23	68	12.4
24	32	5.9
25	12	2.2
26	8	1.5
27	1	0.2
28	4	0.7
29	1	0.2
40	1	0.2
Missing	14	2.6
N	547	100.0

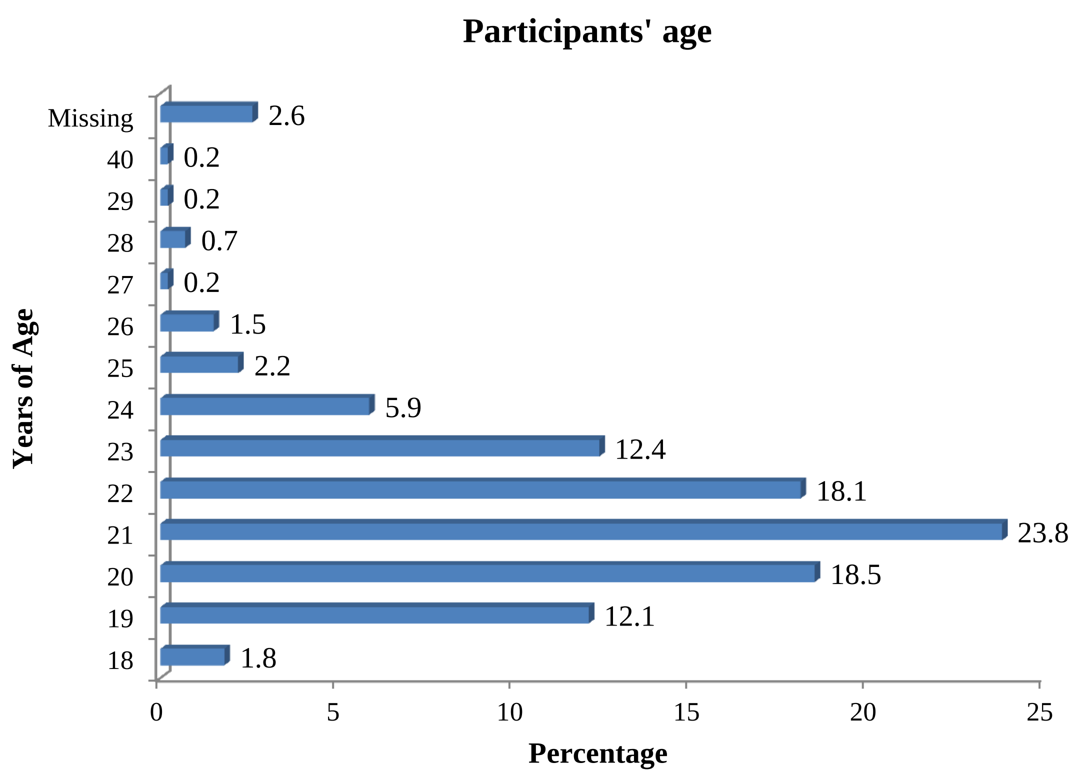


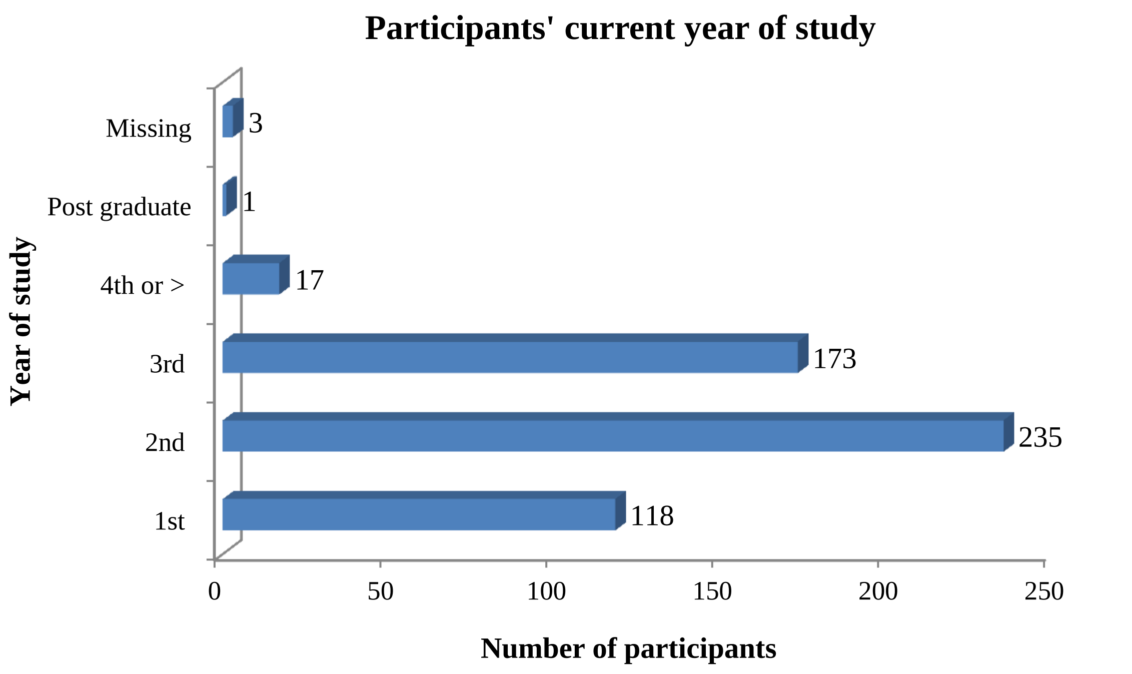
Table 4.13 provides a summary of the distribution information involving the participants'

age. The majority of the participants were 21 years of age, representing 23.8 per cent of the sample. Participants within the 20 and 22 age groups were represented almost evenly with 18.5 and 18.1 per cent respectively. The same applies to the 23 and 19 years age groups with 12.4 and 12.1 per cent representation respectively. The remainders of participants were distributed within the 24 years up to 29 years age group, while one participant reported to be 40 years of age and 1.8 percent of the participants were within the 18 years age group.

Information related to the distribution of participants according to their current year of study is shown in Table 4.14.

Table 4.14: Current year of study

Current year of study	**Frequency** ***f***	**Percentage %**
1st	118	21.6
2nd	235	43.0
3rd	173	31.6
4th or > 4th	17	3.1
Post graduate	1	0.2
Missing	3	0.5
N	547	100.0



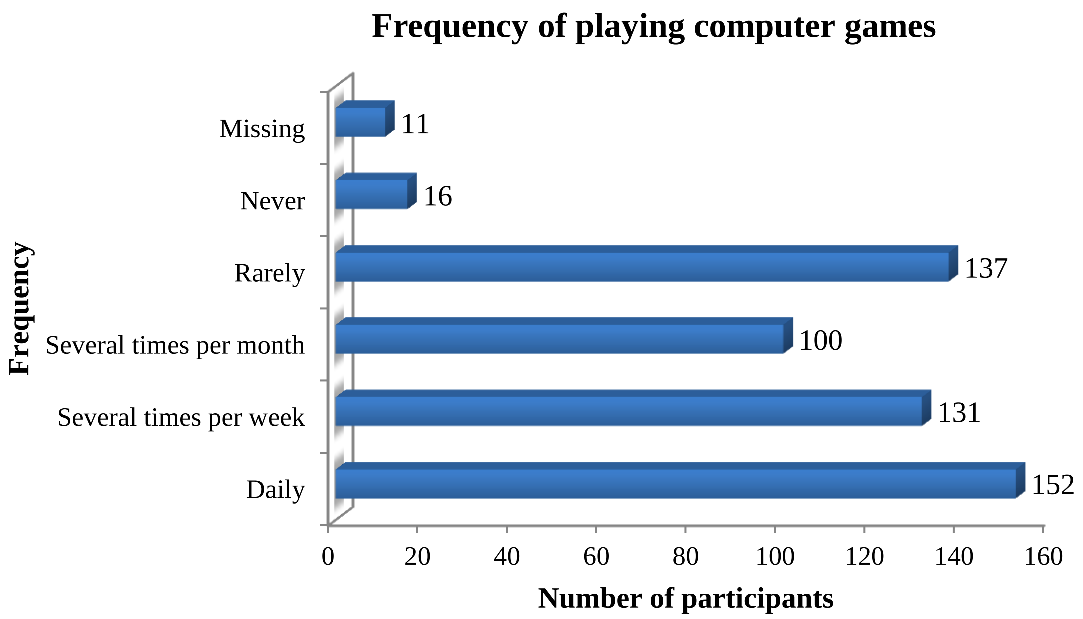
The distribution information pertaining to the participants' current year of study is shown in

Table 4.14. The largest portion of the sample was second year students, with a total of 235 participants, followed by 173 students in their third year of study. The third largest portion of the sample was a total of 118 first-year students, while 17 students indicated that they were in their fourth year of study. One post-graduate student participated in the survey, while three participants failed to answer this question.

Two questions were asked to establish experience participants have in playing digital games. Table 4.15 contains a summary of responses on how frequent participants play computer games, while Table 4.16 contains a summary of the age when participants started playing computer games.

Table 4.15: Frequency of playing computer games

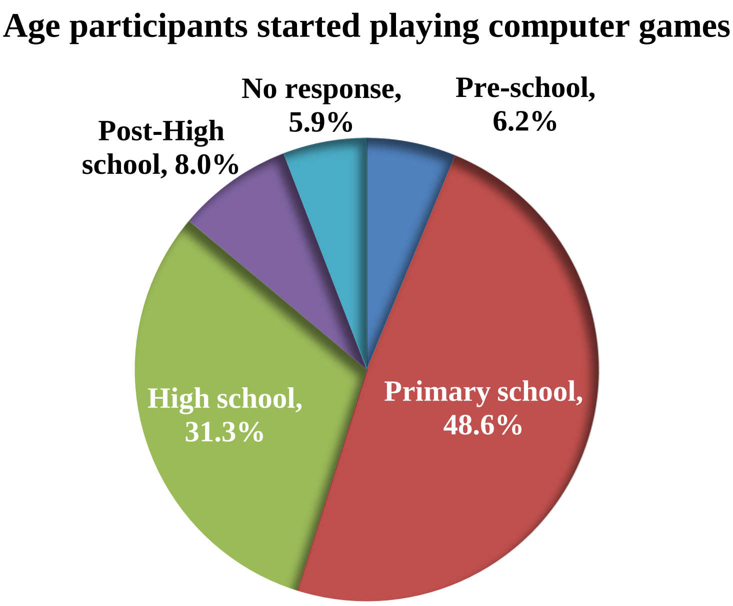
Category	**Frequency *f***	**Percentage %**
Daily	152	27.8
Several times per week	131	23.9
Several times per month	100	18.3
Rarely	137	25.0
Never	16	2.4
Missing	11	2.0
N	547	100.0



The distribution of information involving the age at which participants started playing computer games is shown in Table 4.16. The collected data were categorised according to the age when they enter and leave each phase of their school career.

Table 4.16: Age at which participants started playing computer games

Category	Age limits in years	Frequency *f*	Percentage %
Pre-school	**0 – 5**	34	6.2
Primary school	**6 – 12**	266	48.6
High school	**13 – 18**	171	31.3
Post-High school	**>18**	44	8.0
No Response	**-**	32	5.9
N		547	100.0



Not all the participants had played computer games before. Therefore, the total number of responses to this question was 529 which is 96.7 per cent. More than 50 per cent of the participants indicated that they started playing computer games before they entered high school, while 31.3 per cent started playing computer games as a teenager while they were in high school. Only 8.0 per cent started playing computer games during their adult lives, while 6.2 per cent did not respond to the question. These figures reveal that almost 90 per cent of computer science students who participated in this study had played computer games before.

The next section discusses the reliability and validity of the scale that was used.

4.4.2 Reliability and validity of the scale

When measuring the reliability of a scale, responses to items measuring a specific construct should show a degree of similarity (Maree *et al.*, 2007:216). Statistically, a Cronbach alpha coefficient close to the value of one indicates that a high inter-items correlation exists, which means that the items measuring a construct are reliable. The validity of the scale is assessed when attempting to determine whether the scale is measuring what it is intended to measure (Gray, 2013:155). This section provides an overview of the reliability and validity measures, namely the Cronbach alpha and the average inter-item correlation, computed in this study. Table 4.17 provides a summary of the reliability and validity measures of the research instrument used in this study.

Table 4.17: Reliability and validity analysis of the scale

Items	Number of items	Cronbach alpha	Average inter-item correlation
Internal and external technology acceptance factors	41	0.932	0.249
Sub-scale:			
Internal technology acceptance factors	15	0.933	0.482
Construct 1 – Attitude	3	0.771	0.522
Construct 2 – Behavioural intention (BI)	3	0.862	0.676
Construct 3 – Perceived usefulness (PU)	4	0.920	0.743
Construct 4 – Perceived ease of use (PEOU)	5	0.910	0.669
Sub-scale:			
External technology acceptance factors	26	0.841	0.186
Construct 5 – Subjective norms (SN)	2	*	
Construct 6 – Relevance (R)	2	*	
Construct 7 – Perceived enjoyment (Enjoy)	4	0.782	0.495
Construct 8 – Self-efficacy (SE)	10	0.767	0.249
Construct 9 – Temporal dissociation (TD)	3	0.815	0.604

Table 4.17: Reliability and validity analysis of the scale (continued…)

Items	Number of items	Cronbach alpha	Average inter-item correlation
Construct 10 – Focussed immersion (FI)	2	*	
Construct 11 – Experienced Enjoyment (ExpEnjoy)	3	0.680	0.452
*Minimum of 3 items required to calculate			

The reliability of the scale calculated to a Cronbach alpha value of 0.932, while the Cronbach alpha values of the two sub-scales – the internal and external technology acceptance factors - calculated to the values of 0.933 and 0.821 respectively. The Cronbach alpha values for the individual constructs within the two sub-scales ranged between the values of 0.680 and 0.920. It can be said that the scale used in this study is reliable since all of the calculated Cronbach alpha values exceed the acceptable level of 0.60 (Gomm, 2008:48).

In addition to testing the reliability of the constructs, the validity for the overall scale should be tested as well, using the mean average inter-item correlation (Heckard & Utts, 2012:83). As shown in Table 4.17, an inter-item correlation value of 0.249 was computed for the entire scale. Furthermore, a value of 0.482 was computed for the internal technology acceptance factors sub-scale (15 items), and a value of 0.186 for the external technology acceptance factors sub-scale (26 items). All of these values are within the recommended range of 0.15 to 0.50 (Clark & Watson, 1995:316). The average inter-item correlation computed for the constructs within the two sub-scales range between 0.249 and 0.743 indicating a strong relationship among the items in each construct (Heckard & Utts, 2012:83). Despite the fact that five of these constructs fell outside the recommended inter-item range, it was decided to continue with the study, since the constructs, the overall scale and two sub-scales have proven to be reliable and valid.

A confirmatory factor analysis was conducted on the internal and external technology acceptance factors, which is discussed in the following section.

4.4.3 Confirmatory factor analysis

Confirmatory factor analysis is done on a data set in order to find variables that are interrelated (Williams *et al.*, 2012:2). The objective is to define the interrelationship between variables within a large set of variables and to determine the various factors that underpin the interrelated sets of variables. Confirmatory factor analysis was used on the data set to determine whether the 15 items used within the internal technology acceptance sub-scale, and the 26 items used within the external technology acceptance sub-scale, produced the proposed constructs, and to identify whether the variables loaded on the intended constructs. Principle component factor analysis, using the varimax rotation, was conducted on the 15 variables in the internal technology acceptance sub-scale, and on the 26 variables in the external technology acceptance sub-scale.

The results from the factor analysis are shown in Table 4.18; two factors from the internal technology acceptance sub-scale emerged with eigenvalues greater than 1.0. These two factors explained 47.735 per cent of the variance. However, one item in the current study loaded differently from those in the original study (the item is shown in bold in Table 4.18). As is evident from the table, the items in Construct 2, Construct 3 and Construct 4 loaded as expected on Factor 1, Factor 2 and Factor 3, respectively. With regard to Construct 4, all of the items, except variable B20, which loaded on Factor 3, loaded on one factor (Factor 4).

Table 4.18: Confirmatory factor analysis results: Internal technology acceptance

Items	**Factor 1 (PEOU)**	**Factor 2 (PU)**	**Factor 3 (BI)**	**Factor 4 (A)**
B1				0.855
B2				0.778
B3			0.561	
B4			0.740	
B5			0.733	
B8		0.858		
B9		0.821		
B10		0.823		
B13		0.722		
B14	0.856			
B15	0.874			
B16	0.821			
B17	0.805			
B18	0.722			
B20			**0.690 (must be A)**	

From data captured in Table 4.19, it is evident that the sample did not distinguish between the subjective norms (Construct 5) and relevance (Construct 6) constructs. A possible reason for this fusion is that both constructs describe whether serious games are perceived to be relevant in studying computer science either from the perspective of friends and relatives or the participant's own perspective. In the same way, no distinction is evident amongst the temporal dissociation (Construct 9) and focus immersion (Construct 10) factors. These two constructs both evaluate the level of cognitive absorption while playing serious games. In the field of computer science, which involves higher order thinking skills, the concepts of temporal dissociation (Construct 9) and focus immersion (Construct 10) are critical aspects within the learning environment (Nag *et al.*, 2013:149). Therefore, it was decided to treat these two constructs as separate factors. One of the items measuring experienced enjoyment (Construct 11) loaded on Factor 1, together with the temporal dissociation (Construct 9) and focus immersion (Construct 10) items. This confirms what was revealed in the literature regarding the level of enjoyment game players experience while being dissociated from their surroundings and focussing on the game (Lu *et al.*, 2008:2). Players associate the experience of flow, which includes temporal dissociation and focussed immersion with enjoyment. It was decided to keep the items for Construct 11 as planned and in accordance with the validated construct compiled by Lu *et al.* (2009:37). All four items measuring participants' perceived enjoyment of playing games loaded on Factor 2, which confirms that participants associate serious games with fun and entertainment. Seven of the ten items measuring self – efficacy (SE) (Construct 8) loaded on Factor 3, while three items (B26, B27 and B31) loaded on Factor 5. This distinction could be because measuring items B26, B27 and B31 specifically evaluate the user's sense of self-efficacy when no assistance is available or the game was never played before, while the remaining items indicate that assistance is available or the games have been played before.

Even though several items did not load as expected during the confirmatory factor analysis (these items are shown in bold in Table 4.19), five factors did emerge. The Cronbach alpha for each of the seven constructs contained in the second subscale was considered in addition to the confirmatory factor analysis. The Cronbach alpha for each of the seven constructs range between 0.680 and 0.815, which exceeds the acceptable level of 0.60 (Gomm, 2008:48). It was decided to use five factors but separate the two constructs that fused with two of the five factors and still use them as separate constructs. Table 4.19 shows the confirmatory factor analysis of the items included in the external technology acceptance constructs.

Table 4.19: Confirmatory factor analysis results: External technology acceptance

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
B6				0.811(SN)	
B7				0.740(SN)	
B11				**0.635(R)**	
B12				**0.564(R)**	
B19		0.627(Enjoy)			
B21		0.631(Enjoy)			
RB22		0.759(Enjoy)			
RB23		0.808(Enjoy)			
B24			0.689(SE)		
B25			0.681(SE)		
B26					**0.654(SE)**
B27					**0.711(SE)**
B28			0.672(SE)		
B29			0.7457SE)		
B30			0.424(SE)		
B31					**0.581(SE)**
B32			0.792(SE)		
B33			0.523(SE)		
B34	0.752(TD)				
B35	0.813(TD)				
B36	0.794(TD)				
B37	**0.701(FI)**				
B38	**0.681(FI)**				
B39	**0.608(ExpEnjoy)**				
RB40		**0.636(ExpEnjoy)**			
B41		**0.492(ExpEnjoy)**			

The following section, Section 4.4.4, presents the descriptive statistics of the data for this study. The terms variable and factor will be used interchangeably in Section 4.4.4 and Section 4.5. Both these terms refer to the constructs contained in the two subscales of this study which are presented as the internal and external factors of the TAM.

4.4.4 Descriptive statistics

Quantitative research entails the collection and processing of numerical data from a selected subgroup of a population in order to generalise findings with regards to the relevant population (Maree *et al.*, 2007:145). The distribution of numerical values obtained from participants – one from each participant – across a specific range of values (scale) is meaningful in order to understand the characteristics of the data. The distribution of quantitative data is often described in terms of location (mean), distribution (standard deviation) and shape (skewness and kurtosis), which are calculated across all the scaled-items of the questionnaire. Table 4.20 provides an overview on the descriptive statistics of this study. The number of completed questionnaires is indicated as the Valid *N* in the table. A six-point Likert scale was used that ranged from 1=strongly disagree to 6=strongly agree, which results in higher mean values being associated with greater levels of agreement.

Table 4.20: Descriptive statistics summary

Item	**Valid N**	**Mean**	**Standard deviation**	**Skewness**	**Kurtosis**
Sub-scale:					
Internal technology acceptance factors	**547**	**4.9412**	**0.75067**	**-1.284**	**2.709**
Attitude (A) (Construct 1)	**547**	**4.9360**	**0.96866**	**-1.107**	**1.059**
B1	547	4.845	1.2534	-1.328	1.525
B2	547	4.899	1.1871	-1.295	1.606
B20	547	5.064	1.0611	-1.291	1.647
Behavioural intention (BI) (Construct 2)	**547**	**4.9586**	**.98643**	**-1.402**	**2.468**
B3	547	4.963	1.1589	-1.339	1.737
B4	547	4.967	1.1399	-1.350	1.812
B5	547	4.945	1.0416	-1.247	2.149
Perceived usefulness (PU) (Construct 3)	**547**	**4.9378**	**.99657**	**-1.337**	**2.094**
B8	547	4.925	1.1578	-1.175	1.069
B9	547	4.960	1.0887	-1.245	1.615

Table 4.20: Descriptive statistics summary (continued…)

Item	Valid N	Mean	Standard deviation	Skewness	Kurtosis
B10	547	4.907	1.1706	-1.227	1.328
B13	547	4.960	1.0137	-1.200	1.912
Perceived ease of use (PEOU) (Construct 4)	**547**	**5.190**	**0.7890**	**-1.332**	**2.753**
B14	547	5.170	0.9600	-1.206	1.479
B15	547	5.199	0.9152	-1.282	1.966
B16	547	5.059	0.9513	-1.065	1.330
B17	547	5.230	0.8760	-1.335	2.439
B18	547	5.294	0.8953	-1.597	3.496
Sub-scale:					
External technology acceptance factors	**547**	**4.7285**	**0.55905-**	**-0.847**	**1.630**
Subjective norms (SN) (Construct 5)	**547**	**4.306**	**1.1123**	**-0.648**	**0.307**
B6	547	4.177	1.2766	-0.547	-0.104
B7	547	4.435	1.2093	-0.777	0.468
Relevance (R) (Construct 6)	**547**	**5.133**	**0.9476**	**-1.763**	**4.157**
B11	547	5.234	1.0218	-1.763	3.712
B12	547	5.033	1.0443	-1.461	2.650
Perceived Enjoyment (Enjoy) (Construct 7)	**547**	**4.950**	**0.99226**	**-1.763**	**4.157**
B19	547	5.183	1.0322	-1.585	2.837
B21	547	5.208	1.0520	-1.646	2.836
B22	547	4.578	1.5079	-0.899	-0.251
B23	547	4.832	1.4364	-1.2010	0.485

Table 4.20: Descriptive statistics summary (continued…)

Item	Valid N	Mean	Standard deviation	Skewness	Kurtosis
Self-efficacy (SE) (Construct 7)	**547**	**4.263**	**0.7646**	**-0.618**	**1.148**
B24	547	4.040	1.4570	-0.548	-0.620
B25	547	4.201	1.3919	-0.739	-0.192
B26	547	4.558	1.1774	-0.811	0.348
B27	547	**3.735**	1.5134	-0.317	-0.876
B28	547	4.558	1.2917	-0.987	0.554
B29	547	4.097	1.4775	-0.602	-0.623
B30	547	4.627	1.1546	-0.964	0.986
B31	547	4.293	1.2098	-0.732	0.175
B32	547	4.298	1.3468	-0.753	-0.115
B33	547	4.229	1.3844	-0.689	-0.258
Temporal dissociation (TD) (Construct 9)	**542**	**5.000**	**1.0184**	**-1.216**	**1.511**
B34	542	4.777	1.3139	-1.109	0.571
B35	542	5.079	1.1597	-1.390	1.528
B36	542	5.148	1.0905	-1.560	2.483
Focussed immersion (FI) (Construct 10)	**542**	**4.978**	**0.9659**	**-0.928**	**0.708**
B37	542	4.945	1.1098	-1.079	0.827
B38	542	5.011	1.0407	-1.138	1.273
Experienced Enjoyment (ExpEnjoy)(Construct 11)	**542**	**4.997**	**0.7683**	**-1.157**	**1.391**
B39	542	5.249	0.9354	-1.508	2.831
B40	542	5.146	1.3589	-1.629	1.718
B41	542	5.446	0.9160	-2.173	5.673

On average, participants responded positively to the use of serious games as a teaching tool in the computer science class. Data contained in Table 4.20 indicate that, with the exception of one item, means above the value of four were computed on all of the individual measuring items. Consequently, means above the value of four were computed on all of the constructs in both the internal technology acceptance and the external technology acceptance sub-scales.

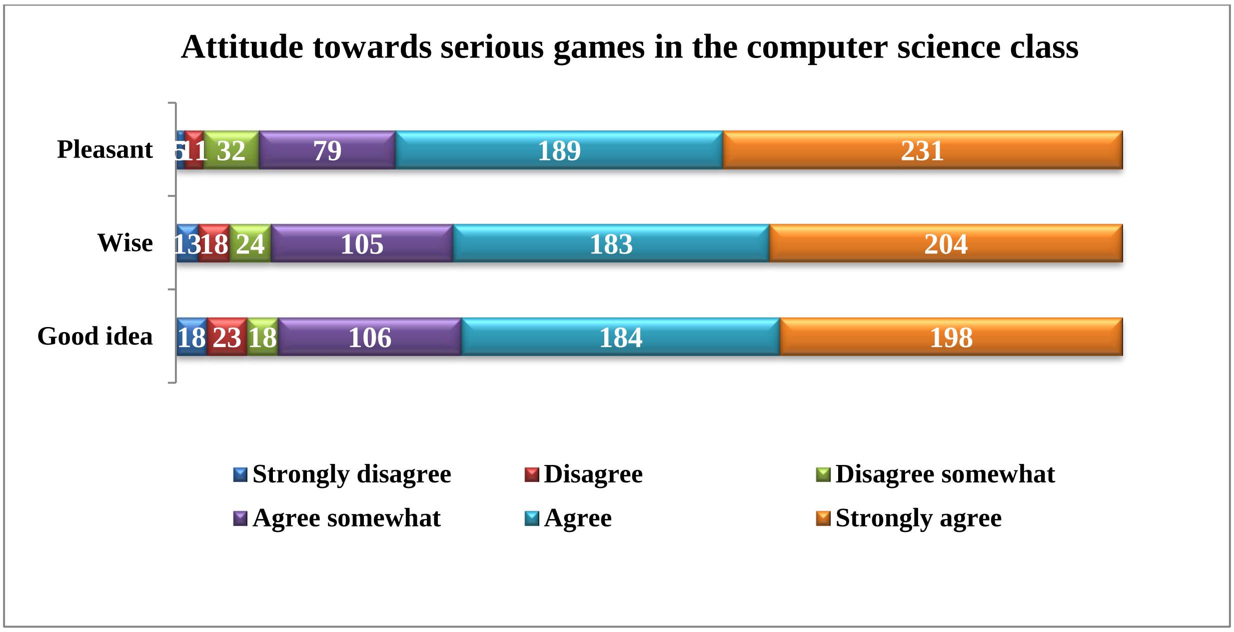
Skewness refers to the symmetry of distribution, where a cluster of negative values represents a negatively skewed symmetry of distribution and a cluster of positive values represents a positively skewed symmetry of distribution (Swanepoel *et al.*, 2011:70).

A kurtosis calculation represents information on the peakedness of the distribution. A cluster of positive kurtosis values (value > 0) indicates a peaked distribution and a cluster of negative kurtosis values (value < 0) indicates a flat distribution (Pallant, 2010:56). As can be seen from Table 4.20, both sub-scales may be classified as normally distributed, since none of the skewness scores fall outside the -2 to +2 range. However, Heckard and Utts (2012:414) suggest that a histogram, dot plot or stemplot should be used to reveal a more accurate picture of how data are distributed in terms of skewness and outliers. Outliers are data items, which are not consistent with the bulk of values and are either unusually high or low (Heckard & Utts, 2012:27). Histograms are recommended for a moderate to large sample size. The SAS software was used to compile histograms to show the distribution of data in the next section.

4.4.5 Participants' responses to internal technology acceptance factors

The participants' responses to the internal technology acceptance measuring items are reported on in this section. The internal factors are attitude (A), behavioural intention (BI), perceived usefulness (PU) and perceived ease of use (PEOU).

The data summarised in Figure 4.1 show that the majority of participants expressed a positive attitude towards the playing of serious games in the computer science class. Even though the majority of participants acknowledge that it would be pleasant to play serious games in class, they are slightly less positive about whether it would be wise and whether it is a good idea to play serious games in class.



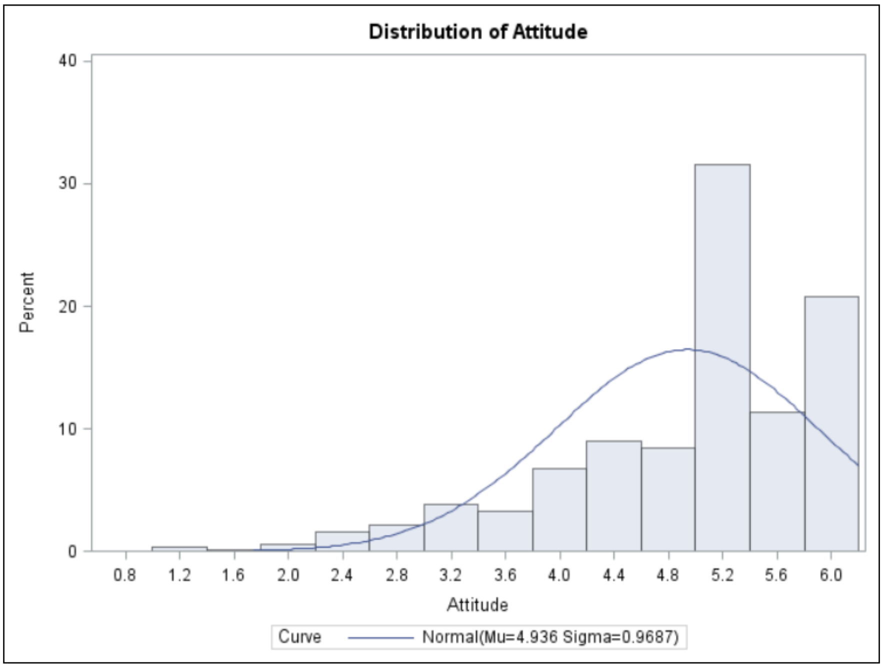
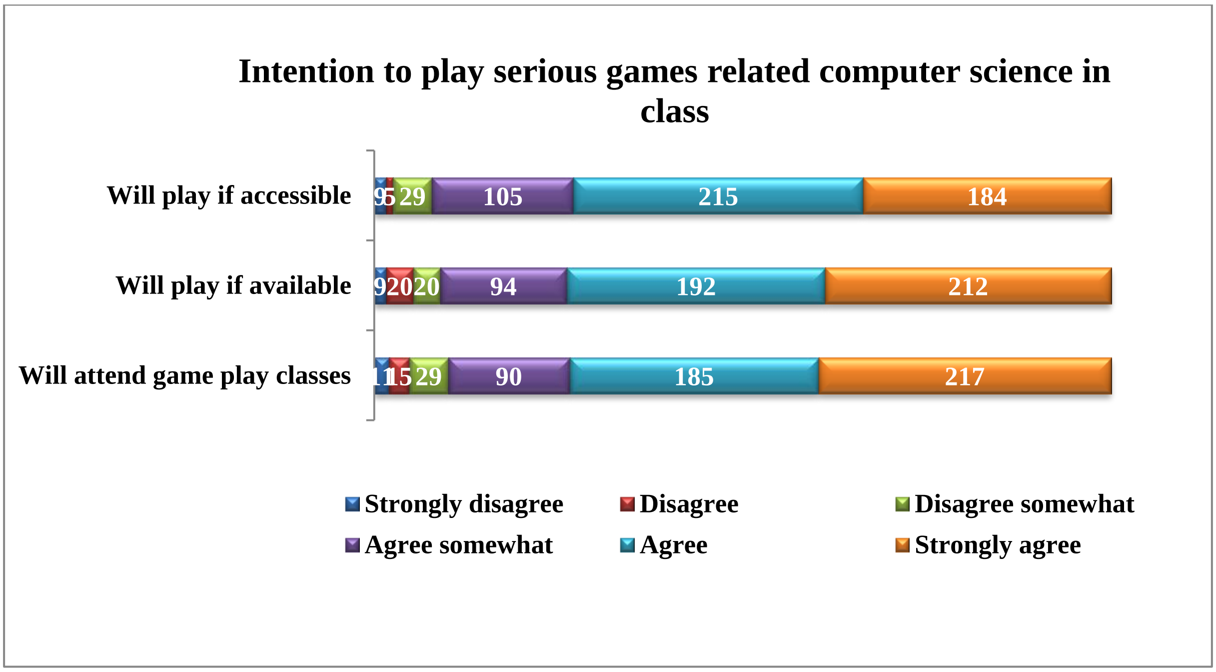


Figure 4.1: Construct 1: Attitude – frequencies and distribution of data

The distribution of data is skewed to the left as indicated in the histogram in Figure 4.1. It starts at two and ends at six with values centred at around the five and tapering off towards the value of three and six. A few outliers are not consistent with the bulk of the values. The skewed distribution of the data is acceptable due to the large enough size of the sample (Heckard & Utts, 2012:414).

The data reflected in Figure 4.2 indicate that the participants intend to attend computer science classes where serious games are used as part of class activities. According to their responses, participants are slightly less convinced that they would use serious games related to class work if they have access to these games.



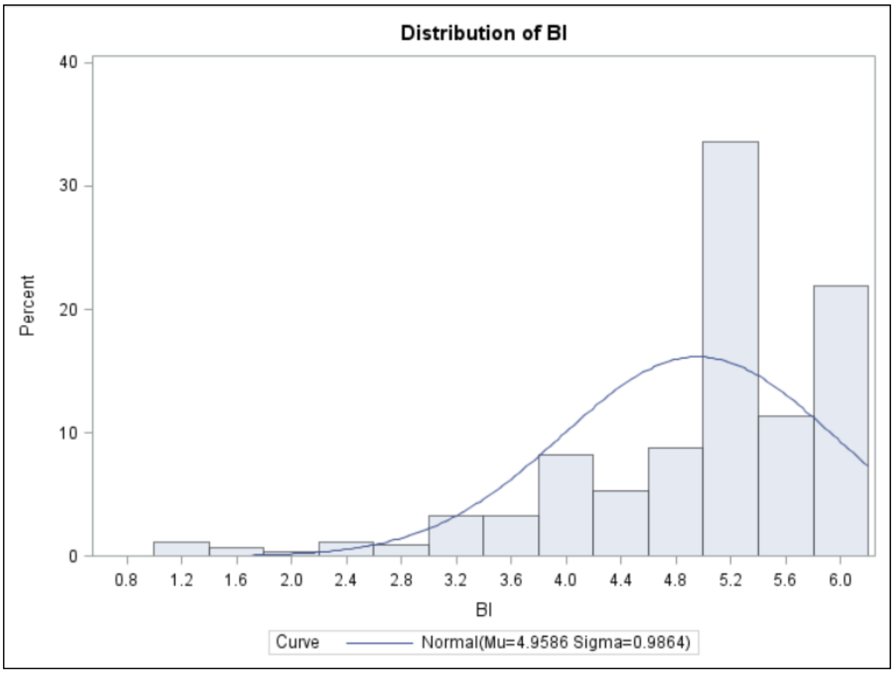
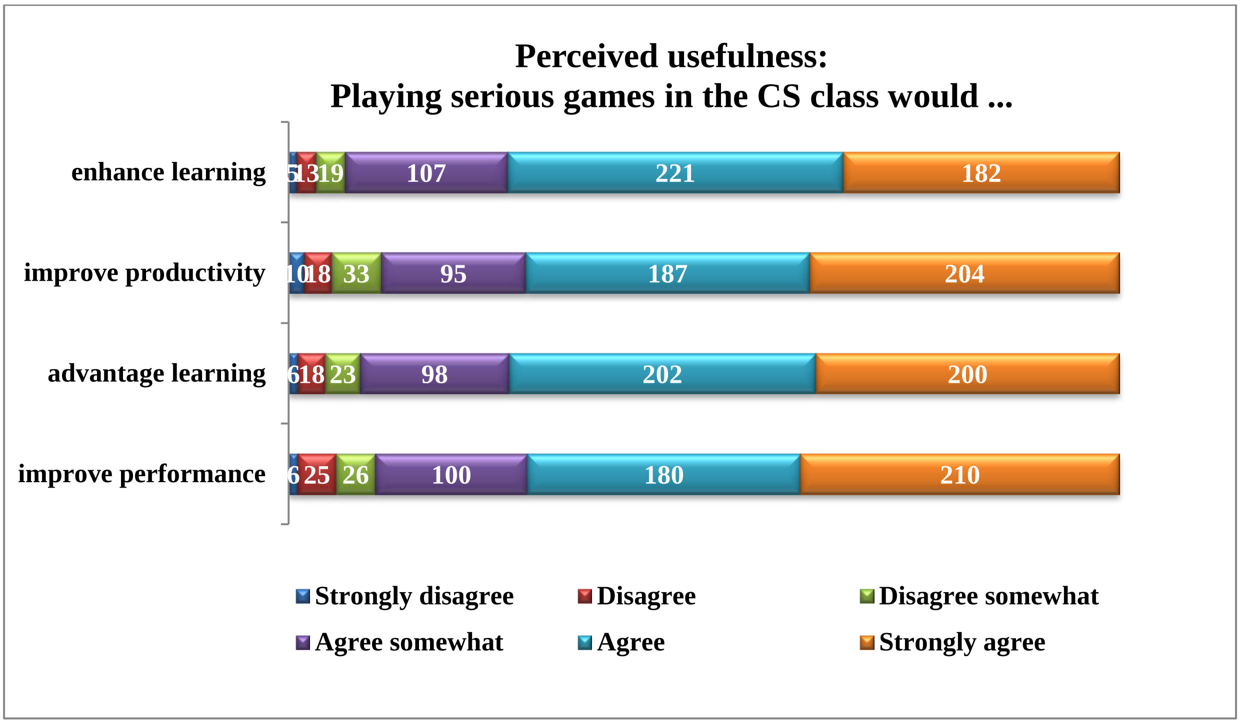


Figure 4.2: Construct 2: Behavioural intention - Frequencies and distribution of data

Similar to the data distribution of the Attitude (A) construct, the distribution of data for behavioural intention (BI) is skewed to the left as indicated in Figure 4.2. The data are centred around the value of five and taper off towards the value of three and six. A few outliers occur at the low end with more data than expected at the higher end of the scale.

Data reflected in Figure 4.3 reveal that the majority of participants are of the opinion that playing serious games related to computer science in class will enhance learning, be useful to improve their performance in class and be to the advantage of their learning experience in class. There is evidence that they are somewhat less convinced that the playing of serious games would improve their productivity in class.



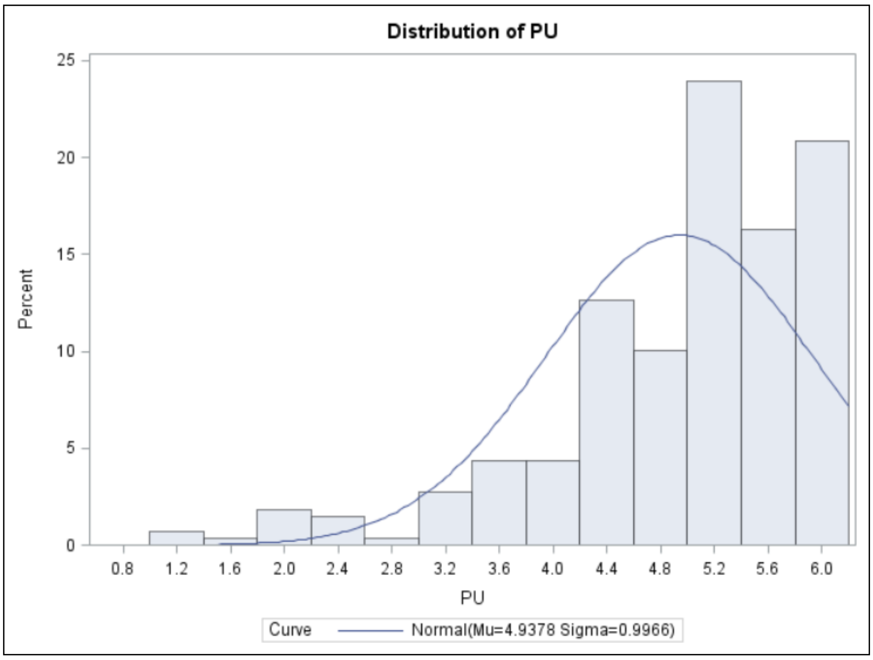
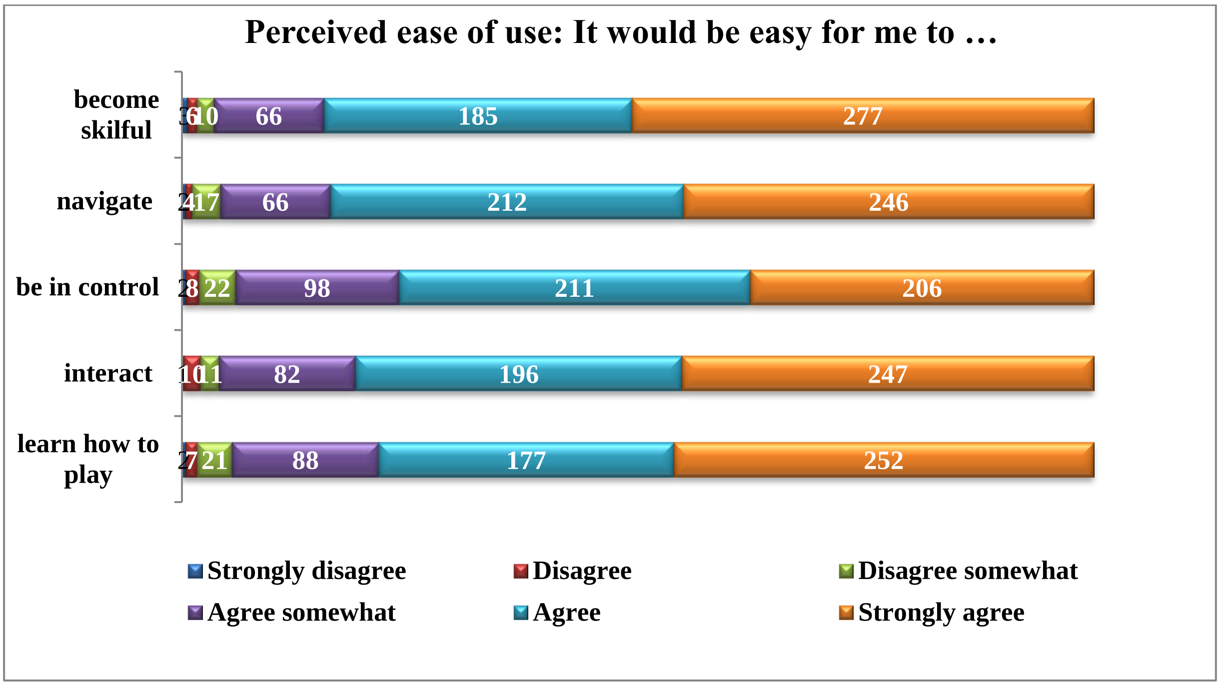


Figure 4.3: Construct 3: Perceived usefulness - Frequencies and distribution of data

The distribution of data for PU is skewed to the left as indicated in the histogram in Figure 4.3. The data are centred around the value of five and taper off towards the value of three and six. At the low end, some outliers occur, while more data than expected are distributed at the higher end of the scale.

Data on participants' perception of ease of use of games as technology in class are summarised in Figure 4.4. According to the distributed data, participants are confident of their ability to become skilful at playing serious games. They are of the opinion that they would find it easy to learn how to play a serious game, interact with the game, and navigate through the stages of a serious game.



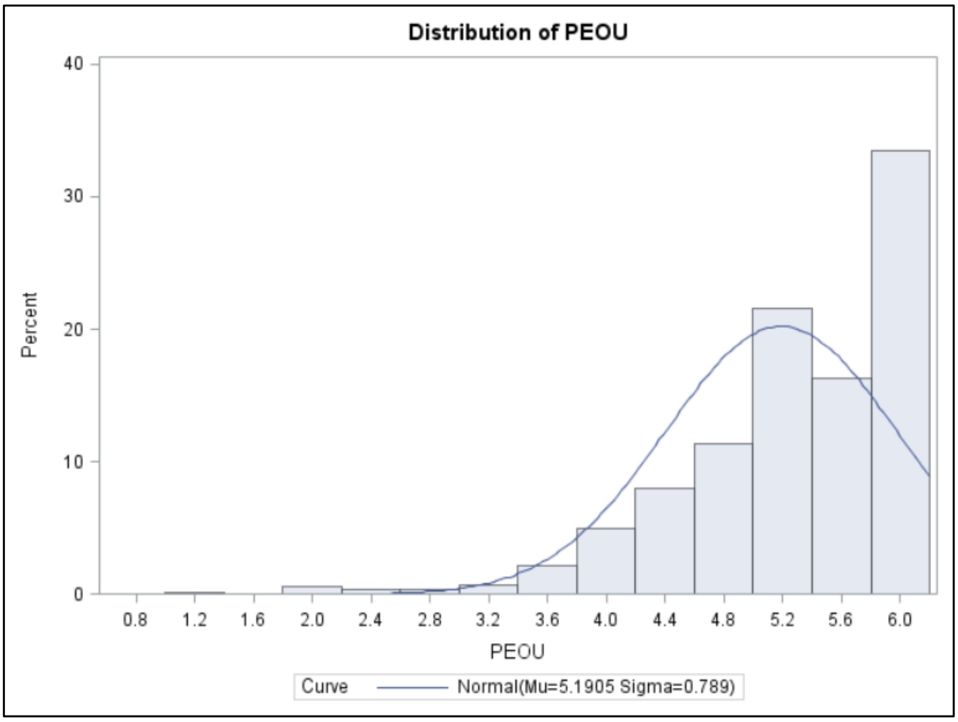


Figure 4.4: Construct 4: Perceived ease of use - Frequencies and distribution of data

Similar to the distribution of data for the previous internal constructs, the distribution of data is skewed to the left as indicated in the histogram in Figure 4.4. Data are distributed around the value of five and taper down to 2.8 and six. Fewer outliers were recorded than for PU.

4.4.6 Participants' responses to external technology acceptance factors

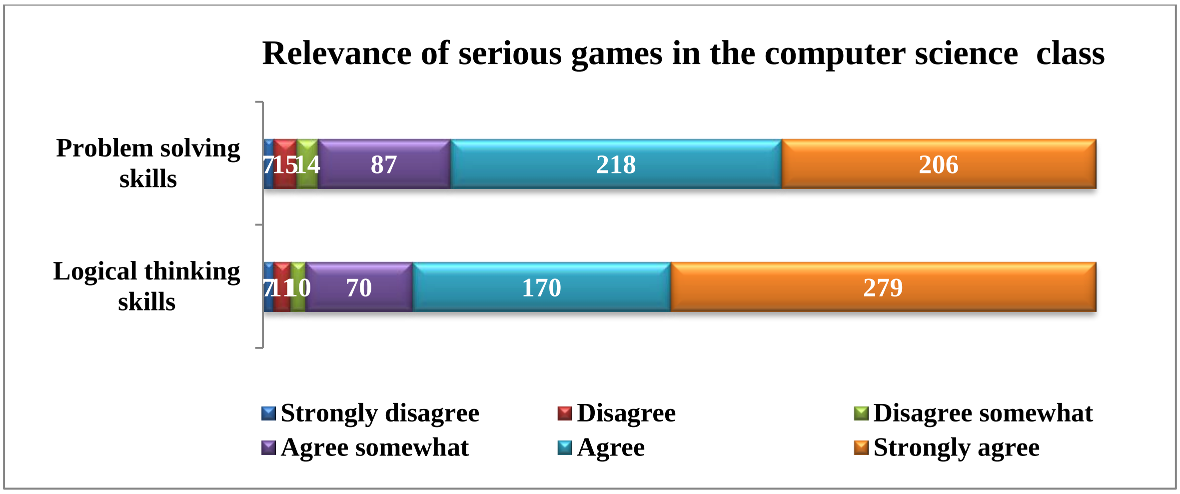
The participants' responses to the external technology acceptance factors are reported on in this section. The external factors pertain to subjective norms (SN), relevance (R), perceived enjoyment (Enjoy), self-efficacy (SE), temporal dissociation (TD), focussed immersion (FI) and experienced enjoyment (ExpEnjoy).

Subjective norm refers to how people close to a person think he should or should not behave (Fishbein & Ajzen, 1975:302). Data from Figure 4.5 indicate that participants from this study think people who influence their behaviour would be significantly more convinced that it is a good idea to play serious games in the computer science class than people who are important to them. A small number of participants indicated that people who are important to them would strongly disagree on using serious games in class.

Figure 4.5: Construct 5: Subjective norm - Frequencies and distribution of data

The distribution of data is skewed to the left as indicated in the histogram in Figure 4.5. Data are clustered around the values of four and five and taper off towards the value of one and six. A few outliers are distributed around the low end of the scale.

Mastering programming skills revolves around the ability to solve problems and to apply logical reasoning to solve problems (Fesakis & Serafeim, 2009:258; Wang & Chen, 2010:39). The data in Figure 4.6 support the fact that participants regard the play of serious games in the computer science class as a tool that could assist in developing these skills. Most participants support the fact that the play of serious games is relevant to computer science in terms of the development of specific skills required to become a successful computer programmer.



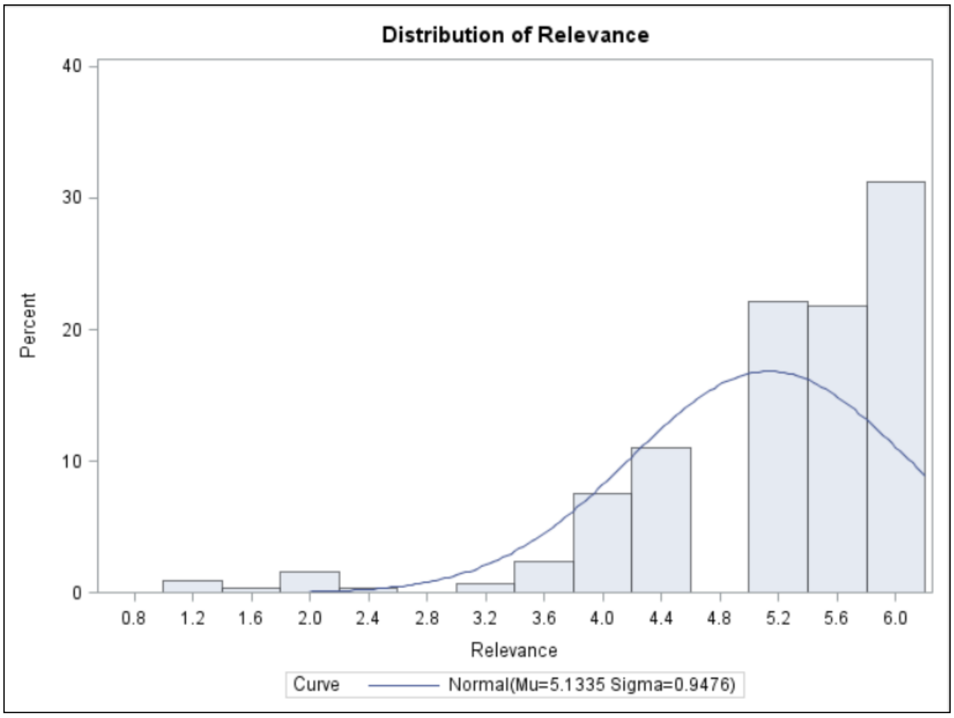
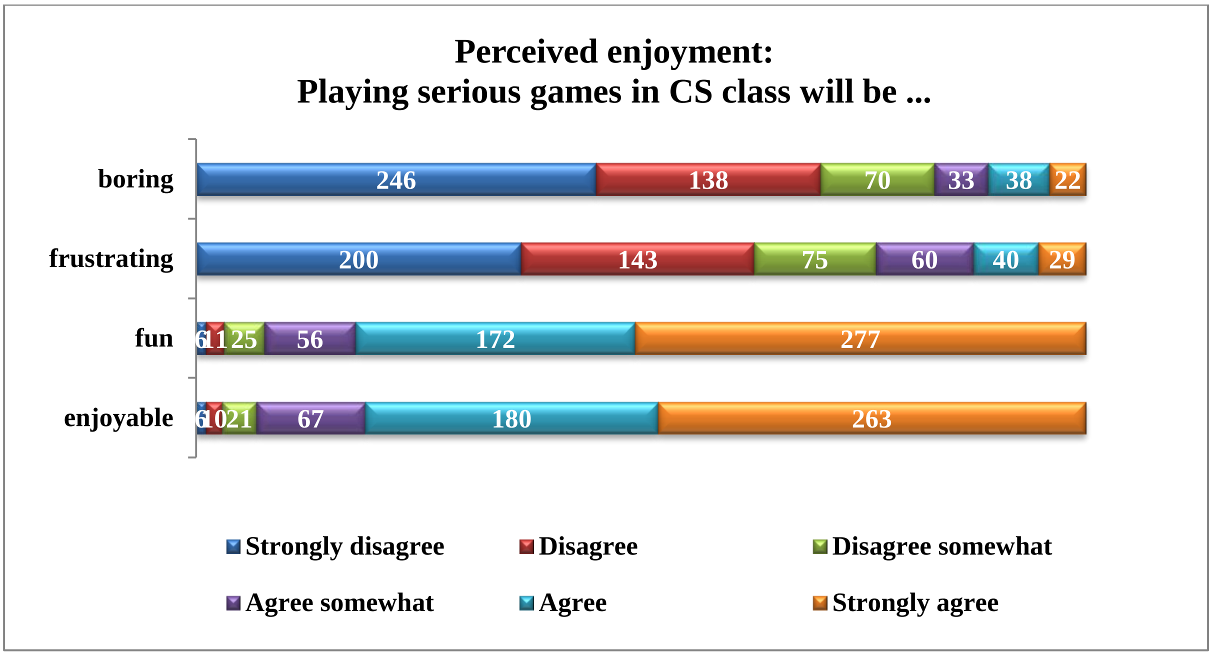


Figure 4.6: Construct 6: Relevance - Frequencies and distribution of data

The histogram in Figure 4.6 indicates that the distribution of data is skewed to the left with data centred around the value of six tapering down to two at the low end and six at the high end of the scale.

Enjoyment has an impact on intrinsic motivation and the attitude of users towards technology (Lu *et al.*, 2009:31; Moon & Kim, 2001). Figure 4.7 shows that a convincing number of participants perceive games in the computer science class as a possible enjoyable activity. This correlates with the small number of participants who indicated that serious games in class would be frustrating and boring for them.



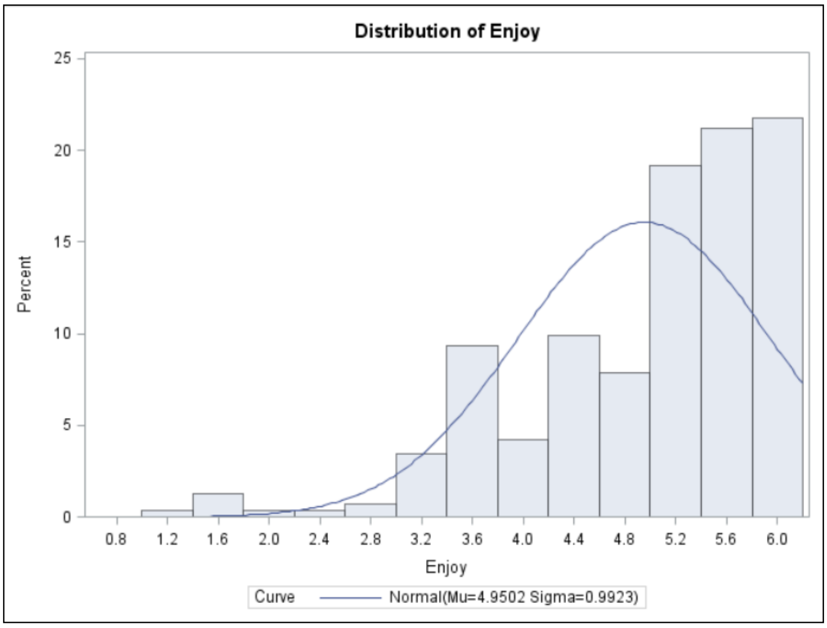
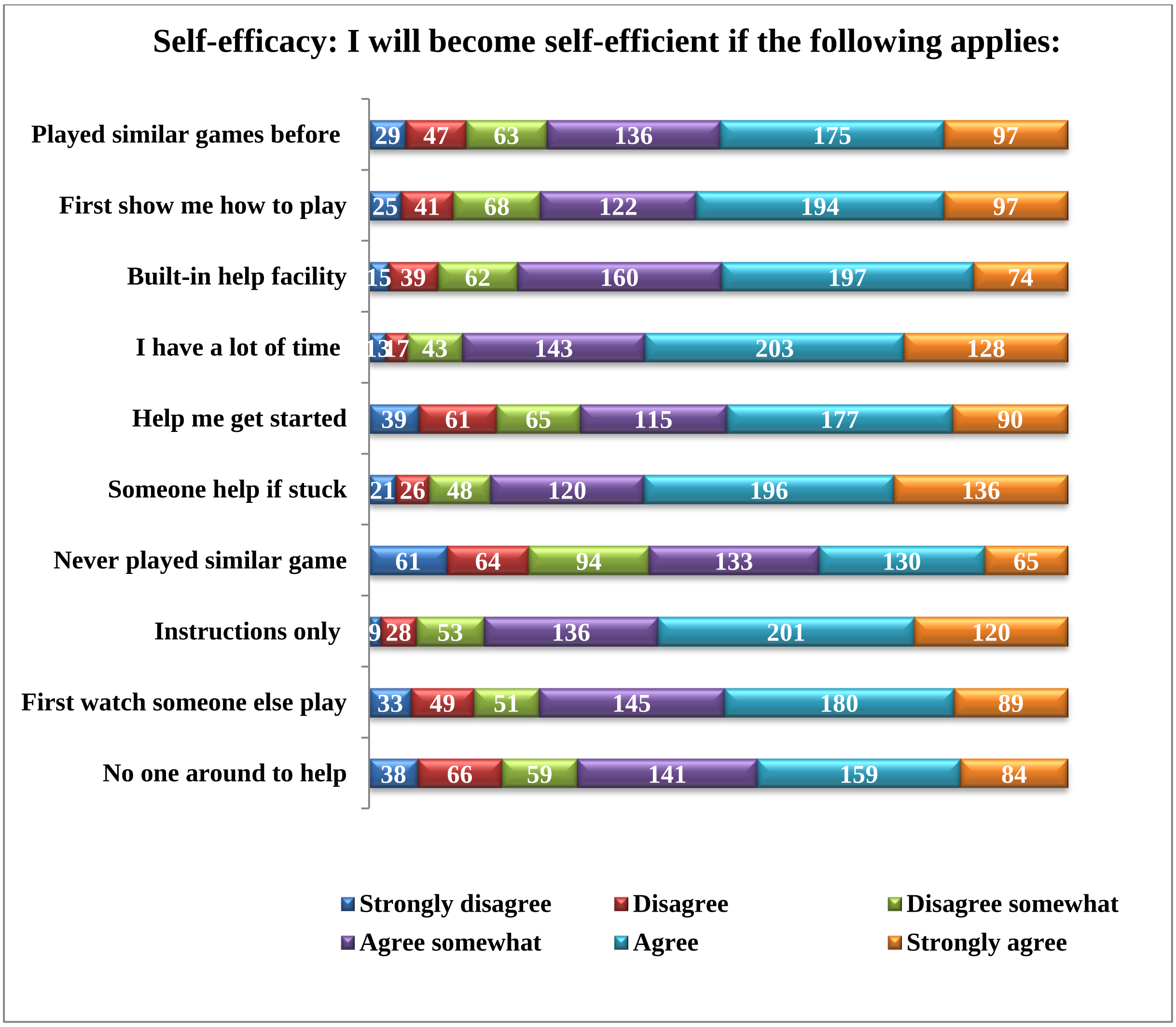


Figure 4.7: Construct 7: Perceived enjoyment - Frequencies and distribution of data

For perceived enjoyment, the distribution of data is skewed to the left as indicated in the histogram in Figure 4.7, with data centred around the value of six and tapering down to the value of two.

According to (Davis *et al.*, 1989:987) a user's inborn drive towards competence is triggered by a sense of efficacy. Bandura (1989) describes self-efficacy as a person's belief in his capability to control events that influence performance of a task. Amongst the measuring items for self-efficacy borrowed from the items validated by Compeau and Higgins (1995:201), participants in this study indicated that they would need assistance to become self-efficient at playing serious games in the form of time, instructions and a person to call for assistance when required according to the data shown in Figure 4.8.



This correlates with the fact that the data show a lesser level of self-efficacy amongst participants if they have never played the game before, only built-in help-facilities are available and there is no-one around to tell them what to do.

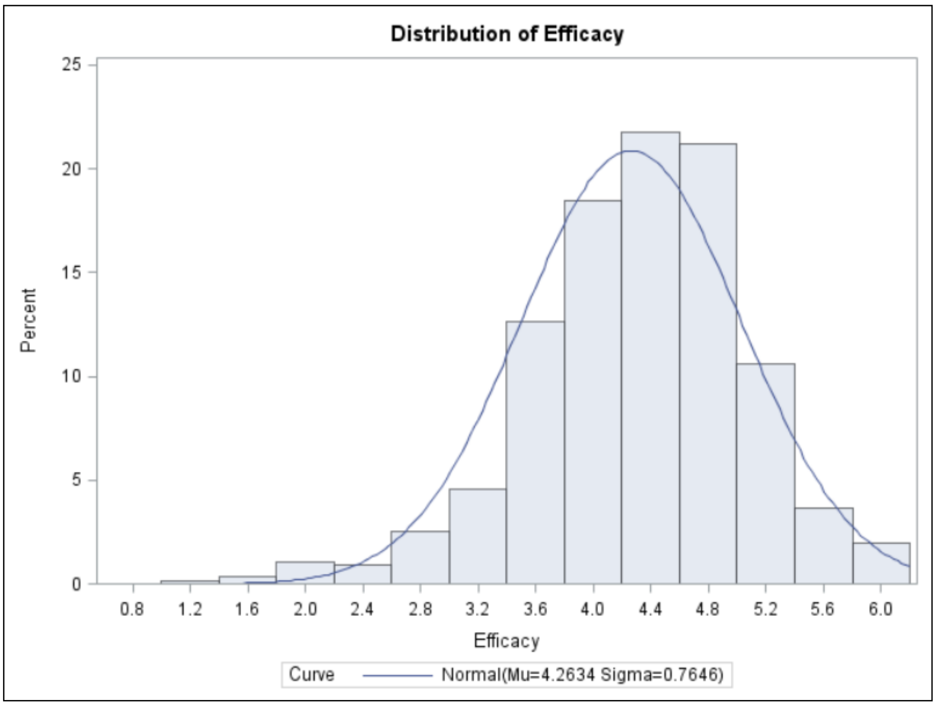
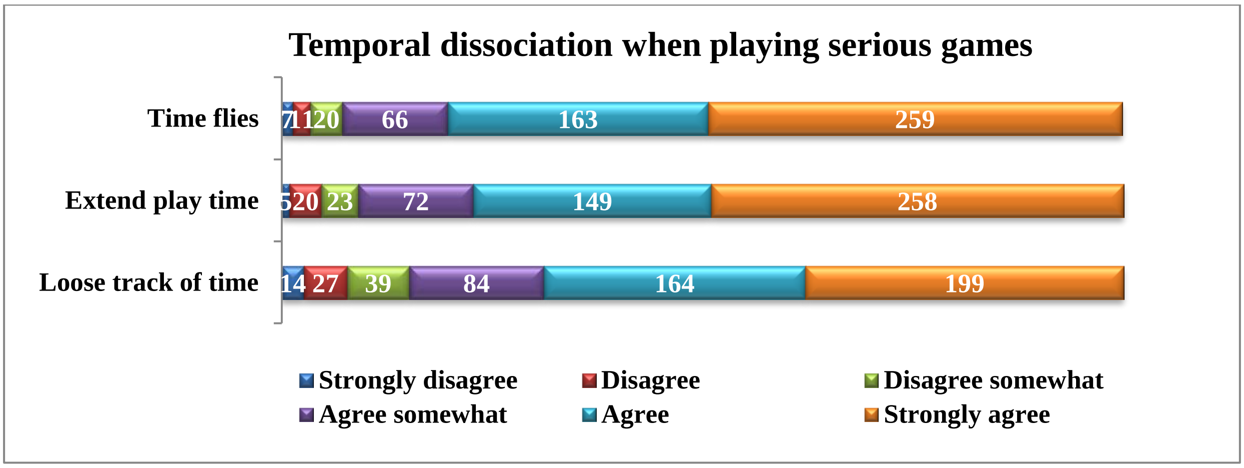


Figure 4.8: Construct 8: Self-efficacy - Frequencies and distribution of data

In terms of self-efficacy, the distribution of data as indicated in the histogram in Figure 4.8 is slightly skewed to the left, with data centred around 4.5 and tapering down to two at the low end and six at the high end of the scale.

Fun and entertainment are intrinsic motivations for users to become totally absorbed in the use of technology (Lu *et al.*, 2008:30). Intrinsic motivation has been realised and investigated over the past decade as an important factor which influences users' attitude towards an activity and drives towards achievement of a set goal (Agarwal & Karahanna, 2000). Temporal dissociation is a characteristic of the flow experience leading to intrinsic motivation. Participants who had played serious games before were asked to respond to the questions contained in Construct 9, 10 and 11. As revealed in Figure 4.9

the majority of participants agree that three prominent characteristics of a flow experience are part of a serious game play activity and will be part of the serious gameplay experience in the computer science class.



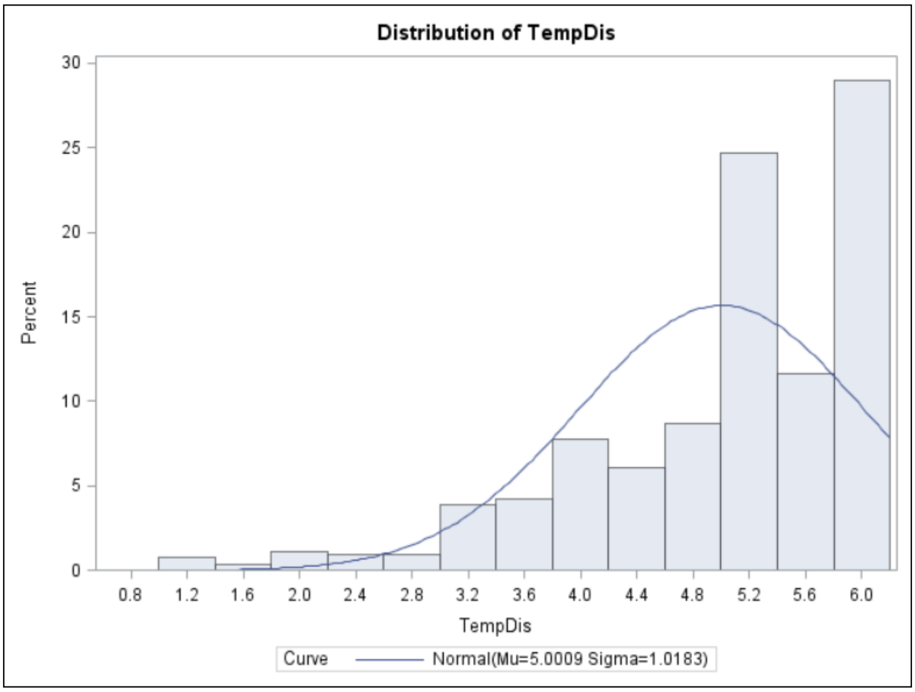
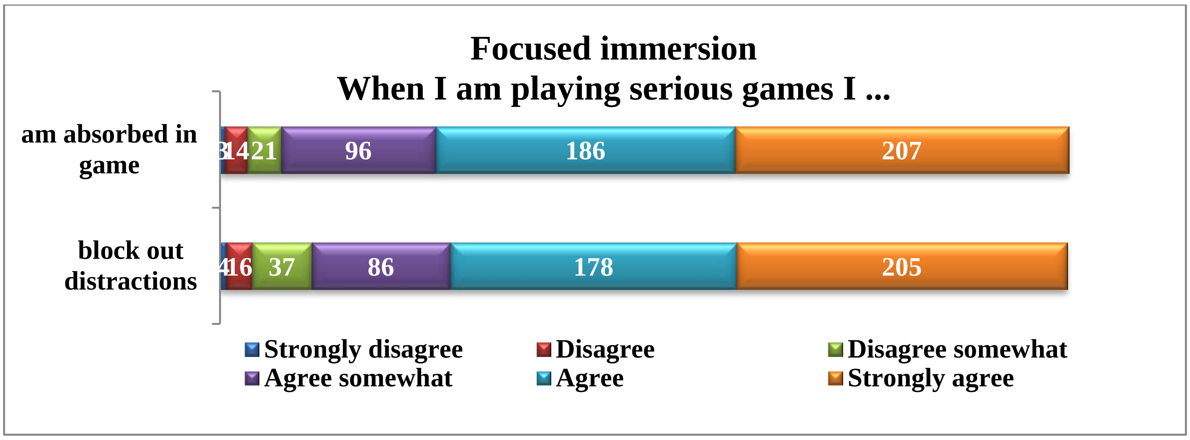


Figure 4.9: Construct 9: Temporal dissociation - Frequencies and distribution of data

The distribution of data for temporal dissociation revealed in Figure 4.9 is skewed to the left with data centred around five to six. The data distribution tapers down to two at the low end and six at the high end of the scale.

To be totally focussed on the task at hand is another factor that influences people's behaviour and attitude, which involves their level of intrinsic and extrinsic motivation (Nag *et al.*, 2013:149). Participants who had played serious games before were asked to respond to the questions contained in Construct 10. Figure 4.10 shows that participants agree to the fact that playing games causes them to experience focussed immersion.



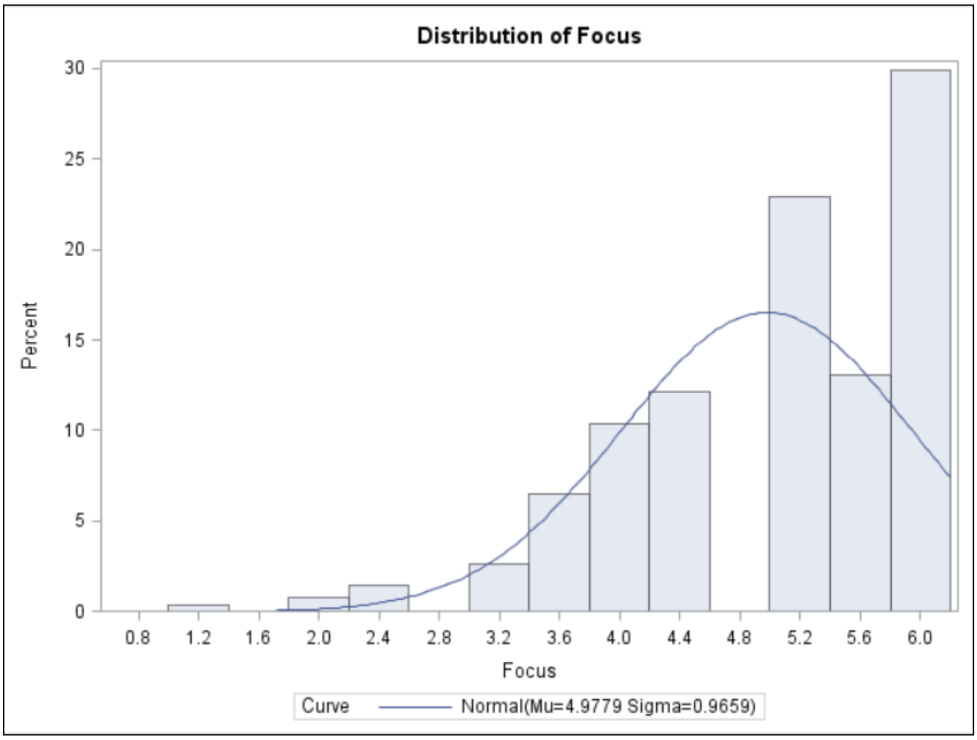
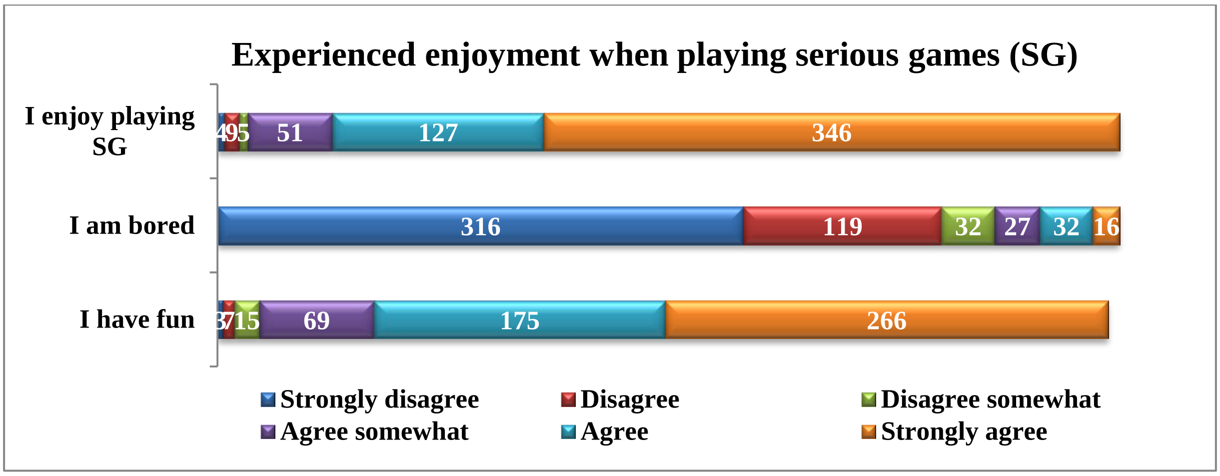


Figure 4.10: Construct 10: Focussed immersion - Frequencies and distribution of data

In terms of focussed immersion, the distribution of data as indicated in the histogram of Figure 4.10 is slightly skewed to the left, with data centred around five to six, while tapering down to two at the low end and six at the high end of the scale.

Participants who had played serious games before were asked to respond to the questions contained in Construct 11. The data from Figure 4.11 confirm that participants enjoy and have fun when playing serious games. The number of students who agree that they are bored when playing serious games are in the minority, which confirms that most students enjoy and have fun when they play serious games.



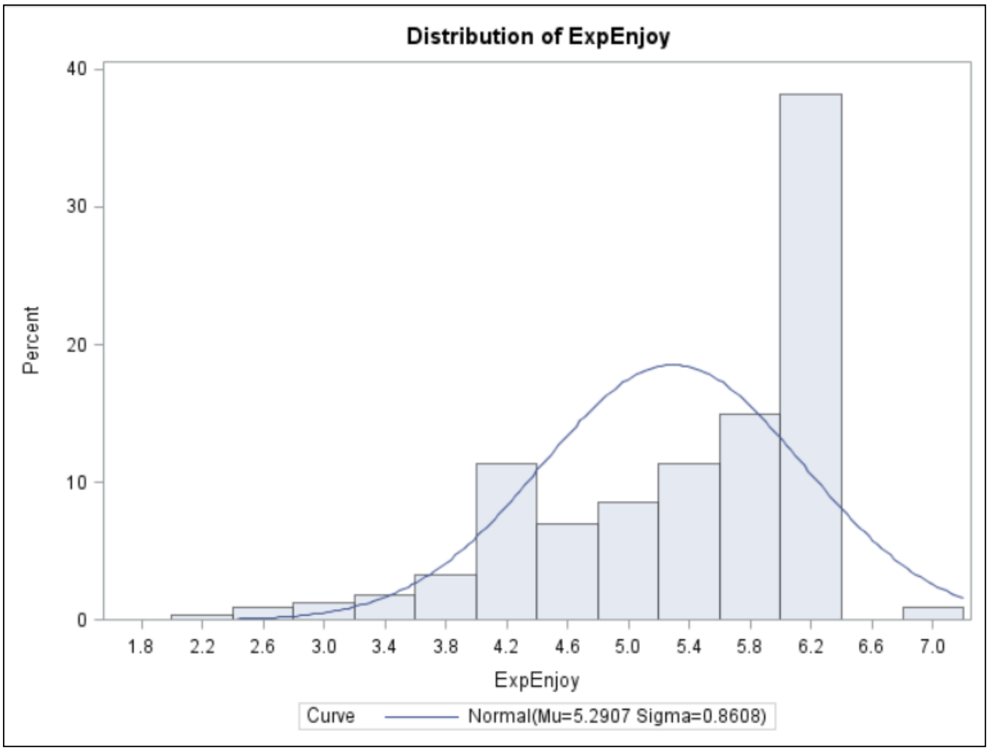


Figure 4.11: Construct 11: Experienced enjoyment - Frequencies and distribution of data

The distribution of data, which indicates experience enjoyment as revealed in the histogram in Figure 4.11, is slightly skewed to the left with data centred around 4.5, and tapers down to 2.5 at the low end and seven at the high end of the scale.

The descriptive statistics of the collected data for this study show a positive attitude towards playing of serious games in the computer science class. The following section, Section 4.5, reports on the dependencies of internal technology acceptance factors on internal and external technology acceptance factors and suggests a model that reflects these dependencies based on the attitude and perceptions of the target group studied.

4.5 MODELLING FACTORS

In the previous section, the descriptive statistics were discussed in order to determine whether the data were distributed normally. A discussion relating to the reliability and validity analysis, including participants' attitude towards the internal and external technology acceptance factors related to this study was also included. This section relates to correlation between the identified technology acceptance factors and dependencies of these factors. The correlations and dependencies will be discussed and projected onto a suggested technology acceptance model for the use of serious games in a computer science class for undergraduates at tertiary institutions.

4.5.1 Correlations

Correlation analysis of associated variables results in a numerical value referred to as a correlation coefficient, which describes the strength and direction of relationships amongst variables (Gray, 2013:485). The correlations between the variables tested in this study were generated using the SPSS software package.

Pearson's correlation is a suitable statistical test for measuring relationships between variables where data were obtained from scale figures (Gray, 2013:488), as was the case in this study.

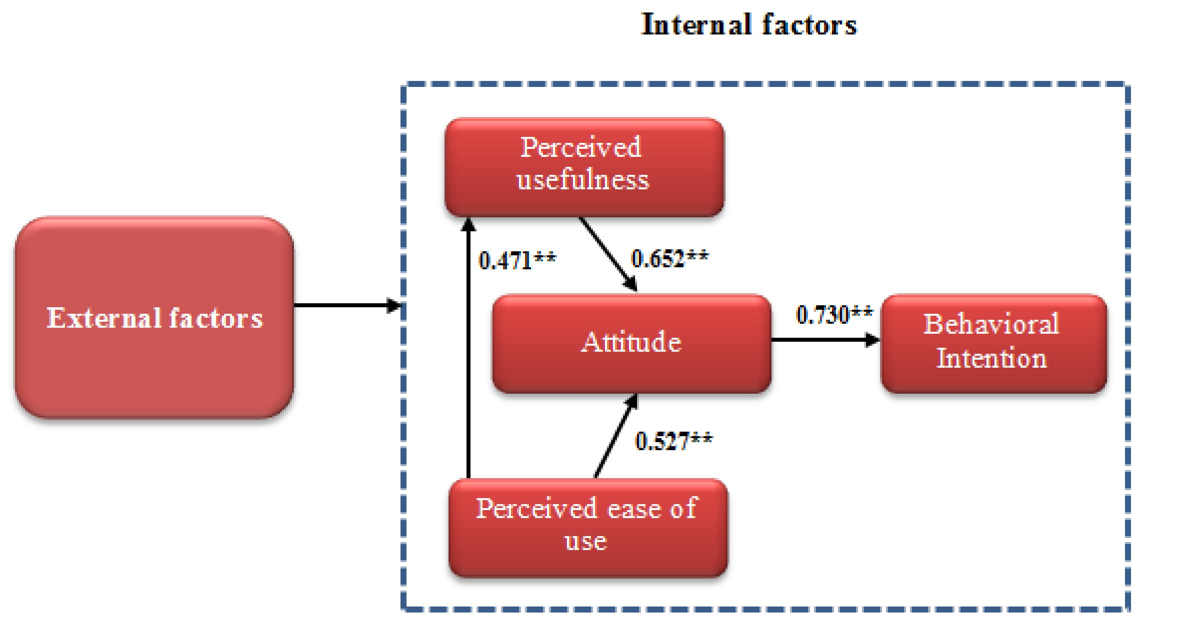
The results of the correlation analysis, as shown in Table 4.21 and Table 4.22, indicate that all the variables (constructs) correlate at a significance level of 0.01 ($p < 0.01$) (2-tailed).

Table 4.21: Correlation table for the internal technology acceptance variables (2-tailed)

		A	BI	PU	PEOU
A	**Pearson Correlation**	1			
BI	**Pearson Correlation**	0.730**	1		
PU	**Pearson Correlation**	0.652**	0.716**	1	
PEOU	**Pearson Correlation**	0.527**	0.475**	0.471**	1

**Correlation is significant at the level 0.01

Table 4.21 shows correlation figures between the internal technology acceptance variables. The correlation between BI and A is strong, with a value of 0.730, while the correlation between PEOU and PU is the weakest (0.471). This confirms the fact that students who have a positive attitude towards using serious games in class intend to use these games if they are available. The perceived usefulness of serious games in class correlates strongly with attitude (0.652) and the intention to use (0.716), while perceived ease of use correlates less with attitude (0.527) and the intention to use serious games in class with a value of 0.475.



**Correlation is significant at the level 0.01

Figure 4.12: Correlation between the internal technology acceptance factors for using serious games in the computer science class

In this study, the correlation between the external and internal technology acceptance variables is of particular interest. Table 4.22 shows the correlation between external technology acceptance variables and PU as internal technology acceptance variable.

Table 4.22: Correlation table for the external technology acceptance variables and PU (2-tailed)

External technology acceptance factor		PU
SN	**Pearson correlation**	0.538**
R	**Pearson correlation**	0.713**
Enjoy	**Pearson correlation**	0.474**
SE	**Pearson correlation**	0.275**
TD	**Pearson correlation**	0.236**
FI	**Pearson correlation**	0.382**
ExpEnjoy	**Pearson correlation**	0.354**
**Correlation is significant at the level 0.01		

Figures contained in Table 4.22 indicate that the external factors of relevance (R) and subjective norms (SN) strongly correlate with PU, with values of 0.713 and 0.538 respectively. A weak correlation is evident between self-efficacy (SE) and PU (0.275), and temporal dissociation (TD) and PU (0.243). These correlation figures are shown in Figure 4.13.

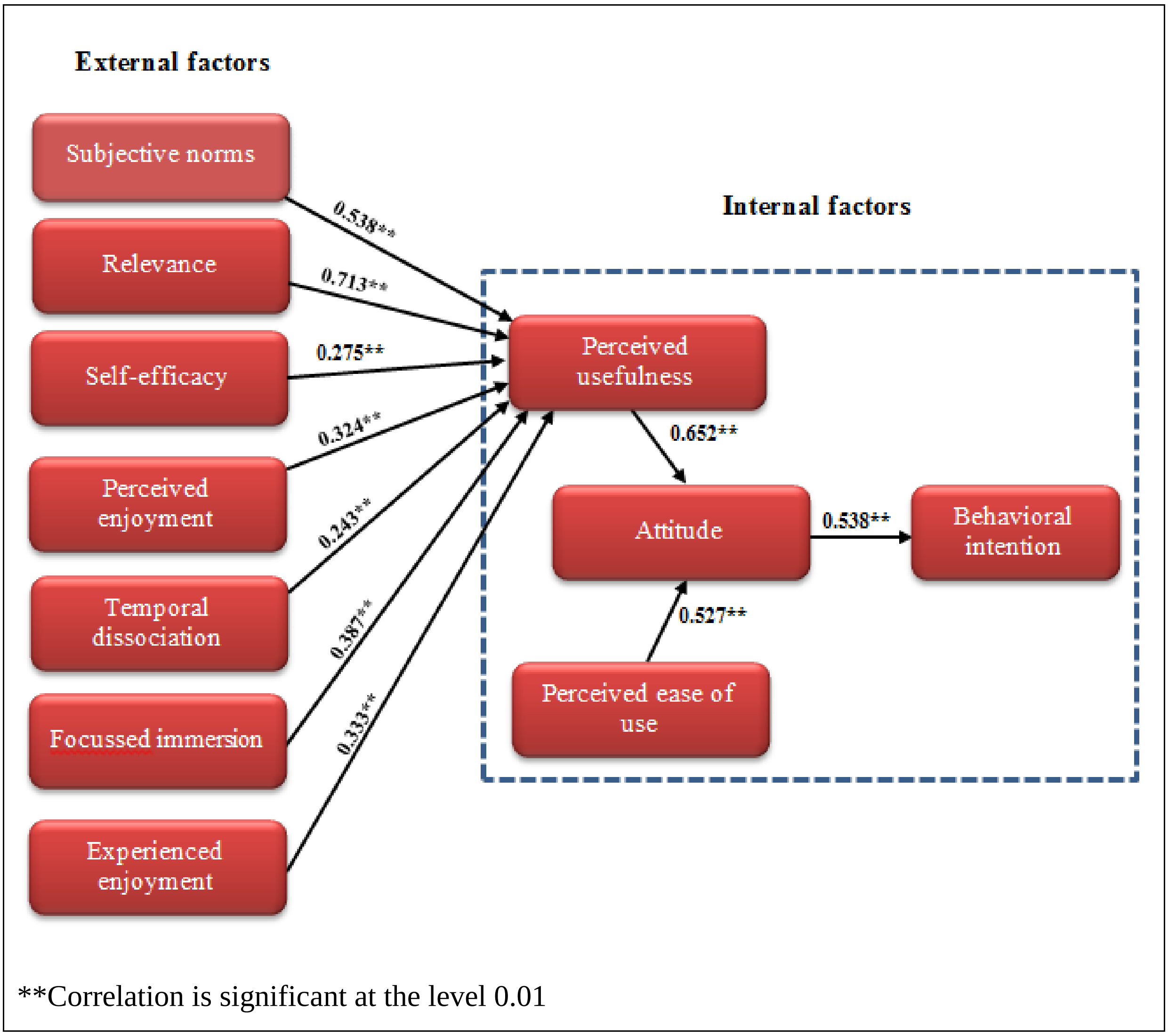


Figure 4.13: Correlation relations between PU and the external technology acceptance variables

Table 4.23 shows correlation figures between PEOU and the seven external technology acceptance variables. The strongest correlation proves to be between PEOU and relevance (R) and perceived enjoyment (Enjoy) both with the value of 0.449. Self-efficacy (SE) relates the weakest with PEOU with a value of 0.112, while the factors SN, TD and FI correlate with PEOU with values in the range of 0.283 to 0.365.

Table 4.23: Correlation table for the external technology acceptance variables and PEOU (2-tailed)

External technology acceptance factors		**PEOU**
SN	**Pearson's correlation**	0.283**
R	**Pearson's correlation**	0.449**
Enjoy	**Pearson's correlation**	0.449**
SE	**Pearson's correlation**	0.112**
TD	**Pearson's correlation**	0.343**
FI	**Pearson's correlation**	0.365**
ExpEnjoy	**Pearson's correlation**	0.447**
**Correlation is significant at the level 0.01		

Correlations between PEOU and the external technology acceptance factors are shown in Figure 4.14 with beta weight values ranging from 0.112 (weakest correlation) to 0.449 (strongest correlation).

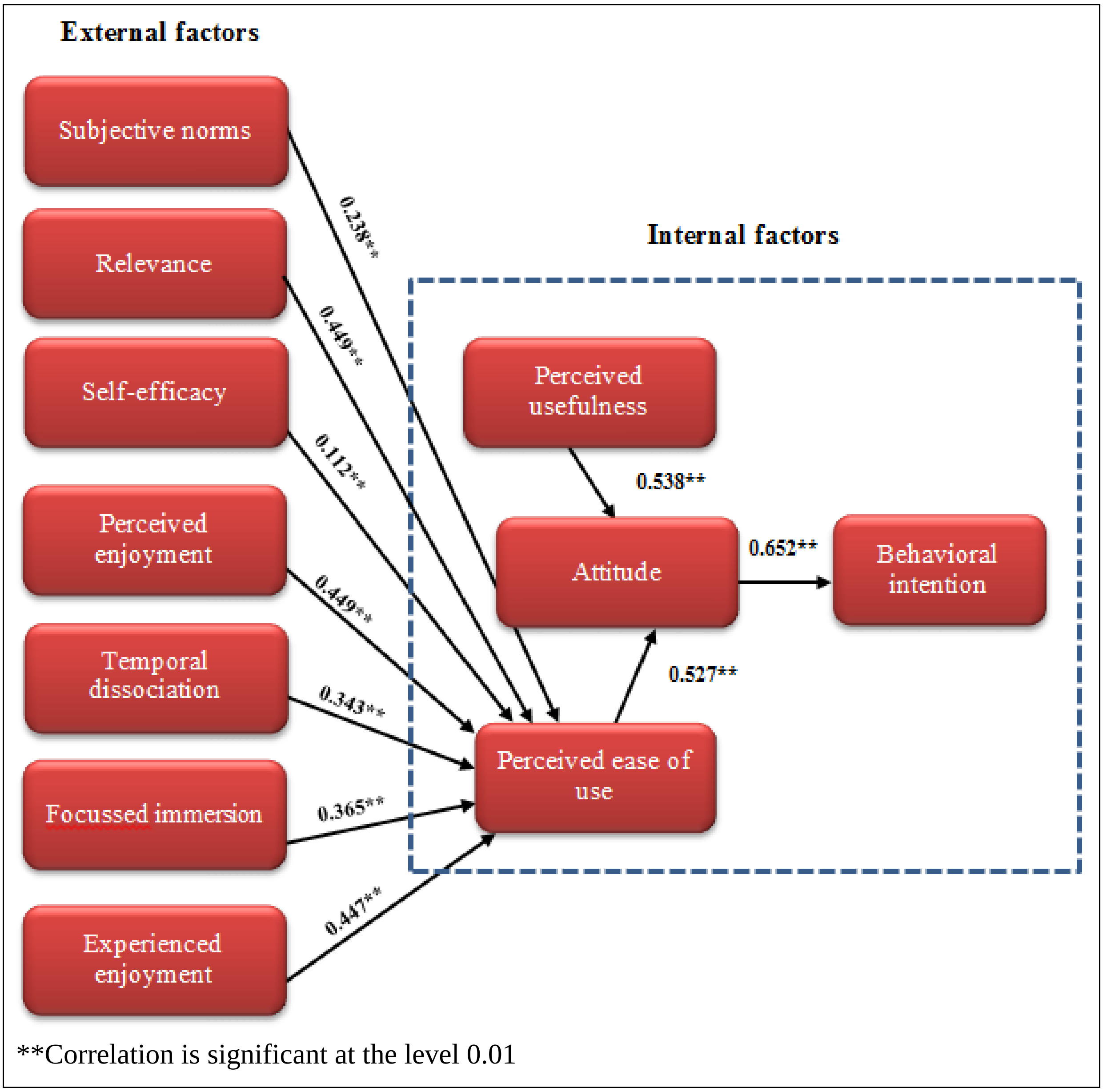


Figure 4.14: Correlations between perceived ease of use (PEOU) and the seven external technology acceptance variables

The external factor relation (R) correlates the strongest with both PU and PEOU. Self-efficacy is amongst the external factors that correlate the weakest with both PU (second weakest) and PEOU (weakest).

The result of the regression analysis of the study is discussed in the next section.

4.5.2 Regression analysis

Regression analysis entails statistics that are used to describe the linear relationship between a quantitative response variable and one or more explanatory variables (Heckard & Utts, 2012:74). Results of regression analysis can also be used to estimate the value of a response variable at any specific value of an explanatory variable. In addition, the value of a response variable can be predicted based on the known value of an explanatory variable (Swanepoel *et al.*, 2011:115). The response variable often is referred to as the dependent variable and the explanatory variables as predictors. For this study, regression analysis was done on dependency relationships between the internal technology acceptance variables, and thereafter between the internal and external technology acceptance variables.

4.5.2.1 Dependencies between internal technology acceptance variables

Davis *et al.* (1989:985) state that the attitude of a potential user towards the actual use of technology is influenced by the user's perceived usefulness (PU) and ease of use (PEOU) of the technology, while the user's PU and PEOU are influenced by external technology acceptance variables. The dependency relationships between the internal variables that were identified and validated by Davis (1986) were tested and analysed using the quantitative data of this study.

The dependent relationships in the proposed technology acceptance model for this study presents the internal variables used in the validated TAM. According to Davis (1989) PU is a dependent variable and influenced by PEOU. The variables PU and PEOU are both predictors of attitude (A), while attitude (A) predicts actual use (BI) of the technology.

Data contained in Table 2.24, 2.25 and 2.26 show the results of regression analysis that was conducted on the dependency relationships between the independent variables (predictors) PU and PEOU and the dependent variable attitude (A), PEOU as predictor and the dependent variable PU and attitude (A) as predictor and the dependent variable BI respectively. Data in these tables include the R^2, the p-value and the beta value of these dependency relationships. The R^2 –value, known as the coefficient of determination, indicates how well the observed data and the least squares curve fits (Swanepoel *et al*., 2011:119). A R^2 value of one implies a perfect fit while a R^2 value of zero indicates that the least squares curve does not fit the observed data (Swanepoel *et al*., 2011:115). The p-value indicates the significance of each relationship (Heckard & Utts, 2012:457). A smaller p-value provides strong evidence to accept a result. A p-value of 0.05 is statistically significant. If the p-value is between 0.05 and 0.01, the result is regarded as marginally significant, while a p-value of less than 0.01 indicates that a result is highly significant.

Multiple regression models were compiled to model the internal variables using ANOVA and SAS (confirmatory). The model contained in Table 2.4 explains 48.8 per cent (see adjusted

R-squared) of the variance in the dependent relationship between attitude (A) and PU and PEOU as independent variables. The dependency relationships between the internal variables used in this study add high significance to predictions, $p < 0.01$.

Table 4.24: Regression analysis of PU and PEOU as predictors of attitude in the proposed TAM for serious games in the computer science class

Model		Unstandardised coefficients		Standardised coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.643	.207		3.101	.002
	PU	.505	.034	.519	14.928	.000
	PEOU	.347	.043	.282	8.119	.000
R = .698, Adjusted R-Squared = .488 (48.8%), Std. Error of the Estimate = .69453, *p* = .000						

Data in Table 4.24 reveal that the attitude (A) of the respondents towards the use of serious games in the computer science class is more dependent on perceived usefulness with a beta value of 0.652 than perceived ease of use (0.527). The relationship between attitude and the predictors PU and PEOU is formulated in the following regression equation:

$$\hat{y}(A) = 0.643(\text{intercept}) + 0.519(PU) + 0.282(PEOU)$$

Table 2.25 shows the dependencies of PEOU as a predictor of PU as the dependent variable. The predictor PEOU adds statistically high significance to the prediction, $p < 0.01$.

Table 4.25: Regression analysis of PEOU as a predictor of PU in the proposed TAM for serious games in the computer science class

Model		Unstandardised coefficients		Standardised coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.848	.251		7.376	.000
	PEOU	.595	.048	.471	12.475	.000
R = .471, Adjusted R-Squared = .222 (22.1%), Std. Error of the Estimate = .87976, *p* = .000						

The model explains 22.1 per cent (see adjusted R-squared) of the variance of the relationship between PU and PEOU and can be formulated with the following regression equation:

$$\hat{y}(PU) = 1.848(intercept) + 0.471(PEOU)$$

Table 2.26 contains data, which represent the dependencies of attitude (A) as a predictor of behavioural intention (BI), the dependent variable. In this model, the predictor adds statistically high significance to the prediction, $p < 0.01$.

Table 4.26: Regression analysis of attitude (A) as a predictor of behavioural intention (BI) in the proposed TAM for serious games in the computer science class

Model		Unstandardised coefficients		Standardised coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.291	.150		8.604	.000
	Attitude	.743	.030	.730	24.909	.000
R = .730, Adjusted R-Squared = .532 (53.2%), Std. Error of the Estimate = .67517, *p* = .000						

The intention to use serious games in class depends on the attitude of the respondents with a beta weight of 0.730, while the model explains 53.2 per cent (see adjusted R-squared) of the variance in this relationship. Based on the information contained in Table 4.26, the regression equation is formulated as follows:

$$\hat{y}(BI) = 1.291(intercept) + 0.730(A)$$

The dependent relationships between the internal technology acceptance variables PU, PEOU, A and BI for the acceptance of serious games in the computer science class as indicated in Table 2.24., 2.25 and 2.26 are represented in Figure 4.15. The standardised coefficients are used in the diagram while the p-values in brackets indicate the significance of the predictor in the relationship, which is high for all the relationships, $p < 0.01$.

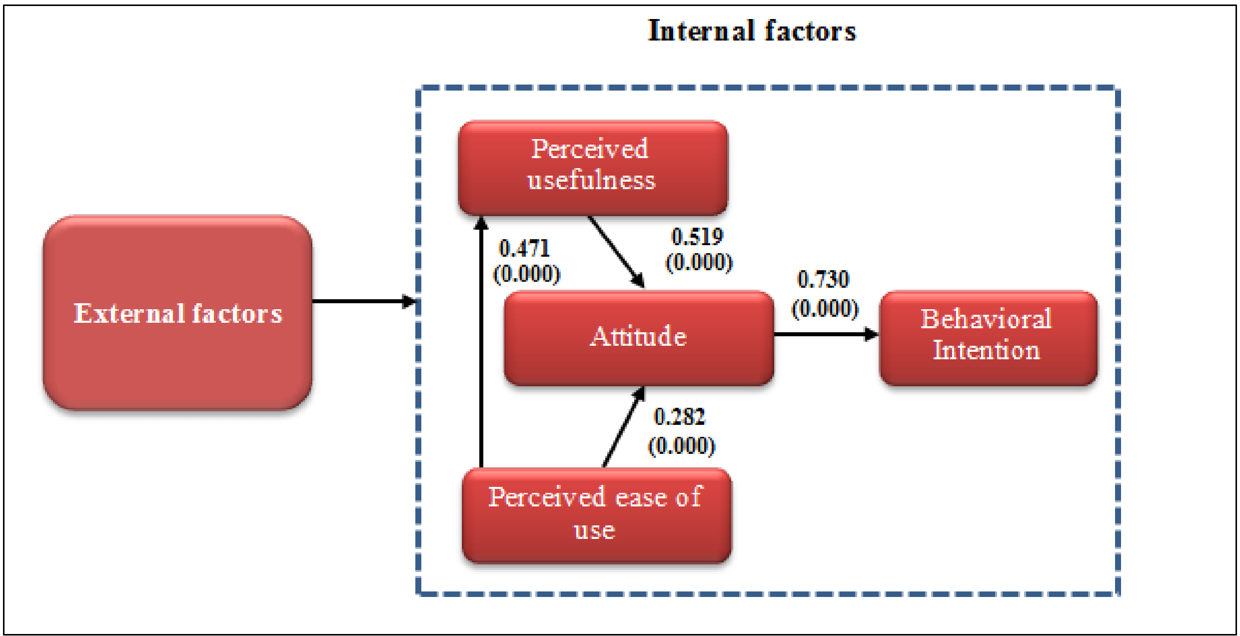


Figure 4.15: Dependencies between the internal technology acceptance factors for using serious games in the computer science class

Relationships between the internal variables as represented in Figure 4.15 are all of high significance, p < 0.010. The relationship between attitude (A) and behavioural intention (BI) shows a value of 0.730, which re-enforces the fact that attitude determines, largely, the actual behaviour of a user. Of the two variables that influence attitude (A), perceived usefulness (PU) predicts attitude to a larger extent than perceived ease of use (PEOU) in this model. The fact that ease of use does not measure as a high predictor of attitude correlates with the fact that young people are comfortable with technology as revealed in the literature (Heersink & Moskal, 2010:446). Technology in many forms, which include games, is part of the world the youth live in from an early age (Gros, 2007:23; Kaiser & Wisniewski, 2012:137; Yusoff, 2010:10).

4.5.2.2 Dependencies between internal and external variables

As revealed in the literature pertaining the original TAM compiled by Davis (1986) (Figure 3.6) and the extended TAM compiled by Venkatesh and Davis (2000) (Figure 3.7), external variables has an influence on the internal variables, which in turn affect a user's attitude towards the use of technology. In this study, seven external factors (variables) have been identified as eminent to retain interest in computer science as a field of study and improve results and throughput rates in computer science courses. These factors (SN, R, SE, Enjoy, TD, FI and ExpEnjoy) are relevant to a serious game play scenario and related to requirements within the field of computer science, users' acceptance of technology, as discussed in paragraph 3.7.2.

Data contained in Table 4.27 reveal results pertaining to a linear regression analysis between the individual external (independent) variables and dependent variable PU and PEOU. All the relationships are highly significant with a p-value of 0.000. The beta value (β) represents the standardised coefficient for the relationship, which indicates the power of the relationship in a regression model.

Table 4.27: Relationships between independent (external) and dependent (internal) variables

Independent variables	**Dependent variables**					
	PU			**PEOU**		
	R^2	**P**	β	**R^2**	**p**	β
SN	0.289	0.000[a]	0.538	0.080	0.000[a]	0.283
R	0.509	0.000[a]	0.713	0.201	0.000[a]	0.449
SE	0.076	0.000[a]	0.275	0.013	0.000[a]	0.112
Enjoy	0.105	0.000[a]	0.324	0.145	0.000[a]	0.381
TD	0.059	0.000[a]	0.243	0.121	0.000[a]	0.347
FI	0.150	0.000[a]	0.387	0.137	0.000[a]	0.370
ExpEnjoy	0.111	0.000[a]	0.333	0.129	0.000[a]	0.359
a. p-value of the predicator (independent variable)						

The beta value (β) of 0.713 that describes the regression between relevance (R) and PU indicates that the relationship relevance (R) is a strong predictor of PU. Subjective norms relate strongly with PU as well with a beta value (β) of 0.538, followed by focussed immersion (0.387). PU is the least predicted by perceived enjoyment with a beta value (β) of 0.105. The strongest predictor of ease of use (PEOU) is relevance (R) while the weakest predictor is self-efficacy (SE) with a beta value of 0.112.

Multiple regression models were compiled to model the external factors in relation to the internal variables using ANOVA and SAS (confirmatory). In multiple regression analysis, more than one predictor variable is used to predict the value of a response variable (Heckard & Utts, 2012:554).

4.5.3 Modelling predictors of PU

Table 4.28 contains four models for predicting PU as the dependent or response variable and external variables. The model incorporating R, SN, Enjoy and FI as predictors, where these predictors all added moderate significance to the prediction ($p < 0.05$), is calculated as the best model for predicting PU as indicated in Table 4.28.

Table 4.28: Multiple regression analysis of external variables and independent and PU as dependent variable

Model		Unstandardised coefficients		Standardised coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.091	.166		6.591	.000
	R	.749	.032	.713	23.599	.000
R = .713, Adjusted R-Squared = .508 (50.8%), Std. Error of the Estimate = .70154, *p* = .000						
2	(Constant)	.668	.161		4.135	.000
	R	.620	.033	.590	18.840	.000
	SN	.252	.028	.282	9.013	.000
R = .756, Adjusted R-Squared = .572 (57.2%), Std. Error of the Estimate = .65460, *p* = .000						
3	(Constant)	.249	.174		1.434	.152
	R	.535	.035	.509	15.131	.000
	SN	.248	.027	.277	8.977	.000
	Enjoy	.176	.031	.175	9.091	.000
R = .772, Adjusted R-Squared = .596 (59.6%), Std. Error of the Estimate = .63672, *p* = .000						
4	(Constant)	.055	.189		.290	.722
	R	.520	.036	.494	14.554	.000
	SN	.236	.027	.264	8.607	.000
	Enjoy	.161	.032	.160	5.080	.000
	FI	.080	.031	.077	2.572	.010
R = .775, Adjusted R-Squared = .601 (60.1%), Std. Error of the Estimate = .63342, *p* = .000						

None of the remaining variables (SE, TD and ExpEnjoy) met the 0.0500 significance level for entry into the model. Therefore, model 4 in Table 4.28 is the best-suggested model for predicting PU. Model 4 explains 60.1 per cent of the variance in the observed data for the relationship. The regression equation for the relationship between PU and relevance (R), subjective norms (SN), perceived enjoyment (Enjoy) and focussed immersion (FI) as predictors:

$$\hat{y}(PU) = 0.055(intercept) + 0.520(R) + 0.236(SN) + 0.161(Enjoy) + 0.080(FI)$$

The residue of a model refers to the deviation of a predicted value for a y variable and the actual (or typical) value of the y variable (Heckard & Utts, 2012:79). The residual values of the relationship between PU and the four external variables (R, SN, Enjoy and FI) in the best suggested model is distributed normally within the acceptable range of -2 and +2 as indicated in Figure 4.16(a). The residual scatterplot in Figure 4.16(b) shows that the bulk of the residual values are distributed around the regression line with some deviation around the bottom end and the top end of the regression line. Therefore, it can be said that no patterns are left in the data with regard to R, SN, Enjoy and FI that are not adequately described by this model. Thus, valid assumptions can be made from the model regarding PU and external factors within the population (Heckard & Utts, 2012:567).

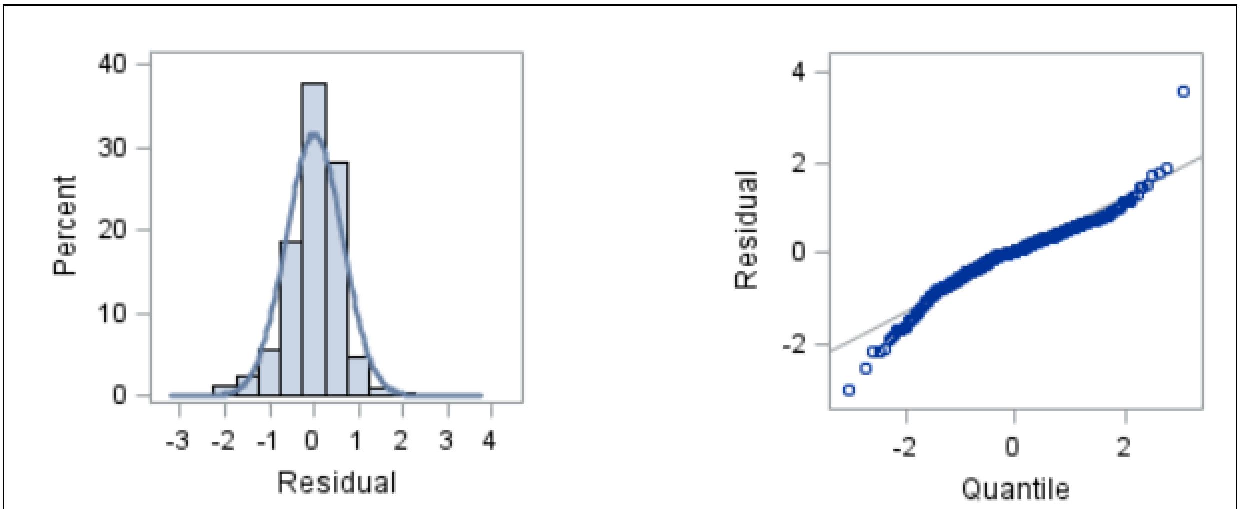


Figure 4.16(a) **Figure 4.16(b)**

Figure 4.16: The distribution of the residuals for the multiple regression of external variables and PU

A few outliers manifested at the low and high end of the residual plot (Figure 4.16(b)) but the sample size permits for these single outliers to be acceptable. Figure 4.17 shows residual plots of each of the four external variables in the model in relation to the dependent variable PU.

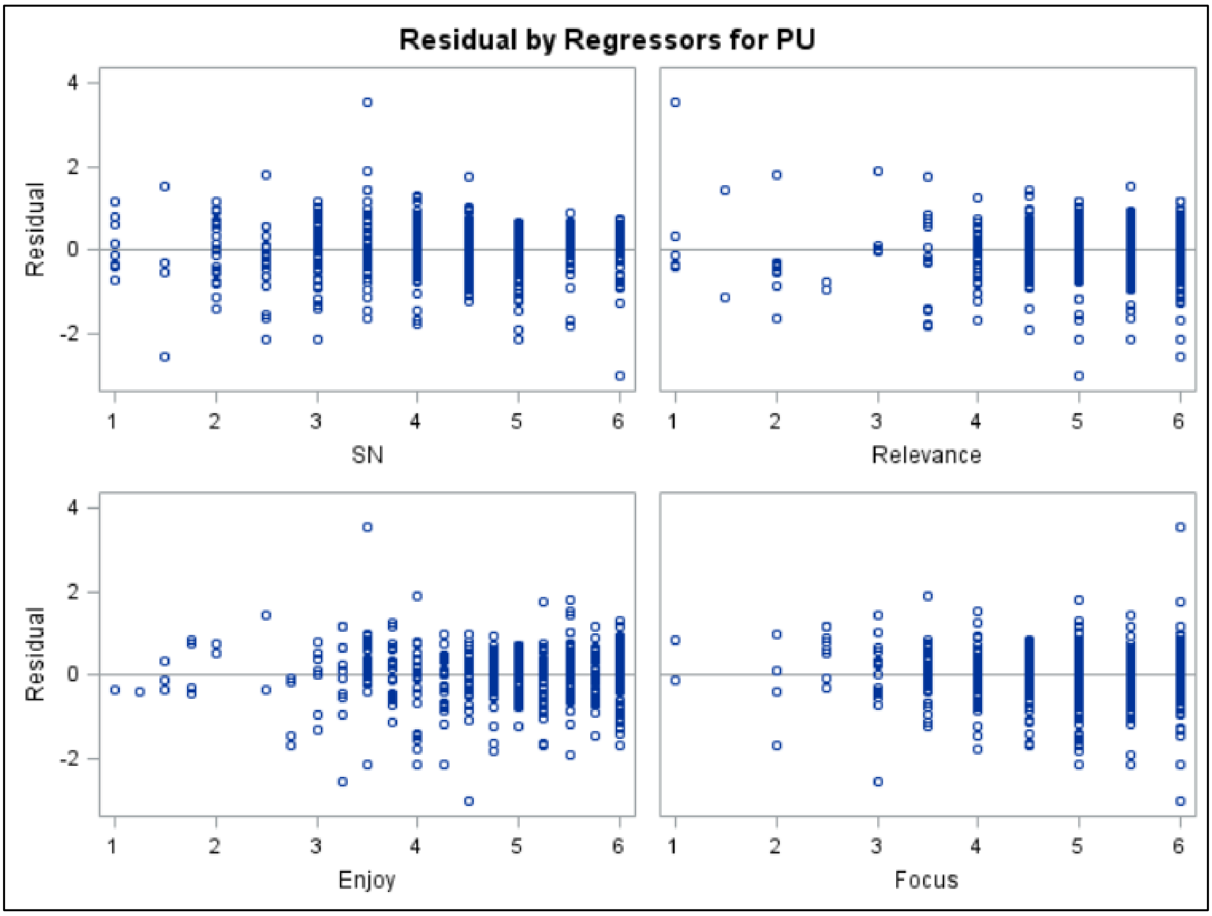


Figure 4.17: Residual plots for the four significant independent variables in relation to PU as dependent variable

The significant dependent relationships between the external technology acceptance variables (independent variables) and PU (dependent variable) are shown in Figure 4.18.

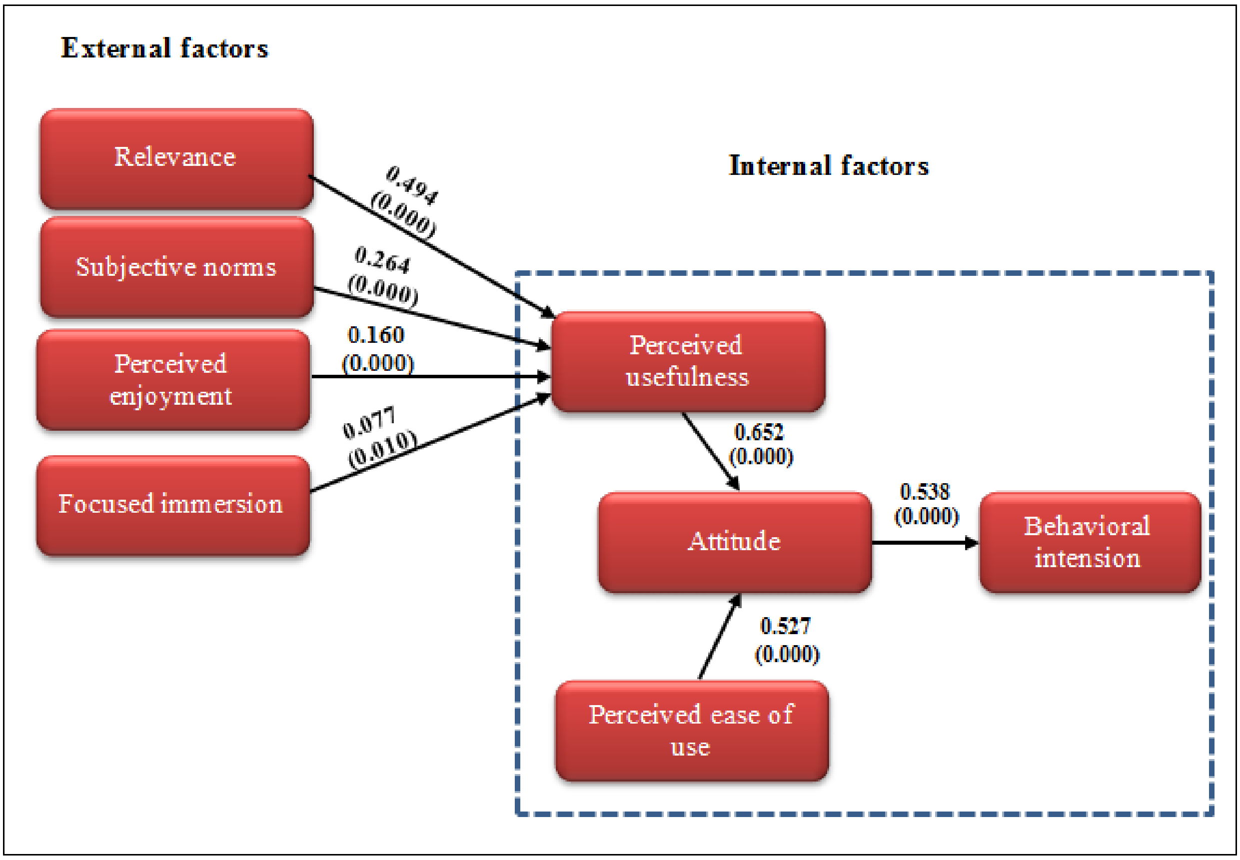


Figure 4.18: Significant relationships between external variables and PU as an internal technology acceptance variable

4.5.4 Modelling predictors of PEOU

Multiple regression analysis was applied to model the external factors in relation to PEOU. Table 4.29 contains data for models representing PEOU as the dependent variable and the most significant independent variables as predictors. These variables were identified as ExpEnjoy, R, Enjoy, TD and SN. In all five models the predictors added significance to the prediction, $p < 0.05$.

Table 4.29: Multiple regression analysis of four external technology acceptance variables on perceived ease of use (PEOU)

Model		Unstandardised coefficients B	Unstandardised coefficients Std. Error	Standardised coefficients Beta	t	Sig.
1	(Constant)	2.891	0.189		15.326	.000
	ExpEnjoy	0.437	.035	.470	12.376	.000
R = .407, Adjusted R-Squared = .220 (22.0%), Std. Error of the Estimate = .76970, *p* = .000						

Table 4.29: Multiple regression analysis of four external technology acceptance variables on perceived ease of use (PEOU) (continued...)

Model		Unstandardised coefficients B	Std. Error	Standardised coefficients Beta	t	Sig.
2	(Constant)	2.058	.201		10.220	.000
	ExpEnjoy	.329	.035	.354	9.291	.000
	R	.273	.032	.329	8.649	.000
R = .562, Adjusted R-Squared = .313 (31.3%), Std. Error of the Estimate = .6538, *p* = .000						
3	(Constant)	1.814	.209		8.700	.000
	ExpEnjoy	.272	.038	.292	7.160	.000
	R	.265	.031	.320	8.486	.000
	TD	.177	.030	.152	3.886	.000
R = .578, Adjusted R-Squared = .331 (33.1%), Std. Error of the Estimate = .6454, *p* = .000						
4	(Constant)	1.764	.207		8.510	.000
	ExpEnjoy	.209	.042	.225	4.944	.000
	R	.227	.033	.274	6.864	.000
	TD	.116	.030	.150	3.881	.000
	Enjoy	.118	.036	.148	3.265	.001
R = .590, Adjusted R-Squared = .348 (34.8%), Std. Error of the Estimate = .6396, *p* = .000						
5	(Constant)	1.673	.210		7.965	.000
	ExpEnjoy	.209	.042	.225	4.979	.000
	R	.197	.036	.237	5.522	.000
	TD	.113	.030	.146	3.231	.000
	Enjoy	.116	.036	.146	3.231	.001
	SN	.063	.027	.089	2.305	.022
R = .595, Adjusted R-Squared = .354 (35.4%), Std. Error of the Estimate = .6371, *p* = .000						

None of the remaining independent variables (SE and FI) met the 0.0500 significance level for entry into the model. Therefore, model 5 in Table 4.29 is the best-suggested model.

Model 5 explains 35.4 per cent of the variance in the observed data for the relationship. The regression equation for the relationship between PEOU and experienced enjoyment (ExpEnjoy), relevance (R), subjective norms (SN), temporal dissociation (TD), perceived enjoyment (Enjoy) and subjective norms (SN) the predictors:

$$\hat{y}(PEOU) = 1.673(intercept) + 0.209(ExpEnjoy) + 0.197(R) + 0.113(TD) + 0.116(Enjoy) + 0.063(SN)$$

Residuals of relationship are distributed fairly normally within the acceptable range of -1.6 to +2 as indicated in Figure 4.19(a).

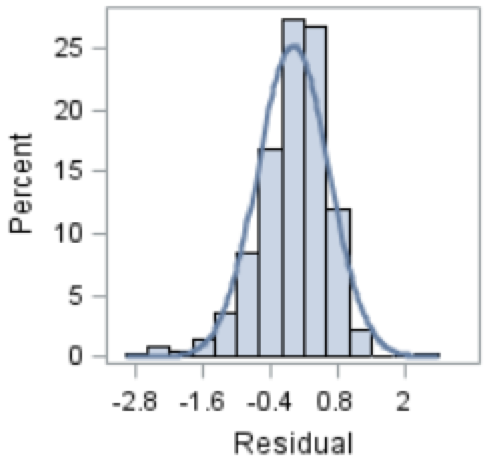


Figure 4.19(a)

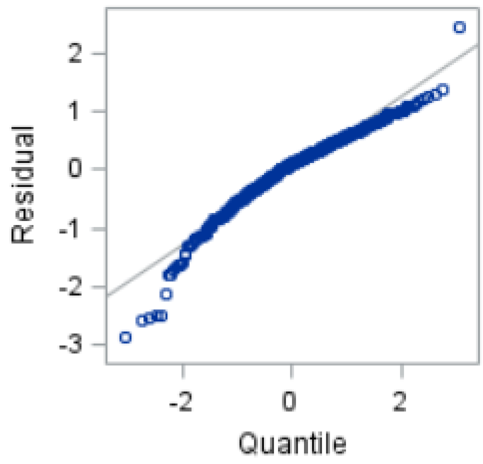


Figure 4.19(b)

Figure 4.19: The distribution of the residuals for the multiple regression of external variables as independent and PEOU as dependent variables

The residual scatterplot in Figure 4.19(b) shows that the bulk of the residual values are distributed around the regression line. The distribution confirms that there is no pattern left in the data that is not described in the model, which allows valid assumptions to be made about deviations within the population. A few outliers are observed at the low and high end of the residual plot in Figure 4.19(b) but the sample size permits for these single outliers to be acceptable. Figure 4.20 displays residual plots of each of the five independent variables in relation to PEOU.

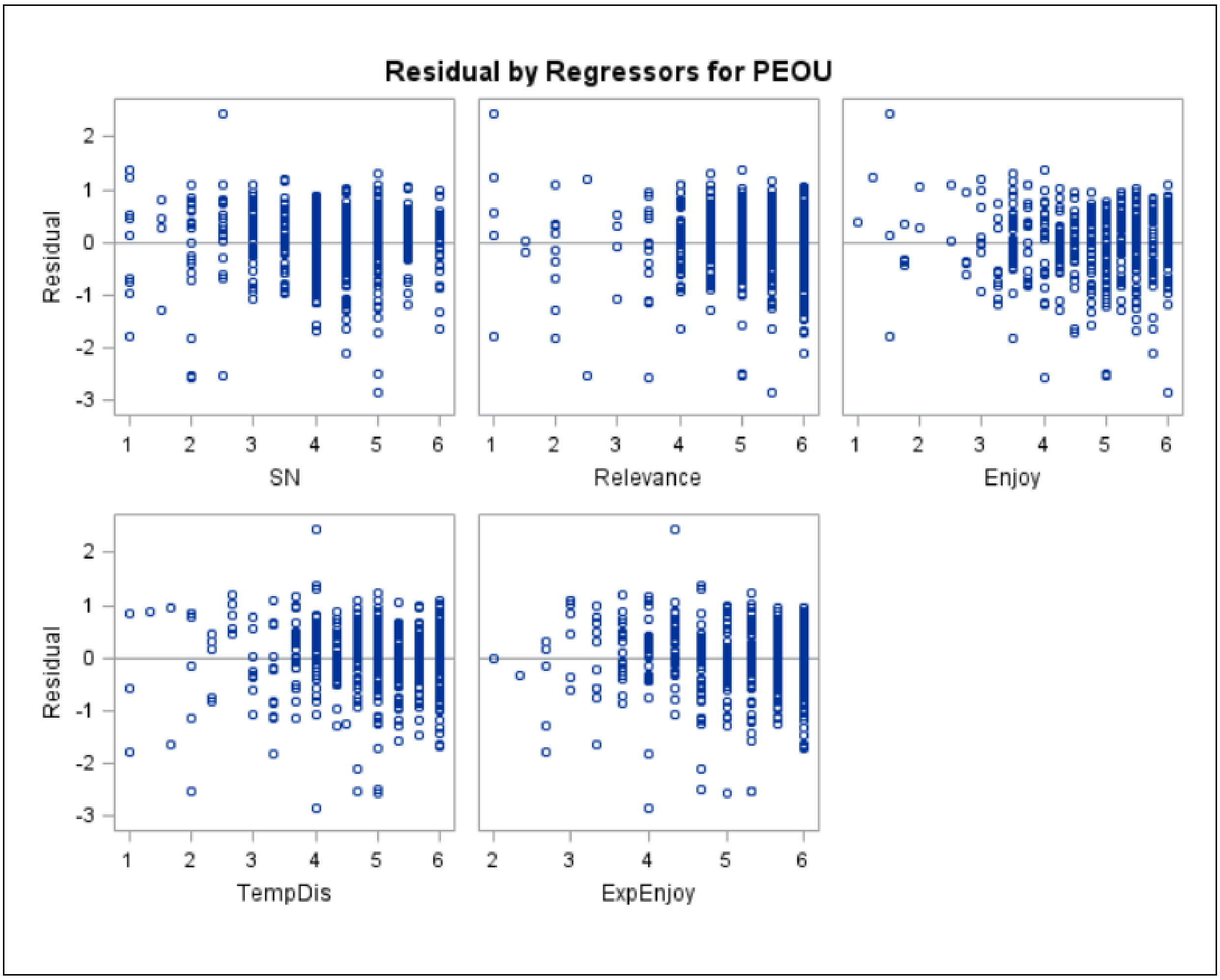


Figure 4.20: Residual plots for the five significant external variables in relation to PEOU as internal variable

The bulk of the residual values are distributed within the -2 to +2 range of the regression line with a few outliers at the low and high end of the scale.

Dependencies between the external technology acceptance factors and perceived usefulness (PEOU) are indicated in Figure 4.21.

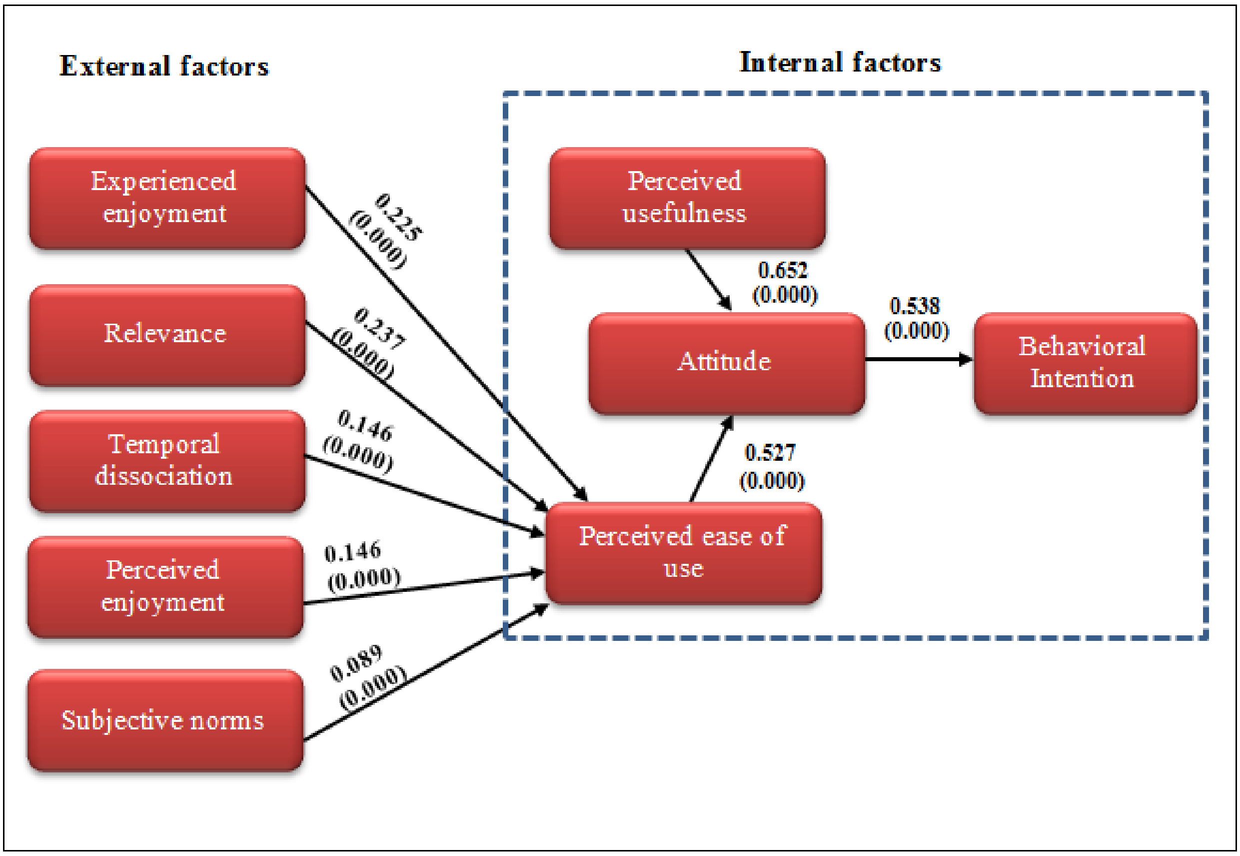


Figure 4.21: Dependencies of perceived ease of use (PEOU) as internal technology acceptance variable on external technology acceptance variable

The strongest predictor in the model presented in Figure 4.21 with a standardised coefficient (beta value) of 0.237 is relevance (R) while SN is the weakest predictor with a value of (0.089).

An analysis of the two models pertaining to predictors for PU (Figure 4.20) and PEOU (Figure 4.21) reveals that relevance (R) is eminent as the strongest predictor of both PU and PEOU, while self-efficacy (SE) is not present as a predictor in either of the two models. The fact that young people are confident in the use of technology (Heersink & Moskal, 2010:446) could be the reason for not regarding self-efficacy (SE) in the use of technology to be a significant predictor of the question of whether a specific technology should be used in class or not. Furthermore, the literature revealed that young people play digital games regularly. Being able to follow instructions, have assistance at hand, or navigate through the stages of a game, therefore, is not a deciding factor for them. The fact that enjoyment calculated as a strong indicator, whether experienced or perceived enjoyment is confirmatory to the fact that young people are familiar with games. One of the reasons why game-based learning was not embraced and incorporated to a large extent in class was the fact that enjoyment and the resulting capturing experience was lacking in serious games before. Therefore, focussed immersion (FI) came to the fore as a predictor in Figure 4.18 and temporal dissociation in Figure 4.21. Both these predictors are features of the flow experience, which is an essential part of cognitive absorption. The fact that SN (subjective norms) is regarded as a predictor in relation to PU as well as PEOU is an interesting observation. The opinion of family and friends are important to young people, specifically in terms of games being useful in class.

4.5.5 Proposed model

The original TAM use PU and PEOU as the only factors having a direct impact on attitude External factors are regarded as secondary to these internal factors in the original TAM. However, several studies revealed that external factors could have a bigger impact on attitude as a primary predictor than a secondary predictor.

To investigate the possibility of external factors in this study having a more extensive impact on attitude as a primary predictor, a multiple regression model was compiled using PU, PEOU and the seven external variables (R, SN, Enjoy, SE, TD, FI and ExpEnjoy) as independent variables and attitude (A) as the dependent variable.

Results of the regression analysis are contained in Table 4.30. In the best model (model 5) in Figure 4.30 the primary independent variables that add high significance to the prediction ($p < 0.01$) are PU, Enjoy, PEOU, SN and ExpEnjoy. Model 5 in Figure 4.30 explains 58.5 per cent of the variance in the observed data for the relationships between the independent variables PU, Enjoy, PEOU, ExpEnjoy, and SN and attitude (A) as the dependent variables. In this model, perceived enjoyment (Enjoy) is indicated as a stronger predictor of attitude than PEOU. This correlates with the fact that how easy it is to use technology is not a deciding factor for young people in the technology-oriented world in which they live. Enjoyment is a deciding factor, both perceived and experienced enjoyment. What people think (subjective norms) is still present as a factor that predicts the attitude of students on whether to accept games as technology in the computer science class.

Table 4.30: Multiple regression analysis of five technology acceptance variables on attitude (A)

Model		Unstandardised coefficients B	Unstandardised coefficients Std. Error	Standardised coefficients Beta	t	Sig.
1	(Constant)	1.799	0.159		11.315	.000
	PU	0.636	.032	.734	20.142	.000
R = .655, Adjusted R-Squared = .428 (42.8%), Std. Error of the Estimate = .76970, *p* = .000						
2	(Constant)	.822	.166		4.965	.000
	PU	.457	.032	.471	14.178	.000
	Enjoy	.375	.032	.384	11.572	.000
R = .737, Adjusted R-Squared = .541 541.1%), Std. Error of the Estimate = .6576, *p* = .000						
3	(Constant)	.204	.198		1.033	.302
	PU	.397	.033	.408	11.879	.000
	Enjoy	.265	.033	.333	9.866	.000
	PEOU	.325	.041	.183	5.423	.000
R = .753, Adjusted R-Squared = .564 (56.4%), Std. Error of the Estimate = .6409, *p* = .000						
4	(Constant)	.039	.197		.196	.845
	PU	.316	.037	.325	8.527	.000
	Enjoy	.333	.032	.341	10.275	.000
	PEOU	.215	.041	.175	5.283	.000
	SN	.133	.029	.153	4.621	.001
R = .763, Adjusted R-Squared = .580 (58.0%), Std. Error of the Estimate = .6292, *p* = .000						
5	(Constant)	-.567	.297		-1.908	.057
	PU	.306	.037	.315	8.260	.000
	Enjoy	.306	.034	.313	9.107	.000
	PEOU	.190	.042	.154	4.563	.000
	SN	.128	.029	.148	4.472	.000
	ExpEnjoy	.215	.079	.090	2.715	.007
R = .767, Adjusted R-Squared = .585 (58.5%), Std. Error of the Estimate = .6255, *p* = .000						

The residual scatterplot in Figure 4.22(b) shows that the bulk of the residual values are distributed around the regression line. The distribution confirms that the observed values do not deviate much from the predicted values. Therefore, valid assumptions can be made about deviations within the population (Heckard & Utts, 2012:567).

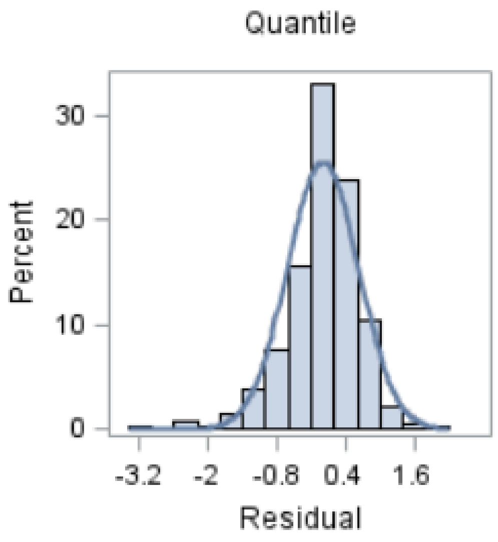


Figure 4.22(a)

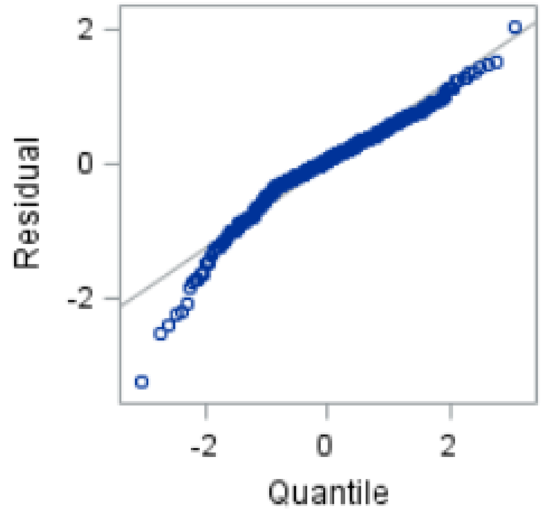


Figure 4.22(b)

Figure 4.22: The distribution of the residuals for the multiple regression of PU, PEOU and the external variables as independent and attitude as dependent variables

The residuals of relationship between attitude (A) and the five variables (PU, Enjoy, PEOU, SN and ExpEnjoy) are distributed fairly normal within the acceptable range of -2 and +1.6 as indicated in Figure 4.22(a). The residual scatterplot in Figure 4.22(b) shows that the bulk of the residual values are distributed around the regression line. The distribution confirms that the observed values do not deviate much from the predicted values. Therefore valid assumptions can be made about deviations within the population.

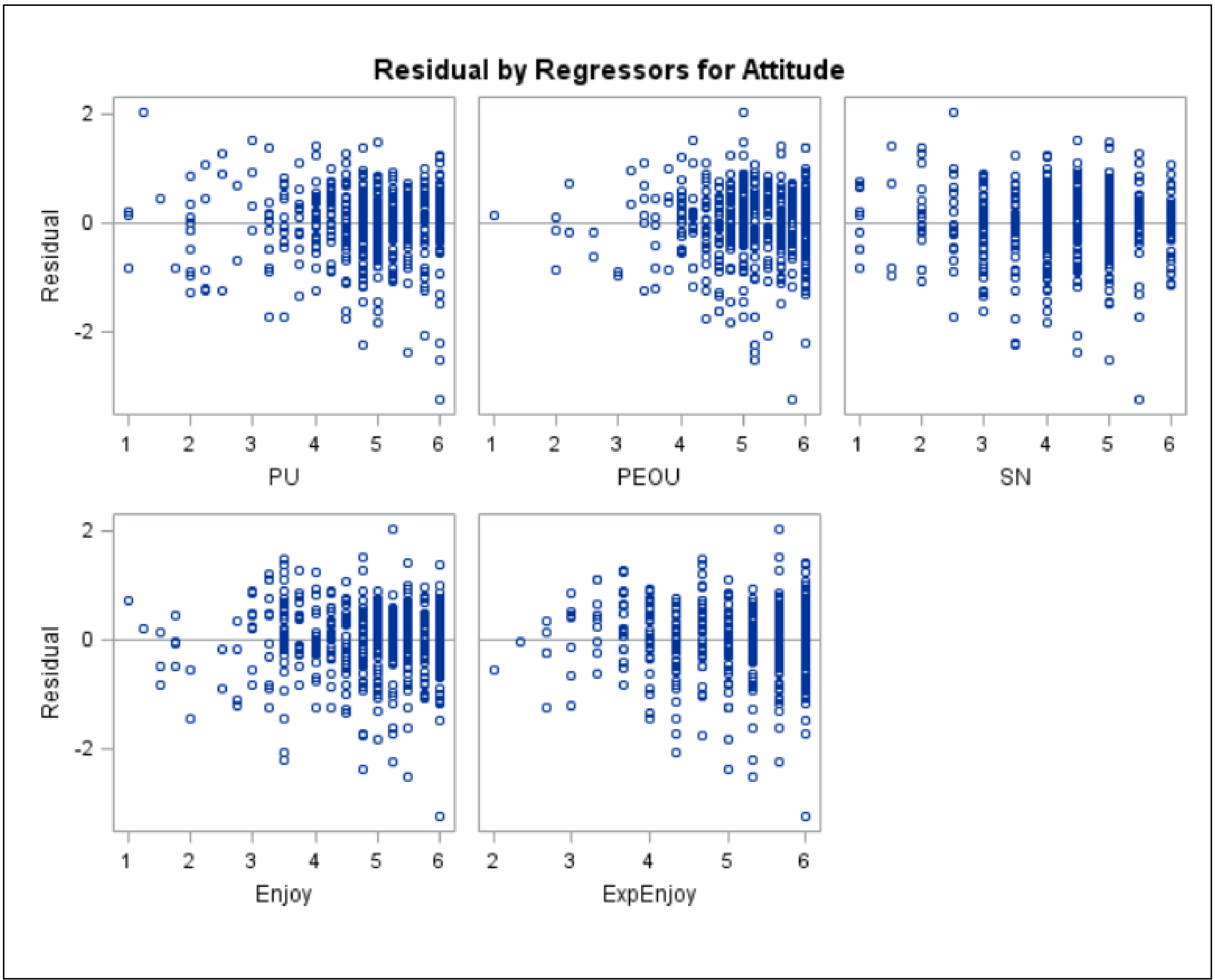


Figure 4.23: Residual plots for the five significant variables in relation to attitude (A)

A few outliers can be seen on the low and high end of the residual plot in Figure 4.23(b) but the sample size permits for these single outliers to be acceptable. Figure 4.24 shows residual plots of each of the five individual variables in the model in relation to attitude (A).

Scatterplots of the relationship between attitude (A) and predicted attitude are shown in Figure 4.24. Figure 4.24(a) displays the distribution of data when PU and PEOU are predictors of attitude, while Figure 4.24(b) shows the distribution of data when PU, PEOU and the three external variables (identified in Table 4.30) are included as significant predictors of attitude.

Attitude in relation to predicted attitude

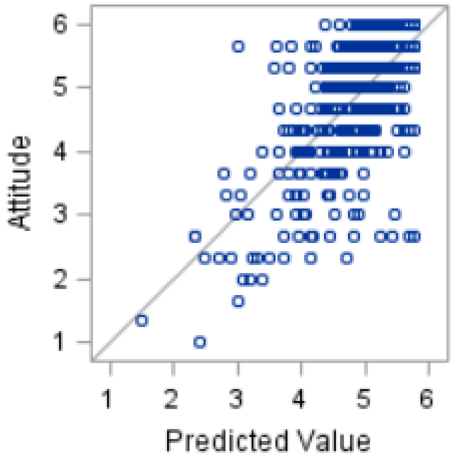


Figure 4.24(a): PU and PEOU as predictors of attitude

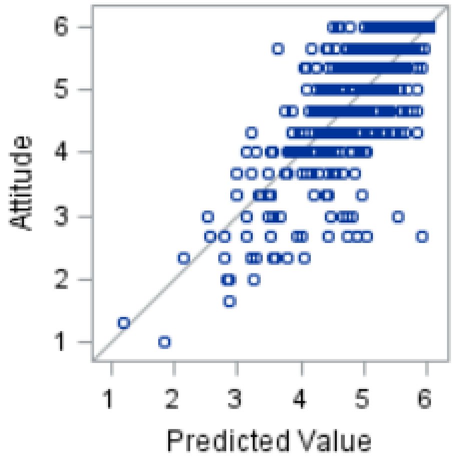


Figure 4.24(b): PU, Enjoy, PEOU, ExpEnjoy and SN as predictors of attitude

Figure 4.24: Scatterplot of relationship between attitude and predicted attitude

The scatterplot in Figure 4.24(b) shows that even though the items are position towards the higher range of the scale, the distribution is more towards the 45 degree line than distribution reflected in Figure 4.24(a)

Results that were obtained from the regression analysis, which include PU, PEOU and external variables as predictors of attitude as indicated in Table 4.30 reveal that model 5 explains 58.5 per cent of the variance in the observed data compared to the 48.5 per cent of the model where only PU and PEOU are used as predictors of attitude (Table 4.24). Furthermore, a comparison of the scatterplots related to the information in Table 4.24 and Table 4.30, respectively, as shown in Figure 4.24, show an improved distribution of data with the inclusion of external variables as predictors of attitude. As a result, the model shown in Figure 4.25 was constructed.

For the sake of clarity and readability, the data contained in Table 4.30 are not included in the model. Therefore the data in Table 4.30 should be read and interpreted together with the suggested model in Figure 4.25

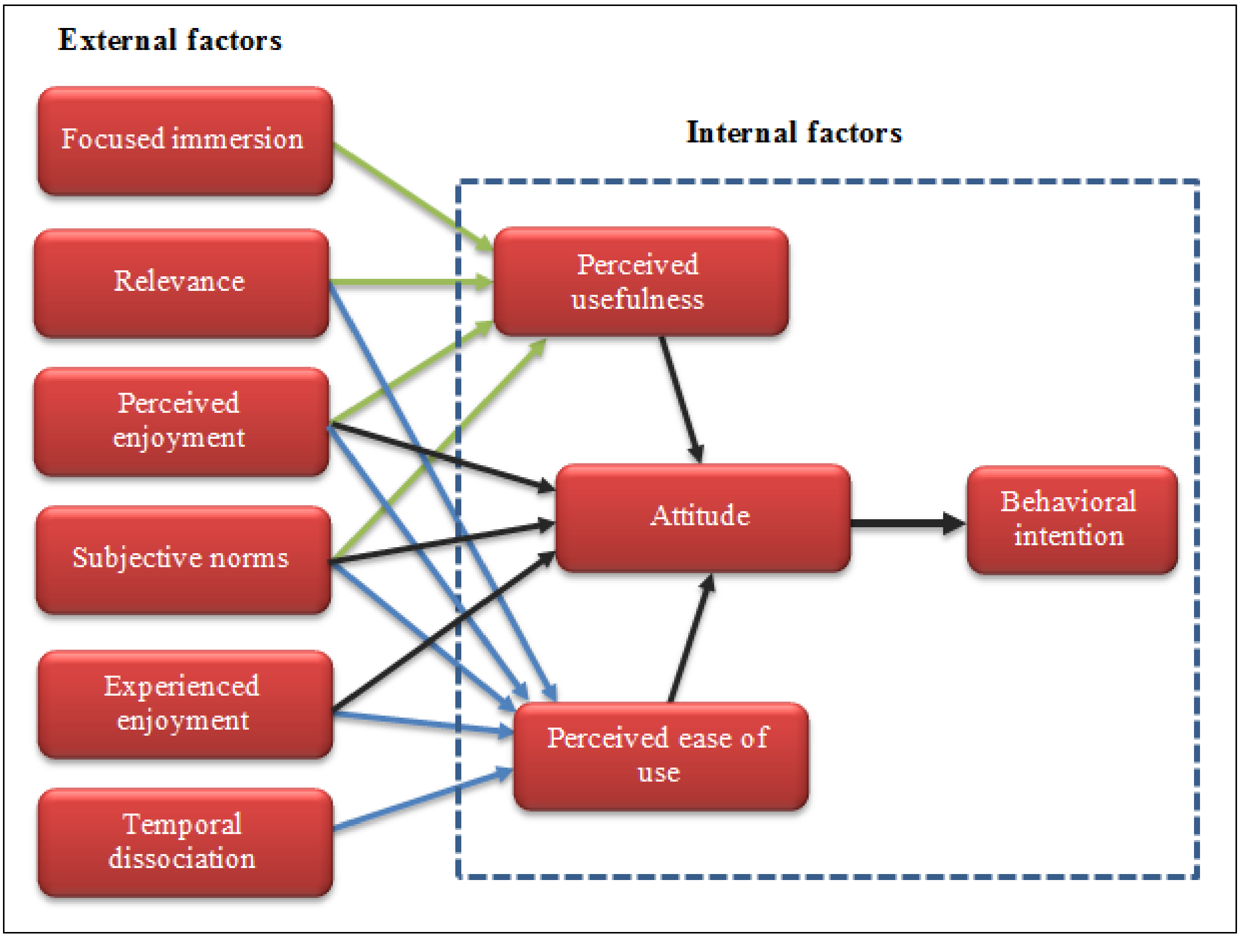


Figure 4.25: Proposed TAM – Factors that influence students' attitude towards the use of serious games in the computer science class

The proposed technology acceptance model for using serious games in the computer science class as shown in Figure 4.25 contains five primary variable as predictors of the attitude of serious games as technology in class. These primary predictors are the two internal factors PU and PEOU and three of the external factors, namely Enjoy, SN and experienced enjoyment. In Figure 2.25, the relationship between the primary predictors, with attitude as the dependent variable, is indicated with red arrows. The secondary predictors of attitude are related to each of the internal factors PU (indicated with green arrows) and PEOU (indicated with blue arrows).

4.6 SUMMARY

This chapter reports on the results found in the empirical part of the study. Section 4.2 provides an overview of the pre-testing process and the pilot test. The procedure that was followed during the pre-test and the pilot test, as well as feedback from participants and the implementation thereof, is discussed. Section 4.3 comprises the preliminary data analysis, including a discussion on the coding, tabulation and the gathering of data process. In Section 4.4, the descriptive analysis of the data set was presented, including the demographic information, reliability and validity of the scale, confirmatory factor analysis as well as the descriptive statistics.

Section 4.5 reports on the modelling section of the study, which includes a correlation analysis to establish the strength of relationships amongst the internal technology acceptance variables. A correlation analysis was conducted thereafter on the external variables associated with PU and PEOU as internal variables. A discussion of the results of the multiple regression analysis followed, which included the establishment of a model to predict the attitude of students towards the use of games in the computer science class, best.

The succeeding chapter, Chapter 5, provides an overview of the study. The contributions of the study, recommendations, limitations and future research opportunities will be included in the overview. An overall conclusion of this study concludes chapter five.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

More than 50 per cent of students who are enrolled for computer science courses at tertiary institutions in the Latin American countries abandon their studies (Rosas *et al.*, 2014). This trend has been reported by many other countries worldwide, and could be as the result of a change in the profile and needs of the current generation of students (Corney *et al.*, 2010; Kirlidog *et al.*, 2011; Muratet *et al.*, 2011; Tedre *et al.*, 2011). Computer science students often get frustrated with the slow paced and old-fashioned teaching and learning strategies in class (Gros, 2007:25). These students are disillusioned by the lack of technology and an interactive learning experience in class (Husain, 2011:1) (Husain, 2011:1). As a result, educators are confronted with students who are bored and restless. Furthermore, previous studies reveal that students find programming a difficult skill to master (Tedre *et al*., 2011). Higher order thinking skills such as abstraction and problem solving skills are required to master computer programming. A constructivists teaching and learning approach is essential in order to comprehend, master and apply abstraction and high order thinking skills (Kiili *et al.*, 2012). Education needs to adapt to the current need of students, which includes presenting computer science in such a way that students find it interesting, engaging and relevant to the world in which they live.

The fact that most students play computer games regularly (Becker, 2001:22; Lenhart, 2008:1; Yusoff, 2010:1) paves the way for games to be applied as part of teaching in class. Abstract concepts can be introduced in a visual way within a context that is more appealing to students. Studies show that gamers experience flow while playing games flow (Ermi & Mäyrä, 2005:92; Tan *et al.*, 2009:4). A flow experience refers to total involvement and enjoyment. Such an experience urges players to stay involved and focussed on what they are doing (Nakamura & Csikszentmihalyi, 2002:89) These features are essential to improve performance in tasks and subjects, which require higher order thinking skills (Annetta *et al.*, 2013b:55). The current lack of motivation, enjoyment and interactivity in class can be addressed using serious games.

This chapter comprises an overview of the study (Section 5.2), the main findings of the study (Section 5.3) and recommendations (Section 5.4) based on the findings of the study. Section

5.5 includes a detailed discussion on the contributions of the study, whereas Section 5.6 provides an overview of the limitations and future research opportunities. This chapter closes with concluding remarks contained in Section 5.7.

5.2 OVERVIEW OF THE STUDY

A brief overview of the study is required for providing a proper conclusion and recommendations. Therefore, insights gained over the previous four chapters will be discussed. Reviewed in Section 5.2.1 is the primary objective of the study, followed by Section 5.2.2 and Section 5.2.3, comprising the theoretical and empirical objectives respectively.

Chapter 1 provided an introduction to the study, which led to a formulated problem statement. Included in Chapter 1 were the objectives and the design of the study.

The objectives of the study were as follows (Section 1.3):

5.2.1 Primary objective

The primary objective of this study was to identify and model the factors that influence the attitude of computer science students towards serious games in class.

5.2.2 Theoretical objectives

In order to achieve the primary objective, the following theoretical objectives were formulated for the study:

- The literature was reviewed on the concept of serious games and its current status and role in education
- The literature was reviewed on the characteristics and potential of serious games to enhance learning in the computer science class
- The literature was reviewed on the current status of computer science and requirements to master computer science and programming skills
- The literature on the technology acceptance model (TAM) as an instrument to identify the factors that influence the attitude of students towards the use of serious games in the computer science class was reviewed.

5.2.3 Empirical objectives

In accordance with the primary objective of the study, the following empirical objectives were formulated:

- Investigate internal technology acceptance factors that could influence the attitude of computer science students towards the use of serious games in class
- Investigate external factors that could influence the attitude of computer science students towards the use of serious games in class
- Propose a model that presents factors that influence the attitude of computer science students towards the use of serious games as a possible teaching approach in a computer science class.

Chapter 2 encompassed a literature review explaining the theoretical objectives as formulated in Chapter 1. Included in Chapter 2 is a detailed discussion on serious games, regarding the definition and scope (Section 2.2.1) overview and background of the development of serious games developed over time (Section 2.2.2), serious games in education pertaining to case studies of success stories (Section 2.2.3) and educational attributes serious games contain, which are key aspects to consider in computer science education (Section 2.2.4). The section on computer science education (Section 2.3) involved a discussion on the status of computer science education (Section 2.3.1), required teaching strategies for computer science education (Section 2.3.2), and the aspects of serious games relevant to teaching computer science (Section 2.3.3). The TAM (technology acceptance model) as an instrument to measure the attitude of users towards new technology was discussed in Section 2.4. This section pertains to the background on the establishment of the technology acceptance model (TAM) as a reliable instrument to determine factors, which influence user attitude towards the acceptance of technology (Section 2.4.1) followed by a thorough discussion of the internal and external factors used as constructs in the TAM measuring instrument (Section 2.4.2). This chapter was concluded with a brief summary of the key aspects that were investigated as part of the literature study (Section 2.5).

The research methodology applied for the purpose of this study was described in Chapter 3. This chapter included a discussion on research paradigms in general, and consequently, identifies the research paradigm for this study (Section 3.2), the research approach (Section 3.3), the research strategy (Section 3.4), the sampling strategy (Section 3.5), the data collection strategy (Section 3.6) and the motivation of the measuring instrument for this study

(Section 3.7). A discussion on statistical concepts and methods relevant to the analysis of results of this study (Section 3.8) concluded this chapter.

Chapter 4 comprised a discussion on the analysis and interpretation of the empirical findings of this study. The pilot test and resulting amendments to the questionnaire have been reported on (Section 4.2), as well as the preliminary data analysis (Section 4.3). The demographical information of the participants, the reliability and validity of the scale, the confirmatory factor analysis of the scale and descriptive statistics were reported on (Section 4.4), which led to the construction of the proposed technology acceptance model to determine the attitude of computer science students towards the use of serious games in class (Section 4.5).

The results concluded in this chapter are in accordance with the empirical objectives formulated in Chapter 1.

5.3 MAIN FINDINGS OF THE STUDY

The main findings obtained in accordance with the empirical objectives of this study, are discussed below:

5.3.1 Internal technology acceptance factors

The first empirical objective listed in Chapter 1 was to investigate internal technology acceptance factors that could influence the attitude of computer science students towards the use of serious games in class.

The internal technology acceptance variables perceived usefulness (PU), perceived ease of use (PEOU), attitude (A) and behavioural intention (BI) were adapted from the original TAM (Davis, 1989) and used as internal technology acceptance factors for this study. Correlation and regression analysis was conducted on relationships among these internal technology acceptance variables within the context of serious games in the computer science class.

The descriptive statistics revealed a stronger correlation between PU and attitude (A) than between PEOU and attitude (A) (Figure 4.12, section 4.5.1). Results of the regression analysis indicate that both PU and PEOU are significant predictors of attitude (A), although PU proves to be a stronger predictor of attitude (A) than PEOU (Figure 4.15, Section 4.5.2.1).

These findings are consistent with previous research studies done by Davis (1989), Davis *et al.* (1989), Hendrickson and Collins (1996), Hsu and Lu (2004), Ibrahim and Jaafar (2011) and Saadé and Bahli (2005). However, the findings from this study are contradictory to the findings of De Grove *et al*. (2012) who found learning opportunities created by digital games in class to be a stronger predictor of attitude than PU, and Lu *et al*. (2009) who found PEOU to be a stronger predictor than PU.

5.3.2 External technology acceptance factors

The second empirical objective listed in Chapter 1 was to investigate external technology acceptance factors that could influence the attitude of computer science students towards the use of serious games in class.

In accordance to an extended version of the TAM, TAM2 (Venkatesh & Davis, 2000) and other related studies (Chow *et al.*, 2012; Compeau & Higgins, 1995; Davis *et al.*, 1989; Hartwick & Barki, 1994; Lee *et al.*, 2005; Lu *et al.*, 2008; Mathieson, 1991; Moon & Kim, 2001; Saadé & Bahli, 2005) external factors can significantly influence perceived usefulness (PU) and perceived ease of use (PEOU) of technology. Subjective norms (SN), relevance (R), perceived enjoyment (Enjoy), self-efficacy (SE), temporal dissociation (TD), focussed immersion (FI) and experienced enjoyment (ExpEnjoy) were identified as external technology acceptance variables relevant to this study. Correlation and regression analysis was conducted on the relationships between these external technology acceptance variables as indirect or secondary predictors of the attitude towards the acceptance of serious games in the computer science class and the internal technology acceptance variables PU and PEOU.

The descriptive statistics revealed that relevance (R) correlated the strongest with both PU and PEOU (Table 4.22). Regression analysis on the relationship between PU and the external variables identified R, SN, Enjoy and FI as significant predictors of PU where R is the strongest and FI the weakest predictor (Table 4.28). Similarly, the external variables ExpEnjoy, R, TD, Enjoy and SN were calculated as significant predictors of PEOU where ExpEnjoy is the strongest and SN the weakest predictor (Table 4.29).

These findings confirm findings from research done by Lee *et al.* (2005).

5.3.3 Proposed a technology acceptance model

The third empirical objective listed in Chapter 1 was to model the factors that influence computer science students' attitude towards the use of serious games in the class.

The original TAM uses PU and PEOU as the two direct or primary predictors of attitude (A) and includes external variables as predictors of PU and PEOU rather than direct predictors of attitude (A) (Davis, 1989). However, studies conducted by several authors revealed that external factors could have a more significant impact on the attitude (A) if employed as direct predictors thereof (Dishaw & Strong, 1999; Teo, 2009).

A multiple regression analysis using PU, PEOU and the seven identified external variables as direct predictors of attitude (A) revealed that the external variables Enjoy, SN and ExpEnjoy have a more significant impact on attitude (A) when employed as direct predictors (Table 4.30).

This finding contradicts the findings from previous research studies, which strictly implemented the structure of the original TAM. These studies regarded external factors as indirect predictors of attitude (A) (Mathieson, 1991; Taylor & Todd, 1995). However, the findings of this study confirm the findings from a study conducted by (Lee *et al.*, 2005) who found that perceived enjoyment has a significant direct impact on the prediction of the attitude of students towards the use of an Internet-based learning medium. The findings of this study are also consistent with previous studies done by authors who evaluated external variables related to various technologies implemented in the TAM as direct predictors of attitude (Agarwal & Karahanna, 2000; Hsu & Lu, 2004; Lu *et al.*, 2008).

The proposed model as shown in Figure 4.25 concluded the main findings obtained in accordance with the empirical objectives of this study.

The following section comprises a discussion on recommendations based on the literature review (Chapter 2) along with the empirical findings (Chapter 4) obtained from the sample computer science students at tertiary institutions in South African) regarding factors that influence their attitude towards using serious games in the computer science class.

5.4 RECOMMENDATIONS

The findings of this study suggest that computer science students exhibit a positive attitude towards using serious games in the computer science class. The following recommendations pertaining to factors which influence computer science students' attitude towards serious games in class, should be considered by educators who are involved in computer science education.

5.4.1 The relevance of serious games to class work

The relevance of serious games to class work is regarded as an important factor on deciding whether serious games should be played in class (Table 4.22 and Table 4.23). The remaining external factors demonstrated to be less significant predictors of attitude than relevance. Therefore, care should be taken to ensure that learning takes place when teaching strategies are adapted for the implementation of serious games in class. Furthermore, serious games should be designed in such a way that programming concepts are conveyed and programming skills are improved. It is imperative for educators to be aware of the fact that serious games in class could be rejected if students are not convinced that the games serve the purpose of learning and developing skills required to enhance their performance.

5.4.2 Enjoyment as part of serious games in class

Even though Marsh (2011) states that games could have no entertaining values, results from this study reveal that the attitude of computer science student towards the employment of serious games in class are influenced significantly by the level of entertainment these games provide (Table 4.30). This could be because young people are familiar with high quality and captivating video games (Yusoff, 2010:1). The goal of these games are to entertain (Susi *et al.*, 2007:6). Therefore, students have specific expectations in terms of entertainment when games are part of the learning experience in class. Educators should be aware of these expectations to ensure that students accept, play and enjoy serious games in class.

Educators should value the entertaining aspect of serious games as a motivating tool to promote enjoyment and the flow experience in class (Kiili *et al.*, 2012). The flow experience provides valuable opportunities for students to become engaged and focussed on tasks in class as discussed in Section 2.3.2.2.

5.4.3 Subjective norms related to the acceptance of serious games

The opinions of people who influence the behaviour of students are important, as revealed in the results of this study (Figure 4.13). The perceived usefulness of games in class is influenced significantly by what people other than the students in class think about the idea. Therefore, educators should plan and implement serious games cautiously to ensure value is added to the learning experience.

5.4.4 Self-efficacy and ease of use

Students regard self-efficacy as an insignificant predictor of PU, PEOU and attitude (A). The majority of students are not concerned about the level of assistance to learn how to play a serious game, nor their ability to be able to navigate through the levels of a serious game. Educators should take note of this and not frustrate students by conducting training sessions on how to use the game and providing lengthy manuals or instructions. Engaging with technology is part of the young people's lives (Heersink & Moskal, 2010:446). Discovering how a game works often is regarded as part of the challenge and excitement games provide. Educators should use the fact that students prefer to figure a game out to the advancement of the learning process in class. However, it is important to provide for students who are not familiar with a game, and collaboration by means of teamwork could be used effectively to assist these students.

5.4.5 Implementation of the TAM for serious games in class

Although serious games have gained significant momentum recently, students may still reject the implementation of serious games in class. The proposed TAM for serious games in computer science classes in this study could be utilised as a model to determine the attitude of computer science students towards the use of serious games in class.

5.5 CONTRIBUTIONS OF THE STUDY

The positive attitude towards the use of serious games in the computer science class expressed by the results of this study emphasise the fact that a change in teaching strategy in the computer science class is inevitable. This study confirms that the majority of students in the computer science class will accept the implementation of serious games in class positively.

The external factors identified in this study can be used as guidelines to select serious games suitable to enhance the learning experience in the computer science class.

Results from the study provide insights into the internal and external factors that influence the attitude of students towards the use of technology in class. Being familiar with technology and playing serious games are two aspects that were revealed in the results. Therefore, emphasis should be placed on content and relevance to computer science rather than ease of use. Games presented in class should be enjoyable, challenging, captivating and add meaning to the learning experience. These aspects are important in order to understand the needs of the modern technology-oriented computer science student.

The suggested technology acceptance model can be used to determine the attitude of students towards a serious game prior to implementing the game as part as a learning experience in class.

5.6 LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

This study examined factors that influence computer science students' attitude towards using serious games in class. Furthermore, the sample for this study was selected using a non-probability convenience sampling approach. For that reason, the interpretation of these results should be done with care.

This study is limited, as participants from only two HEIs in one province formed the sample for this study. As a result, there is an opportunity to conduct this study on a wider scale, including other HEIs within other provinces. This will improve the accuracy of the data obtained. Comparisons could be made between research results obtained from the different HEIs and the different provinces.

The sample used for the purpose of this study comprised only full-time undergraduate students enrolled at two HEIs. This provides an opportunity for future research, as studies could be conducted to examine the attitude of part-time, post-graduates as well as the non-student segment of society towards using serious games in computer science education and training.

By making use of a qualitative research approach, reasons why some external factors were not influential and some were in terms of the attitude of students towards the use of serious games in class could be understood better.

As this study only investigated specific selections of external variables, further studies can be conducted to investigate other relevant external variables such as experience in playing games, gender, cultural differences and difference in game preferences.

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APPENDIX A

QUESTIONNAIRE – COVER LETTER

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
VAAL TRIANGLE CAMPUS

Modelling the factors that influence computer science students' attitude towards serious games in class

Information

A serious game is a game with an educational purpose.

Almost all games are serious as knowledge is gained and skills are mastered while playing almost all games.

I am currently working towards completing my dissertation under the supervision of Prof DB Jordaan as part of the requirements for completing my MSc in Computer Science at the North-West University (Vaal Triangle Campus). The purpose of this research project is to determine the factors that influence computer science students' attitude towards serious games in class.

Please assist me by completing the attached questionnaire. The questionnaire is user-friendly. It should take only approximately 10 minutes to complete. All responses are confidential and the results will only be used for research purposes, outlined in the form of statistical data.

Thank you your assistance and contribution is highly appreciated.

Malie Zeeman (Malie.Zeeman@nwu.ac.za)

School of IT

North-West University (Vaal Campus)

APPENDIX B

QUESTIONNAIRE – DEMOGRAPHIC INFORMATION

SECTION A: Demographical Information. Please mark the appropriate box with a cross(X).

A1	**Name of institution where you are enrolled:**	North-West University	Vaal University of Technology

A2.1	**Country of origin:**	South Africa	Other: (Please specify)

A2.2	**Province of origin:**	Eastern Cape	Free State	Gauteng	KwaZulu-Natal
		Limpopo	Mpumalanga	Northern Cape	North West
		Western Cape	Not applicable		

A3	**Nationality:**	Asian	Black/African	Coloured	Indian	White	Other

A4	**Please indicate your mother tongue language:**					
	Afrikaans	English	French	IsiNdebele	IsiXhosa	IsiZulu
	Sesotho sa Leboa	Sesotho	Setswana	SiSwati	Tshivenda	Xitsonga
	Other:(Please specify)					

A5	**Gender:**	Male	Female

A6	**Your age in years:**	

A7	**Current year of study:**	1st year	2nd year	3rd year	4th or > year	Post graduate

A8	**How frequently do you play computer games?**				
	Daily	Several times per <u>week</u>	Several times per <u>month</u>	Rarely	Never

A9	**At what <u>age</u> did you start playing computer games**?		Never

APPENDIX C

QUESTIONNAIRE - SCALES

SECTION B: Serious games in the computer science class

Please indicate the extent to which you disagree/agree with each of the following statements by placing a mark(X) in the appropriate box.

Scale: 1 = strongly disagree through to 6 = strongly agree.

		Strongly Disagree	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Strongly Agree
B1	I like the idea of playing (serious games) as part of the learning process in class.	1	2	3	4	5	6
B2	I think it is wise to use games to enhance learning in class.	1	2	3	4	5	6
B3	I would like to attend classes where games related to class work are played.	1	2	3	4	5	6
B4	I intend to play games related to class work if available.	1	2	3	4	5	6
B5	Given that I have access to class related games, I predict that I would use it.	1	2	3	4	5	6
B6	People who are important to me will think it is a good idea to play games as part of learning in class.	1	2	3	4	5	6
B7	People who influence my behaviour will think it is a good idea to play games as part of learning class.	1	2	3	4	5	6

		Strongly Disagree	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Strongly Agree

I think playing games as part of the learning experience in class will ...

B8	improve my performance in the course	1	2	3	4	5	6
B9	be to the advantage of my learning experience in class.	1	2	3	4	5	6
B10	cause me to be more productive and do more class related work.	1	2	3	4	5	6
B11	improve my logical thinking skills.	1	2	3	4	5	6
B12	improve my problem solving skills.	1	2	3	4	5	6
B13	be useful to enhance learning in class.	1	2	3	4	5	6

It would be easy for me to ...

B14	learn how to play a game.	1	2	3	4	5	6
B15	interact with a game.	1	2	3	4	5	6
B16	be in control of the game to do what I want it to do.	1	2	3	4	5	6
B17	follow instructions and navigate through the stages of a game.	1	2	3	4	5	6
B18	become skilful at playing games.	1	2	3	4	5	6

Playing serious games as part of the learning experience in the computer science class will be...

B19	enjoyable for me	1	2	3	4	5	6

		Strongly Disagree	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Strongly Agree
B20	very pleasant	1	2	3	4	5	6
B21	fun	1	2	3	4	5	6
B22	frustrating	1	2	3	4	5	6
B23	boring	1	2	3	4	5	6

I will be able to play a serious game related to class work if ...

B24	there is someone around to tell me what to do.	1	2	3	4	5	6
B25	I have watched someone else play the game before trying it myself.	1	2	3	4	5	6
B26	I have only the instructions on how to play the game for reference.	1	2	3	4	5	6
B27	I have never played a game like it before.	1	2	3	4	5	6
B28	I can call someone for help if I get stuck.	1	2	3	4	5	6
B29	someone else helps me get started.	1	2	3	4	5	6
B30	I have a lot of time to complete the class work for which the game is provided.	1	2	3	4	5	6
B31	I have only the built-in help facility for assistance.	1	2	3	4	5	6

		Strongly Disagree	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Strongly Agree
B32	someone shows me how to play the game first.	1	2	3	4	5	6
B33	I have played similar games before to do the same class work.	1	2	3	4	5	6

If you have played any type of computer/tablet/smartphone game before, please answer the following questions:

B34	Sometimes I lose track of time when I am playing a game.	1	2	3	4	5	6
B35	Most times when I start playing a game, I end up spending more time playing the game than I had planned.	1	2	3	4	5	6
B36	Time flies when I am playing a game.	1	2	3	4	5	6
B37	When I am playing a serious game, I am able to block out most other distractions.	1	2	3	4	5	6
B38	While playing a game, I am able to block out most other distractions..	1	2	3	4	5	6
B39	I have fun when interacting with games.	1	2	3	4	5	6
B40	Playing games bores me.	1	2	3	4	5	6
B41	I enjoy playing games.	1	2	3	4	5	6

Thank you very much for your participation!