An Evaluation of the Impact of Gaming Technology on Learning

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Declaration

I declare that the research contained in this thesis was solely carried out by me. It has not been previously submitted to this or any other institute for the award of a degree or any other qualification.

Abstract

Education systems continue to face extensive challenges stemming from the on-going technological revolution, and e-books have now become one of the most important resources for learning. The majority of university students today use e-books to perform their tasks and research. In addition to e-books, gaming technology is frequently thought of as a promising technology that can have a substantial effect on future learning. The gaming technology environment has the potential to make learning more engaging and interesting as well as to enhance learners' knowledge, skills and experience.

Based on the literature review conducted for this study as well as previous academic discussions, there are gaps in the existing literature regarding the effects of gaming technology on learning. This research thus aims to explore whether game-based learning environments have a greater effect on learners' attitudes, higher-order thinking and cognitive load than e-book-based learning. This research investigates and clarifies effects such as the impact of gaming technology on attitudes (autonomous learning, curiosity and motivation) and cognitions (critical thinking and problem solving), evaluates the cognitive load and then compares it to the e-book impact.

The study utilised mixed intervention methods with a mixed-methods sequential explanatory design to test and explore factors affecting the use of e-books and gaming technology. This approach enabled the creation of e-book and gaming technology platforms for an experiment conducted by 30 doctoral students at the University of Salford (15 in the e-book group and 15 in the gaming technology group). Several data collection methods were also used, including questionnaires, interviews and observations via the FaceReader system and the Snagit software. Statistical analyses were performed using the SPSS and Excel software, as well as the NVivo software for content analysis, in order to answer the research questions.

The results show that gaming technology is an effective learning tool and that it has a more positive impact on learners' attitudes than e-books as it enhances autonomous learning, curiosity and motivation. Moreover, gaming technology and e-books have a similar effect on cognition, critical thinking and problem-solving ability. Finally, gaming technology has a more positive impact on cognitive load than e-books.

Chapter 1. Introduction

1.1 Motivation

Most people continuously learn and enhance their knowledge and skills in an effort to gain experience and to succeed in life (Pecorino, 2015); this implies that learning is important for enhancing the quality of life. Learning is the result of students' action and thinking (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). Ambrose et al. (2010, p. 3) define learning as 'a process that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning'. Learning is thus a development process that enhances students' attitudes, beliefs, social aspects, emotions, experience, values, knowledge and thinking (Ambrose et al., 2010).

Various technological improvements in the twenty-first century have influenced learners' thinking skills; learners now use digital tools and resources to acquire knowledge and improve their skills and experience. The field of higher education is on the verge of massive changes in future learning models due to various technological developments in recent years (Huer, 2015). As a result, higher education establishments need to research the effects that this new technology will have on learning and leaders in the field need to prepare for this change. As Holliday (2016, p. 54) argues, many higher education leaders are not prepared for the potential impact that technology will have on the ability to attract and retain students. Baseline technology has so far been a necessity but not a distinguishing feature of institutions. This may change as technology becomes more visible, differentiated and integral to teaching and learning.

In addition, as Huer (2015, p. 61) states, 'teaching today needs to provide students with the opportunity to acquire skills in critical thinking, problem solving, analysis and creativity'. According to Bhattacharya, Mach, and Moallem (2011) and Pivec and Dziabenko (2004) (2004), each new generation is different, and the members of the newest generation will be influenced by new technologies. This situation leads to the need to discover how technology can be used to improve the learning environment, to enhance effective attitudes and to support understanding and cognition. According to Valenti (2015, p. 38), 'The next generation of learning space will take the characteristics of an active learning environment – flexibility, collaboration, team-based, project-based – and add the capability of creating and making'.

E-books have become one of the most important resources for learning (Clay, 2012; Mulholland & Bates, 2014). The majority of students at universities today use e-books to perform their tasks and research (Clay, 2012; Mulholland & Bates, 2014). In addition to e-books, gaming technology is frequently thought of as a promising technology that could have a substantial effect on learning in the future. The use of gaming technology for learning, however, has long been in need of further exploration. As Pivec and Dziabenko (2004) state, the specific ways in which gaming technology enhances and supports learning are not entirely clear; more research is necessary to make gaming a more practical and useful learning tool. As Dix, Roselli, and Sutinen (2006) note, the use of gaming technology for learning requires further evidence and exploration to determine its exact effects on learning. Previous research has also suggested that educational games must be well designed if an effective learning environment is to be built in the future (Gee, 2005).

Recent studies have focussed on testing and exploring the effects of using gaming technology for learning (Van Eck, 2015). Effective gaming environments for learning must be further explored because several researchers have found that the deployment of gaming technology to be lacking in learning. For example, Van Eck (2015) found that the gaming revolution of the past few years has focussed on providing fun at the expense of providing gaming technology for learning objectives; he discussed the need to prepare the education system to use gaming technology for learning. According to Van Eck (2015, p. 13), 'Games could play a role in education,'. Van Eck found that there is currently no agreement or evidence that gaming technology promotes or enhances learning, he recommended that more research should be undertaken to explore the impact of gaming technology on learning – particularly on students' attitudes and beliefs about learning through a gaming technology environment – and by exploring the influence of gaming technology on learners' cognition (such as their problem-solving and critical-thinking abilities).

Technology-based learning, however, is an interdisciplinary area that must involve education, psychology, computer science, information science and human computer interaction (HCI) if it is to be an effective learning tool (Churchill, Bowser, & Preece, 2013). According to Churchill et al. (2013, p. 47) 'we, as educators and learners, need to embrace new perspectives and new

areas of focus; the areas where these are embraced are subjects typically taught in art and design schools, and in the information and library sciences'.

The digital-gaming environment has the potential to make learning more engaging and interesting and to enhance learners' concentration levels (Yang & Chang, 2013). Gaming technology can also foster higher-order thinking and enhance learning outcomes, because gaming environments have the ability to display information and knowledge; they can also allow learners to explore 'what-if' scenarios and to gain experience in solving problems or conducting tests within an attractive format (Martin, 2013; Rettig, 2013; Yang & Chang, 2013). In digital-game learning, students are at the centre of learning and can adopt a problem-solving approach, both of which can help learners to improve their critical-thinking abilities (Yang & Chang, 2013, pp. 3-4).

According to McBride (2014), learning in the future must embrace several important cognition skills (such as critical thinking and problem solving) as well as various collaboration activities. It is thus necessary to explore the effects of gaming technologies on cognitive skills and how they can enhance learning

E-books have now become the norm. Does gaming technology provide better learning outcomes (such as attitude (autonomous learning, curiosity and motivation), cognition ability (critical thinking and problem solving), and memory process by reducing cognitive load) over and above e-books? This is the subject of this research.

This research is attempting to answer:

- 'Does gaming technology affect learners' attitudes (autonomy, curiosity and motivation), higher-order thinking (critical thinking and problem solving), and cognitive load over and above the effect caused by e-books?'.

1.2   Aim

The aim of this research is to establish whether game-based learning environments have a greater effect on learners' attitude, higher-order thinking and cognitive load than e-book based learning.

1.3   Objectives

The objectives of this research are:

- To investigate the learning factors which are impacted upon by gaming technology and e-book technology by defining a framework that provides a basis for measuring learners' attitudes, higher-order thinking and cognitive load, both subjectively and objectively;

- To design and establish a technology-based learning environment to compare the learning differences via e-books versus gaming technology;

- To explore gaming technology's impact on learning by conducting experiments to compare outcomes when using game-based learning versus e-books to establish the benefit of game-based learning.

1.4   Deployment content:

The author believes that gaming technology can be used as an addition to the e-book resources provided by libraries. There are numerous reasons for this goal.

- Academic libraries play a significant role in supporting learning in the academic community. As they provide the main source of information and the core tool for most academic subjects, such libraries may be described as instruments for learning (Nwofor & IIorah, 2006).

- Academic libraries provide organised programmes, service delivery and a variety of collections.

- Academic libraries are major learning spaces for improving knowledge and for promoting student self-development in universities and wider academic communities (Okeke, 2000).

- The most effective academic libraries link past and present knowledge to support future knowledge and targets (Okeke, 2000).

- Knowledge and information are widely considered to be valuable components for future developments that have the potential to provide the impetus to advance both people and entire nations (Daluba & Maxwell, 2013).

- Games are already used in many libraries to gain a variety of advantages (such as enhanced engagement with the library) and have a positive effect on enhancing users' knowledge, skills and experience (Nicholson, 2013).

- Games can support courses and sessions in universities and are a valuable tool that instructors can use to teach more effectively. Nicholson (2013) suggests using gaming technology in libraries in order to enhance learning outcomes and learning performances.

In summary, the results of this research can enhance the use of gaming technology as an e-resource within academic libraries.

1.5   Research process

The research process for this study followed the steps shown in Figure 1.1. Firstly, the initial data was collected via the secondary data relating to the research area; this concerned which technologies enhance of learning in order that appropriate technologies may be used for online learning in an academic library system setting. The secondary data led to the discovery of a gap in previous research in this area. This, in turn, led to the establishment of a research question. A research design was then developed that would answer the research question and achieve the aim and objective; this involved the development of a conceptual framework that was created to test and explore the effects of gaming technology on learning. Both a gaming technology platform and an e-book platform were designed and developed for this research in order to compare the effect of gaming technology with that of e-books; this is because e-books are currently the main resource for online learning in an academic library setting. Both platforms were employed in a data-collection experiment; several processes and instruments (including a questionnaire, semi-structured interviews and observation) were used.

The data was then collected and analysed to confirm the conceptual framework for both technologies. The data indicated that the gaming-technology environment has several advantages over e-books.

In summary, this study has tested and explored the effects of gaming technology and e-books on learning and has built a relationship between technologies and enhanced learning.
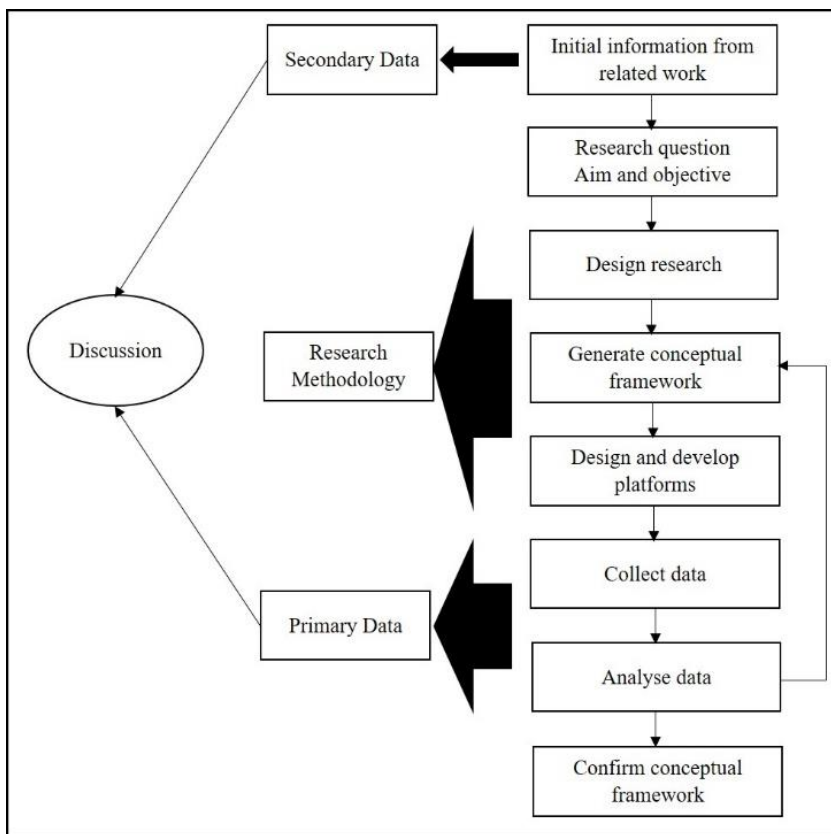
Figure 1.1 The research process followed in this study

1.6 Research contribution

The aim of this research was to explore whether game-based learning environments have a greater effect than e-books-based learning on learners' attitudes, higher order thinking skills and cognitive loads. The following contributions were made while fulfilling this aim.

- Establishment of a conceptual framework. The framework resulting from this research demonstrates and presents the important factors that are needed to evaluate the technological environment for learning (such as gaming technology and e-books) and to assess these technologies' impact on attitude (autonomous learning, curiosity and motivation), cognition (critical thinking and problem solving ability) and cognitive load.

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Through primary and secondary research this research established that:

- Gaming technology enhances autonomous learning, curiosity and motivation and gaming technology has a more positive impact on learners' attitudes than an e-book.

- Gaming technology reduces the cognitive load and has a positive influence on cognitive load, more so than an e-book.

- Gaming technology and e-books have a similar impact on critical thinking and problem solving ability.

1.7   Thesis structure

This thesis is divided into nine chapters. Chapter 1 provides an introduction to the research and includes its motivation, research questions, aim and objectives; it also presents the study's contributions to the field and its potential impact. Chapter 2 presents a literature review in several parts, including previous work that has focussed on learning and on the most effective technologies that are used to enhance learning and in gaming technology in online learning. Chapter 2 then presents various learning theories. It focusses mainly on two theories that support the use of gaming technology in learning. The chapter reviews the factors that can affect learning, such as attitude and cognition, as well as discussing HCI (human-computer interaction) – in particular how humans conduct learning by using human factors and by interaction with systems to gain information and knowledge. The chapter also examines the resources that are used for online learning (such as e-books) and explores the use of gaming technology in the learning field. The use of technology in learning (specifically, gaming technology) is then explored and is compared with the technology of e-books. Chapter 3 is concerned with the research path and the methodology that were used to design the research and collect the data. Chapter 4 discusses the theoretical framework as well as the creation of an e-book platform and the design for the creation of a gaming platform. Chapter 5 presents and compares the effects of the use of gaming technology with the use of e-books on learners' attitudes; this comparison is based on the conceptual framework that was created for the use of technology within the learning field. Chapter 6 compares the effect of gaming technology with that of e-books on learners' higher-order thinking, also based on the conceptual framework. Chapter 7 compares the effects of e-books versus gaming technology on learners' cognitive load, while Chapter 8

presents a discussion of the research and its outcomes. Finally, Chapter 9 presents conclusions and recommendations for further research.

1.8   Summary

This chapter has provided an outline of the research and has laid the foundations for the study by explaining the main motivations of the research. This chapter has focussed on the study's aim, objectives and its contribution to knowledge, as well as delineating the research question in section 1.1.

The next chapter (the literature review) will present the background to (and information about) gaming technology. It examines several learning theories and factors, effective technologies in learning, and the concepts of HCI that have led to the use of these technologies in academic learning environments.

Chapter 2. Literature review

2.1   Introduction

This research looks at the use of gaming technology in learning and examines various learning theories that support gaming technology as a learning tool and as an e-resource for learning. This chapter primarily discusses the main concepts that have been explored in previous research. A review and explanation of the most important learning theories is provided, focusing on the constructivism theory and the cognitive load theory and their uses. This chapter then explores learning factors based on the constructivism theory and the cognitive load theory. These factors include: (1) attitude, which includes autonomous learning, curiosity and motivation; (2) cognition, which includes higher-order thinking based on problem solving and critical thinking, and (3) cognitive load, which supports memory to acquire knowledge effectively. By studying the use of gaming technology in learning, this chapter explores the connections between the constructivism and the cognitive load learning theories to discover the effect of gaming technology on learners' attitude and cognition as a learning tool. The focus then switches to human-computer interaction (HCI) to explain how learners interact with systems by using human sensors, responders and the brain.

This research also focuses on e-learning and discusses some of the effective technology tools that are used in such learning, such as e-books and gaming technology. Subsequently, the gamification concept is explained, followed by a review of previous research on the impact of gaming technology.

This chapter also explores the role of an academic library in providing services and resources for online learning. An academic library can provide an essential destination for learners who are searching for effective resources and learning services. Academic libraries use games, virtual reality and e-books for several purposes such as improving reference services, enhancing engagement and improving learning services and resources. This chapter looks at the use of gaming technology within academic libraries to support learning and academic performance based on academic library targets.

Finally, this research will test learning theories, add to previous research and contribute to filling gaps in knowledge in addition to employing the results to help improve academic libraries' role,

services, collections and programmes by using gaming technology to support learning approaches and objectives.

2.2   Learning

Learning is undertaken by people to help them enhance their lives by going through processes to change and increase their understanding and improve their abilities in order to enhance their experiences. According to Ambrose et al. (2010, pp. 3-4) learning is a developmental process that intersects with other developmental processes in a student's life, and students enter our classrooms not only with skills, knowledge and abilities, but also with social and emotional experience that influence what they value, how they perceive themselves and others, and how they will engage in the learning process. In addition, information is a fundamental human need and enhances the quality of civilisation whereby people obtain appropriate information in a timely manner (E. A. Fox & Marchionini, 1998). Learning which increases learner knowledge is defined by the Cambridge dictionary (2016) as 'the understanding of information about a subject that you get by experience or study, either known by one person or by people generally'.

Moreover, learning develops people's skills. Skill is defined by the Cambridge dictionary (2016) as 'an ability to do an activity or job well especially because you have practised it'. Knowledge and skills support a learner's experience and enables him/her to be a proactive member in a community because learning focuses on changing the level of knowledge and skills; this experience will endure over the time (Schunk, 2012).

2.2.1   Learning experience

Experience is 'the process of getting knowledge or skills from doing, or feeling things' (Cambridge dictionary, 2016). According to the Oregon College of Education (1970, p. 123), learning experiences are elicited through the following four categories: orienting experience, foundation experience, synthesising experience and consolidating experience. These are described as follows:

- Orienting experience: this involves learning experiences that supply the learner with a set of references necessary for significant study within a qualified establishment where he or she can experiment with, and practice, the ideas and components included in the education system. Orienting experience can be built by observing learners and teachers.

Moreover, it can be used at any level of a learning system based on the needs of the learner.

- Foundation experience: this involves learning experiences that guide learners to the cleverness of knowledge, to conceptual frameworks and achievement capabilities, which require the demonstration of a standard competency. Bloom's Taxonomy is an example of this.

- Synthesising experience: here, learning experiences are established through the following approaches:

  o The synthesis of two or more types of knowledge and skills that enhance the foundation activities, for example, using questions to enhance various levels of thinking by sharing with classmates.

  o The synthesis of total learning, knowledge and skills developed in the foundation activities, for example, when the teacher combines approaches in a geography lesson and requires students to see and recognise what was on a map reviewed in the lesson.

  o Using syntheses to standardise a problem's solution in the same situation and position of the problem; for example, in giving students a mathematics problem to solve so that they must use their experience, knowledge and thinking processes in order to solve the mathematical problem.

- Consolidating experience: this gives learners the opportunity to practice the knowledge that has been obtained and the syntheses that have been established. For example, an instructor may create a group and give the members a practicum setting and objective to practice solving problems. In such a case, the students are the ones who diagnose the problems. Since each student has a different background, the students will each have different perspectives on coming to a solution and they will apply these ideas and then evaluate the solutions. This will help the students to develop experience and practice their knowledge.

Dewey (1998) defined experience as a continuous relationship and interaction between people and their environment. Experience is a result of interaction between the current state and previous experiences. In addition, Forlizzi and Battarbee (2004) describe experience as an interaction between people and a system or product that is concerned with emotion, behaviour,

cognition and visual aspects. Thus, the learning process assesses and explains through learning theories which can enhance the creation of an effective learning environment for learning.

To understand the learning process, several learning theories need to be reviewed. The next section will do so and then some theories will be selected that will help to test and explore the impact of gaming technology in learning.

2.3 Learning Theories

Learning theories demonstrate the process of learning through answering questions such as how can we learn and know? How can we gain and learn new knowledge? What are the sources of information and knowledge? (Schunk, 2012). 'A theory is a scientifically acceptable set of principles offered to explain a phenomenon. Learning Theories supply a framework for explaining environmental observations and building a relationship between research and education' (Suppes, 1974). Based on this definition, learning theories provide factors to explain the learning process which can also be used to explain the learning phenomena and to assess and test learning principles.

In addition, learning theories help to explain the impact of gaming technology in learning and explain the appropriate situation of learning through using gaming technology.

There are relationships between the various learning theories and each theory can support the concepts of the others. For example, humanism supports the experiential theory which may help to understand the phenomenon of learning. Several learning theories are explained in this section.
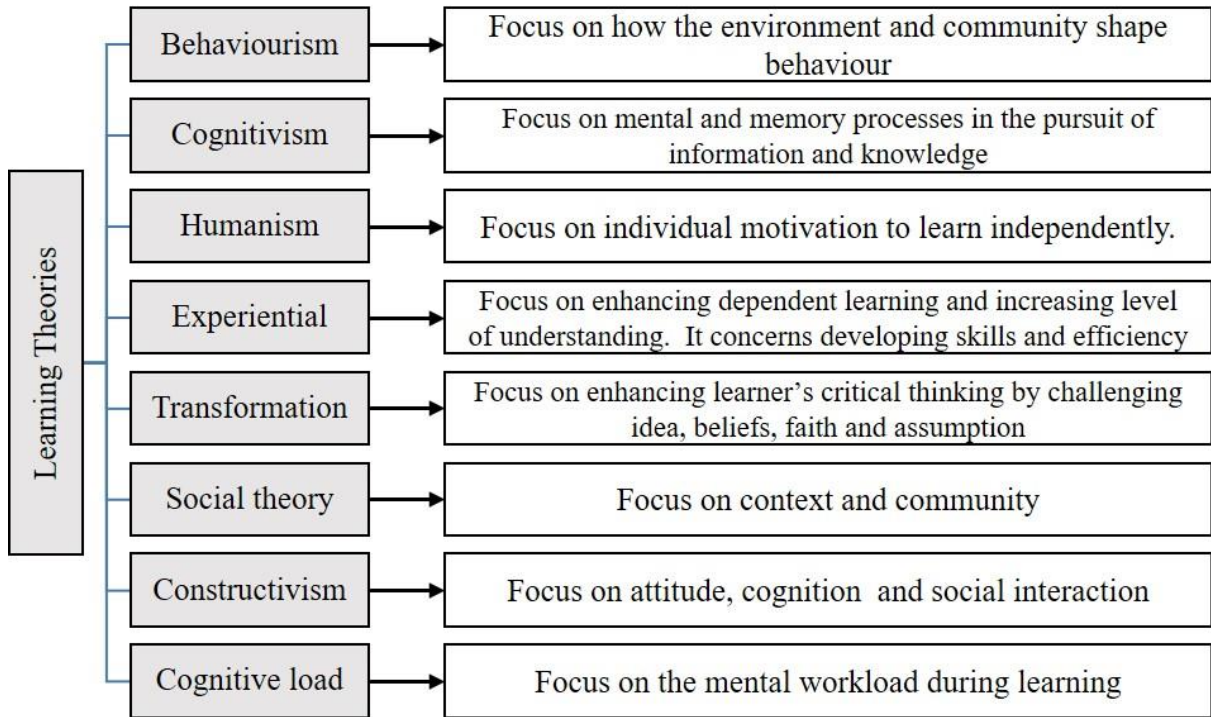
Figure 2.1 Learning theories

2.3.1 Behaviourism

Researchers employ behavioural theory when developing curricula and training sessions in order to improve user experience and competency (Skinner, 1954; Thordike, 1911). Accordingly, new user behaviour leads to the use of learning theories and behaviour theories for measuring an event or phenomenon with standard outcomes (Taylor & Hamdy, 2013).

The behaviourism theory makes three major assumptions: learning is evident by its effects upon behaviour; environment and community shape behaviour; communication and fostering are required to demonstrate the method of learning (Grippin & Peters, 1984; Shlechter, 1991; Watson, 2013). Behaviourism has three representative requirements:

(1) Direct instruction: general learning by lecture rather than discovery.
(2) Programmed instruction: individual learning with support from books, guides and targeted learning tools which require students and learners to successfully answer questions in order to move forward.

(3) Social learning theory: learning from other people via 'observation, imitation and modelling' (W. H. Wu, Hsiao, Wu, Lin, & Huang, 2012, p. 267).

2.3.2 Cognitivism

Cognitive learning focuses on mental and memory processes in the pursuit of information and knowledge (Ausubel, 1968; J. S. Bruner, 1966; Gagne, Briggs, & Wagner, 1992; P. Moore & Fitz, 1993; Piaget, 1952). Cognitivism consists of four essential theories: the attribution theory, the elaboration theory, the stage theory of cognitive development and conditional learning. The attribution theory, created by Weiner (1974), attempts to discover the reasons behind behaviour by observing the learning process. The attribution theory includes two sets of attributes: external attributes that concentrate on outside factors such as success and chance, and internal attributes that are closely related to a learner's abilities, intelligence and talents. The elaboration theory, established by Reigeluth (1983), holds that the learning content should be ordered and organised from easy to difficult, from basic to complex (Learning Theories Knowledgebase, 2008). Moreover, the elaboration theory assumes three principles: (1) guidelines and instruction encourage understanding, build meaning and motivate the learner; (2) a planned approach to learning enhances the speed at which a learner may gain understanding and knowledge, and (3) fast prototyping improves the pedagogical improvement process. The stage theory of cognitive development, established by Piaget in 1969, explains the four cognitive improvement periods of children: 'sensorimotor, preoperational, concrete operational and formal operational' (W. H. Wu et al., 2012, p. 267). The conditional learning theory, developed by Gagné (1965), suggests that there are a number of learning types and stages and that these classifications are important when developing specific learning instructions for each level or type. Gagne defined the five categories of learning as 'verbal information, intellectual skills, cognitive strategies, motor skills and attitude' (W. H. Wu et al., 2012, p. 267). In addition, internal and external situations play an important role in the different types of learning.

2.3.3 The humanism theory

The humanism theory holds that individual motivation is the key to obtaining knowledge and improving a person's experience. Learners form their own goals and plans for learning and they measure and evaluate their progress based on independent learning (Taylor & Hamdy, 2013). Students are at the centre of learning, performing activities that expand their knowledge and

develop their skills. Humanism is especially important and useful for experiential learning (Kolb, 1984) which requires no teacher; it offers instead a process of gaining knowledge based on individual experiences through the learning environment. According to Kolb (1984), the humanism theory allows for several learning styles: the diverger style that originates out of solid experience and pensive observation; the assimilator style that strives for understanding through thoughtful observation; the converger style in which concepts are confirmed through experiments, and the accommodator style that features both solid experience and active experimentation.

2.3.4   Experiential learning

Experiential learning enhances dependent learning and increases the level of understanding and knowledge within a social environment (Hart, 1992). It is often used in medical learning because it is helpful for developing skills and promoting efficiency in that context (Yardley, Teunissen, & Dornan, 2012). Moreover, experiential learning offers learners the opportunity to monitor their educational progress. The learner is empowered to create, organise and experience in ways that aid learning (Taylor & Hamdy, 2013).

Experiential learning is also supported by Kolb (1984). It is a learning style that is mentioned in the humanism theory.

2.3.5   The transformative learning theory

The transformative learning theory creates a path to enhance a learner's critical thinking by challenging ideas, beliefs, faiths and assumptions (Mezirow, 2000). This theory includes three distinct processes. Firstly, there is a disorienting dilemma, which is a method used to empower learners to express their perspectives. Next, there is a context formed by social, community, expert, professional and personal factors. A critical reflection occurs that leads to the transformation of rules, ideas, processes, meanings and premises. Finally, premise reflection provides a critical test of long-used axioms (Brookfield, 2000).

2.3.6   The social theory of learning

The social theory of learning considers two aspects: context and community (Choi & Hannafin, 1995; Durning & Artino, 2011). Wenger developed the social theory of learning and focused on the role of communities and the effect of educators (Lave & Wenger, 1991; Wenger, 1998).

However, Land and colleagues mulled over the methods that learners use to share the community of learning in order to satisfy their needs and improve their knowledge (Meyer et al., 2008).

2.3.7 Constructivism

The constructivist theory was established in the 18th century by Giambattista Vico who said learners can understand that knowledge shares construction and development (J. T. Fox, 1972). The constructivism theory incorporates an active and constructive learning process. Constructivists view the learner as a constructor or creator of information. Learners create their individual subject by exemplifying the reality of their objectives (Bednar, Cunningham, Duffy, & Perry, 1992). The constructivist theory was developed by Piaget, Dewey, Vygotsky and Burner (Thanasoulas, 2002). It focuses on different aspects of certain disciplines, such as psychology, social science, philosophy and critical learning theories (Thanasoulas, 2002). Constructivism makes the learner the most important element in the education process and thus reduces the significance of teachers (Thanasoulas, 2002). Thus, learner engagement and interaction are the most important factors in gaining knowledge and building experience. By solving problems and finding solutions, learners can build their understanding and conceptualisations independently (Thanasoulas, 2002). Learners interact with the learning environment and build communication between the information gathered to establish knowledge (Thanasoulas, 2002). The constructivist theory focuses on supporting learners in the construction of previous knowledge and in recognising ways of building new knowledge from real experiences, which is called experiential learning (Rogers & Freiberg, 1994). New information builds upon previous knowledge to improve learners' experiences (J. S. Brown, Collins, & Duguid, 1989; Resnick, 1987). Dewey's theory states that learners take part in the learning environment by engaging in activities that motivate them to understand the subject and experience. Piaget's theory focuses on the psychological aspects of child development; knowledge and understanding are built up by learners while being involved in activities and interacting with the educational environment step by step (Piaget, 1973). Burner described learning as a social process that focuses on learners building on current knowledge and experiences and students choosing information, building assumptions and making decisions, alongside combining new experiences with previous experiences, supporting cognitive learning

(J. Bruner, 1973). Constructivism was promoted by Vygotsky (1962). To connect learning to the social and cultural impacts of shared experience, it focuses on social interaction (Crawford, 1996). Learners use conversation and writing to build up culture and a community (Vygotsky, 1962). Furthermore, in 1962, Vygotsky established the concept of a zone of proximal development (ZPD) which examines the ability of a learner to accomplish an assignment under an instructor's direction as compared with a team's ability to find that solution independently (Nassaji & Cumming, 2000). The process in the ZPD that supports student learning is called 'scaffold learning' (Vygotsky, 1962).

Constructivism focuses on how people learn by concentrating on behaviours when interacting with the learning system, and on cognitive outcomes by discovering and finding solutions for game tasks. Learners enhance their experience by comparing new and current knowledge with their previous experience which leads them to develop and discover new experiences (K. J. Kiili, Perttula, Lindstedt, Arnab, & Suominen, 2014).

According to Mayer (2004), constructivism is the main theory that can be used to explain how people obtain knowledge and learn. Moreover, the constructivism learning theory is an excellent theory to use for developing a learning environment (such as a gaming technology environment for teaching and learning) in order to make learning efficient and useful (Overby & Jones, 2015). The constructivism theory is an effective theory for developing a gaming technology environment for learning because the constructivism theory supports discovery and interacting with a system to build knowledge, experience and skills. Furthermore, discovery supports higher-order thinking, such as critical thinking and problem solving. As a result, constructivism can cover most of the concepts of gaming technology that are needed to support learning at universities and within academic libraries.

Overall, the previous explanation justifies the use of the constructivism learning theory to create a research methodology game.

2.3.8   Cognitive load theory

The cognitive load theory focuses on short-term memory during learning. The cognitive load theory studies and explains human cognitive architecture based on an understanding of the brain and the memory process. In order to recognise learning in an interactive environment such as a

game, an understanding of the structure of memory and the cognitive process is required in order to build an effective learning environment (Kirschner, Sweller, & Clark, 2006). The cognitive load theory puts forward the structure of the memory process which helps in understanding how memory works through the three parts of the cognitive process (which are sensory memory, short-term memory and long-term memory).

The cognitive load theory defines memory types, long-term memory and short-term memory and their relationships in order to gain information and acquire knowledge (Van Merriënboer & Kirschner, 2012). Moreover, the cognitive load theory explains the processes and capacity of short-term memory (Chandler & Sweller, 1991), then uses a strategy to reduce cognitive load by transferring load to learning or by sending information to long-term memory.

The cognitive load theory divides the mental workload of obstructed learning into three parts. The first part is the intrinsic load which focuses on the complications of what learners are trying to learn. The second part is the extraneous load which gives attention to the complication of the system and the device from which the students are learning. The last part is the germane load which is essential in merging new information with current information and switching it to the long-term memory (K. Kiili, Lainema, de Freitas, & Arnab, 2014; Wilson & Wilson, 2013). Indeed, if a learner's cognitive load is high, it may negatively affect the learner's performance and learner behaviour while playing the game (K. J. Kiili et al., 2014). If learners have difficulty in learning and obtaining new information - or cannot learn and gain new information because of overloaded intrinsic and extraneous loads - technology tools can be used to assist these learners by decreasing intrinsic and extraneous loads because the learners interact with a system to gain knowledge (Mayer & Moreno, 2003). Hence, cognitive load is important because it affects a learner's ability to understand.

Cognitive load can measured based on several aspects, including learning performance, the mental effort required to learn, and the difficulties that participants face during learning.

Performance is the main indicator of gaining knowledge or learning. Furthermore, cognitive load affects performance as the amount of cognitive load a person carries can affect his/her performance (Sweller, Ayres, & Kalyuga, 2011). Cognitive load requires the use of instructional time. Performance by using instructional time means that learners use a strategy to learn and understand a subject which increases cognitive load which, in turn, influences performance

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during acquisition and in the future (Sweller et al., 2011). Sweller et al. (2011) pointed out that a high cognitive load may have a negative effect on learning time and on achieving tasks accurately.

The other measure of cognitive load is mental effort. It is based on a five-point Likert Scale starting with very high and ending with very low mental effort. Learners rate the mental effort at several points during tests (mental effort depends on the research questions and their variables). This helps to measure the effect that cognitive load has on achieving well in the learning stage; in addition, learners can rate the difficulty of the learning task (Sweller et al., 2011).

Paas and Van Merriënboer (1993) established an effective cognitive load measurement which is an efficiency measure. They combined self-rating efforts and task performance aspects to measure cognitive load (Sweller et al., 2011).

After the participants complete the task, effective performance needs to be measured. (Sweller et al., 2011). A sense of accomplishment enhances performance (Behn, 2003). Furthermore, performance in a comfortable environment makes a learner feel at ease during learning and enhances an effective performance (Lynch & Dembo, 2004).

The use of new technologies, such as gaming technology, in learning may help to reduce cognitive load and make learning more interesting and fun when building knowledge and improving learning skills and experience. Thus, it is worthwhile to rate the effect of gaming technology and e-books on participants' effort, difficulties and performance in order to measure cognitive load.

Learning theories can support research that investigates and tests gaming technology through the use of constructivism and cognitive load theory factors. Indeed, learning comprises three aspects, knowledge, skills and attitudes, and each of these can be observed through testing.

All these learning theories lead to establishing learning factors that are based on the constructivism theory and the cognitive load theory (because the constructivism theory can cover the attitude and cognition part of research and the cognitive load theory help to measure the work load that is caused during learning in the memory).

2.4   Learning Factors

Learning theories provide significant factors that can be used to measure learning and the acquisition of knowledge. Effective and complex learning requires knowledge, skills and attitude (Van Merriënboer & Kirschner, 2012). Based on the constructivism theory, this research demonstrates that attitude within learning (including autonomous learning, curiosity and motivation) enhances learners' capabilities to develop their knowledge and abilities. Furthermore, this research infers cognitive aspects and focuses on higher-order thinking, namely the problem-solving skills and critical thinking skills that lead to effective academic performance. The cognitive load theory interprets the psychological aspects of learning by explaining the information processing within the mind and its effect on cognitive learning. Hence, it is important to choose and define suitable tools and the environment for effective learning. A combination of learning theories can help in interpreting the learning process due to their different aspects and concepts.
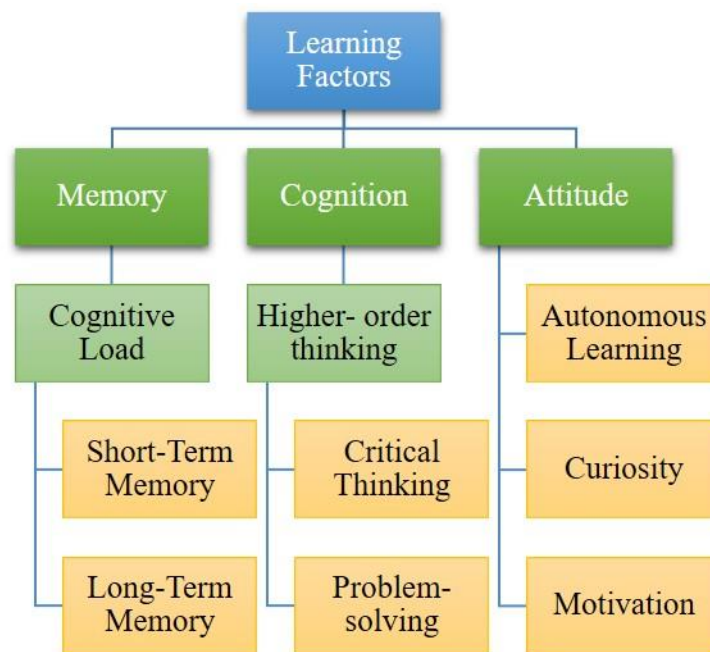
Figure 2.2 Learning Factors

2.4.1 Attitude

Attitude includes the behaviour that a learner needs in order to acquire knowledge, skills and experience for the future. Past research has discussed the main attitudes that are required for future learning (such as autonomous learning) which helps learners improve themselves by obtaining knowledge independently (Biggs & Tang, 2007; Grasha & Yangarber-Hicks, 2000; Luke & Hogarth, 2011; M. G. Moore, 1973). Moreover, learners need curiosity to discover new information and to increase their ability and talents to create innovations (Arnone, 2003; Loewenstein, 1994; Reio, 2013). In addition, curiosity leads to motivation which enhances learners' educational skills and encourages learners to undertake learning and acquire information, knowledge and skills.

Hence, attitude can explain the effect of the learning environment on learners' autonomy, curiosity and their motivation to achieve success in the future which, in turn, leads to creating and utilising an effective technology for future learning.

2.4.1.1 Autonomous learning

With regard to independent learning, there is an important question: what is the main issue concerning independent learning if learners do not have or cannot improve their independent learning skills (Luke & Hogarth, 2011)? This issue is based on an individual's ability for self-discovery and self-reliance in order to gain knowledge, experience and skills (Dempster, 1993). According to M. G. Moore (1973), independent learning concerns 'what students learn and how they learn'.

Independent learning has been defined as the learning structure that gives learners an opportunity to learn by themselves and be separate from their teachers in time and space. Moreover, this learning process is undertaken by utilising print or electronic resources (M. G. Moore, 1973). Technological improvements have influenced the learning structure by encouraging independent learning (Grasha & Yangarber-Hicks, 2000). The fundamental concept is for learners to motivate, manage and control their learning by undertaking activities and actions to fill their knowledge gaps and to improve their experience and skills (Biggs & Tang, 2007).

Grow (1991) sketched a model for independent learning. Grow created four stages for learning: dependent, interested, involved and self-directed. The first stage is 'dependent' covering learners who are not able to gain knowledge without supported instruction from a teacher who provides lectures, directions and specific tasks (Heresy & Blanchard, 2001). The second stage is 'interested' wherein learners are ready and confident to learn and make an effort to achieve tasks. However, learners still need direction and support from an instructor to guide them. This means that learners do not have the ability to achieve tasks until they have received direct and specific explanations (Heresy & Blanchard, 2001; Warring, 2013). The third stage is 'involved' which means that the learners are clever and able to achieve tasks but have a need for motivation and confidence in order to perform tasks. In this stage, learners need encouragement and motivation and instructors need to be involved in decision making (Heresy & Blanchard, 2001). Stage-three learners have the opportunity to succeed with support from an instructor because they have talent and ability (Warring, 2013). The fourth stage of independent learning is 'self-directed' which incorporates a high level of independent learning. The learner at this level does not need direction and support because the learner has confidence and ability. In the fourth stage, learners can plan their own systems/techniques in order to achieve the learning outcomes they desire (Heresy & Blanchard, 2001).

Table 2.1 Grow's Model for Independent Learning

1	Dependent	Learners are unable/unwilling and/or insecure. Decisions are made by the teacher.
2	Interested	Learners are unable but are willing and/or confident. Decisions are made by the teacher with explanation and support given to the learners.
3	Involved	Learners are able but are unwilling and/or insecure. Decisions are shared.
4	Self-directed	Learners are able/willing and/or confident. Decisions are made by the learners.

(Source: Warring, 2013, p. 27)

Independent learning has a variety of benefits. Independent learning increases and encourages the ability to learn autonomously and allows learners to create a framework to analyse and solve problems (Dawkins & Holding, 1987). Furthermore, independent learning enhances learners' critical thinking and supports the understanding of deep and complex concepts (Percy & Salter, 1976). In addition, independent learning supports learners in maintaining life-long education (Koper & Tattersall, 2004). Although independent learning is fruitful for students, it also helps to develop organisations, employers and professional people (Luke & Hogarth, 2011).

The information processing theory enhances independent learning by providing a self-regulation model and by supporting this model with learning strategies. The information processing theory has improved the connection between the cognitive and self-regulation processes (Schunk, 2012). This research adopts theory concepts to measure independent learning by using gaming technology. The information processing theory is based on the encoding of information in the long-term memory. Learners retrieve information from the long-term memory and transfer it to the short-term memory which utilises existing information in order to understand and recognise new knowledge as well as organising and storing knowledge in the long-term memory for future use (Schunk, 2012).

Self-regulated learning requires an individual to monitor, direct and coordinate activity in order to achieve learning goals (Paris & Paris, 2001). It concerns 'what is to be learned, when and how it is to be learned' (Schunk, 2012, p. 416). A model for self-regulated learning involves three important phases which are (1) a task's definition, (2) goals and plans, and (3) studying tactics. In addition, there is an optional phase of adaptation (Schunk, 2012). The first phase is about defining the task and includes two parts: (1) learners receive clear information and direction from the teacher or instructor concerning the successful performance of the task; (2) the cognitive part is based on learners retrieving information from the long-term memory in order to understand the task (Schunk, 2012). The second phase concerns setting the goals of learning and planning in order to achieve the goals effectively. Then, in the third phase, learners set some tactics to acquire knowledge and improve their knowledge and learning experience. Later, in the optional phase, learners can adapt and evaluate how successful they have been (Schunk, 2012).

All in all, autonomous learning requires willingness and confidence as well as management skills and memory processing in order to perform learning successfully via this learning system. This leads to using effective tools for future learning.

2.4.1.2 Curiosity

Curiosity empowers learners to discover, interact and make meaning of their environment. Teachers and educators enhance curiosity in learners to encourage their disposition to dig for information to improve their awareness; it is the first step in motivating learners. In addition, curiosity is a key component for fostering creativity (Arnone, 2003; Loewenstein, 1994). Furthermore, any improvement in learning is related to two factors which are cognitivism and curiosity (Piaget, 1952). Fostering learners' curiosity is a significant means of enhancing learning (Arnone, 2003). Curiosity incorporates seeking and exploring behaviour that helps to develop cognitivism (Giambra, Camp, & Grodsky, 1992). Thus, a researcher needs to understand aspects of curiosity in order to measure curiosity successfully.

Curiosity is a significant factor within human behaviour (Reio, 2013). Berlyne (1960), coming from his neurophysiological background, defined curiosity as an 'exploratory behaviour' and that exploratory behaviour can be divided into two styles: 'diversive' and 'specific'. The diversive style undertakes action to avoid being bored and the specific style seeks clarification of information to remove conflicting ideas (Berlyne, 1960). Curiosity is based on learners' interests; it raises learners' willingness to search for knowledge (Arnone, 2003; Berlyne, 1960).

Moreover, curiosity has a connection with cognitive and information needs; it is linked to gaps in knowledge. A feeling of deprivation encourages learners to improve their existing knowledge by acquiring new knowledge (Loewenstein, 1994). Arnone (2003) pointed out elements that arouse curiosity, such as incongruity, contradiction, novelty, surprise, complexity and uncertainty. These elements enhance learners' curiosity to explore new knowledge around these elements and to improve their own knowledge and their need for cognition (Arnone, 2003).

Educational designers need to take learners' individual differences into account when designing in order to arouse learners' curiosity (Görlitz & Wohlwill, 1987). Indeed, learners need to be in a comfortable situation to learn effectively.

This research decided upon using the Melbourne state-trait curiosity inventory in order to measure the effect of gaming technology on learners' curiosity. The trait inventory was used before the experiment and the state inventory was used after experiment. Moreover, interviews and a face reader system also measured levels of curiosity.

2.4.1.2.1 The Melbourne State-Trait curiosity inventory

According to Naylor (1981, p. 172), 'The Melbourne Curiosity Inventory concerns descriptive statistical characteristics of the trait curiosity and state curiosity scales, and the validity of the state-trait distinction for curiosity research' A state-trait curiosity inventory has been continually developed since 1974 and now it is at the stage where it can measure learners' curiosity (Naylor, 1981).

Naylor (1981, p. 173) suggested, 'Trait curiosity refers to individual differences in the capacity to experience curiosity. It is presumed that persons possessing more trait curiosity experience a wider range of situations as curiosity arousing than do persons possessing less. It is also presumed that those possessing more trait curiosity experience greater intensities of state curiosity. A scale which measures trait curiosity should therefore be stable, homogeneous and possess high internal consistency. State curiosity indicates individual differences in reaction to a specific curiosity arousing position. It is a guide of the arousal of curiosity'.

The measurement of trait curiosity and state curiosity can explore how the independent variables, gaming technology or e-books, can affect learners' curiosity.

Curiosity affects learners' motivation. It enhances learners' desires to explore new concepts and increase their information and knowledge.

2.4.1.3 Motivation

There are several definitions for motivation in dictionaries. According to the Longman dictionary (2016), motivation is 'eagerness and willingness to do something', 'the reason why you want to do something'.

Motivation has an important impact on all phases of learning and achievement (Schunk, 2012). There is no special theory for motivation in the constructivism theory. However, research can use learner-centred psychological principles for testing the constructivism theory. In this

research, motivation was assessed by using several concepts of evaluation from different frameworks and theories, including the motivational and affective factors in the learner-centred psychological principles' framework and from the intrinsic motivation theory.

There are 14 learner-centred psychological principles. The first six concern cognitive and metacognitive factors; the next three concern motivational and affective factors; then there are two principles that confirm developmental and social factors; and the final principles focus on individual differences' factors (American Psychological Association, 1995).

The motivational and affective factors include three principles. The first principle is 'motivational and emotional influences on learning' which assesses the impact of motivation on learning, and how learner motivation can be influenced by individual emotion such as beliefs, interests, targets and thinking habits that can help in achieving success or failure (Alexander & Murphy, 1998; American Psychological Association, 1995).

The second principle of motivation is intrinsic motivation. Intrinsic motivation is the desire to share and engage in an activity and phenomenon to reward knowledge and experience; it empowers learners' higher-order thinking, curiosity and creativity (Alexander & Murphy, 1998; American Psychological Association, 1995; Kapp, 2012; Schunk, 2012). Intrinsic motivation is important because it reflects learners' interests which enhance learners' higher-order thinking and cognitive processing and performance (Alexander & Murphy, 1998; Schunk, 2012). Intrinsic motivation is inspired by the novelty of a task, the difficulty of a task, and personal interests which stem from learners' choice and control (American Psychological Association, 1995). Some researchers also talk about extrinsic motivation that comes not from the participants' desires, but rather it comes from outside influences, such as a high score within a game (Kapp, 2012). Some technologies employ this principle and others do not use extrinsic motivation.

The third principle of motivation is the effect of motivation on effort. Acquiring new knowledge, skills and experience requires expanded learner effort and requires guidelines and a strategy on how to achieve these (American Psychological Association, 1995).

Motivation helps learners to gain knowledge successfully and supports cognitivism by helping learners to obtain the best understanding possible about the knowledge they are looking for and are interested in discovering.

2.4.2 Cognition

In this section, this research focuses on acquiring information and enhancing understanding concerning subject concepts during learning. This can help learners to build knowledge successfully. This, in turn, has an effect on learners' academic performances. This research emphasises higher-order thinking, such as critical thinking and problem solving.

2.4.2.1 Higher-order thinking

In any learning system, an educator needs to ask the following question: 'Where do we begin in seeking to improve human thinking?' (Houghton, 2004). This research supports using gaming technology in order to enhance higher-order thinking and learning experiences in academic libraries.

The following are some examples of higher-order thinking:

- Critical thinking: this involves a high level of information use rather than just collecting data. Critical thinking involves a variety of knowledge fields that contribute and add to knowledge (Gerber & Scott, 2011). Moreover, it involves appropriate reasoning to determine whether or not a claim is true (B. N. Moore & Parker, 2009).
- Problem solving: this involves using knowledge and information with support from critical thinking to create a solution (Huang, Rauch, & Liaw, 2010)
- Concentration: this is the initial element associated with learning steps and process and represents the power of the mental process when it comes to engaging in knowledge acquisition (Yang & Chang, 2013).

Bloom (1956) and L. W. Anderson and Krathwohl (2001) have explained lower-order thinking and higher-order thinking which has helped to obtain a better understanding of the level of thinking required for academic performance.

2.4.2.1.1 Bloom's taxonomy

Higher-order thinking is related to Bloom's taxonomy. In this categorisation, the first three stages represent lower-order thinking, specifically knowledge, comprehension and application, while the next three stages represent higher-order thinking which are analysis, synthesis and evaluation (Forehand, 2005).

Benjamin Bloom created his taxonomy in 1956. Bloom's taxonomy 'is structured into categories and classifies academic educational objectives and cognitive ability' (L. W. Anderson & Krathwohl, 2001; Bloom, 1956).

Bloom's taxonomy defines the levels of understanding. It starts with the basic beginner levels of understanding and then it moves from one level to another, until it reaches the highest degree of understanding and the most profound. The taxonomy includes six fundamental levels which are knowledge, comprehension, application, analysis, synthesis and evaluation (L. W. Anderson & Krathwohl, 2001; Bloom, 1956; Petty, 2006).

L. Anderson et al. (2000), Spring (2010) and Wilson and Wilson (2013) defined Bloom's taxonomy levels. The first level is knowledge (remembering); at this level, a person recalls or recognises relevant information, ideas, procedures and theories from the long-term memory. Comprehension (understanding) is the second level; in this level, the learner translates and interprets information and also summarises, compares and explains information. The third level is application (applying); at this level, the learner works through procedures to determine the extent of the benefit of this information, so that it is applied and added to, or rejected by, learners whether or not it is related to the leaner's needs. Moreover, the application level includes the employment of information for a particular situation that meets the needs of the learner. The fourth level is analysis; at this level, the learner separates and disassembles complex information into its basic parts and then, in order to understand and organise information as well as identify the relationships between the different parts of the information, makes links between hypotheses and facts. In addition, the fourth level connects relevant and extraneous variables. At the fifth level, namely synthesis, the learner uses old information to create new information. In addition, at this level, the learner links relevant information from multiple locations. This level depends on the learner's ability to collect, draft, design, innovate and organise information in order to achieve the learner's requirements. The final level is evaluation, where the learner assesses the

information and makes a judgment concerning the ideas and the chosen checks based on discussion, debate and substantiated reason, thus giving the learner the ability to evaluate, decide, select, discriminate, compare, order and rank the information in order to meet the learner's needs.

L. W. Anderson and Krathwohl (2001) revised Bloom's taxonomy and changed its terminology, structure and emphasis. The terminological changes included altering the six stages or levels from nouns to verbs and changing the highest level of thinking from evaluation to creating.

Old version

Evaluation
Synthesis
Analysis
Application
Comprehension
Knowledge

New version

Creating
Evaluating
Analysing
Applying
Understanding
Remembering
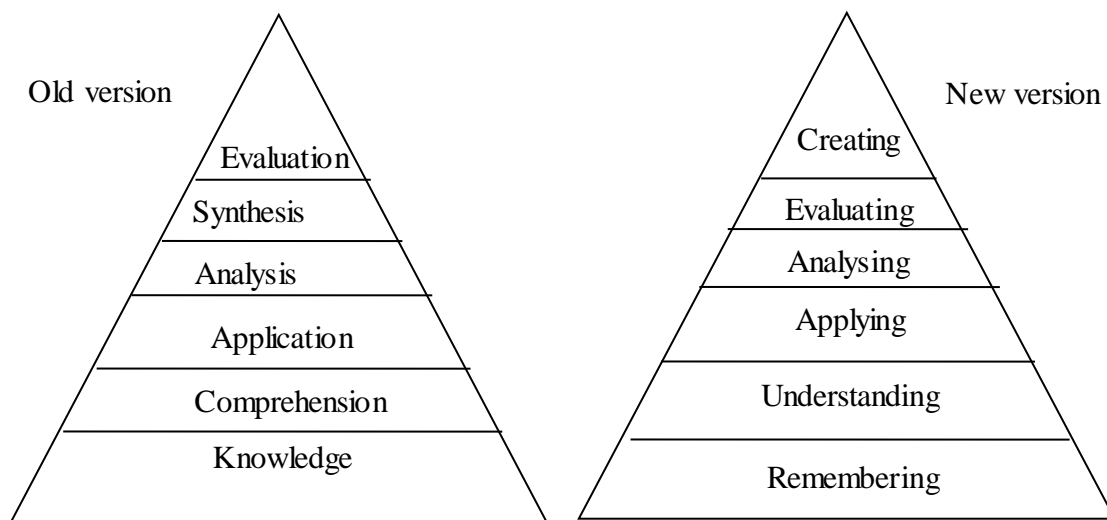
Figure 2.3 Terminological changes from the old version of Bloom's taxonomy to the new version (Source: Forehand, 2005)

According to L. W. Anderson and Krathwohl (2001, pp. 67-68), the stages in the new version can be characterised as follows:

Table 2.2 Bloom's taxonomy (Sources: Anderson & Krathwohl, 2001, p. 68; Bloom, 1956; Spring, 2010)

Remember	Retrieve relevant knowledge from long-term memory	• Observation and recall of information • Description of key concepts • Ability to list, define, describe, show, identify, etc.
Understand	Construct meaning from instructional messages, including oral, written and graphic communication	• Understanding information • Grasp meaning • Translate knowledge into a new context • Ability to describe, interpret, distinguish, differentiate, associate, etc.
Apply	Carry out or use procedures in a given situation	• Use information • Use concepts and theories in new situations • Ability to apply, experiment, calculate, discover and demonstrate.
Analyse	Break material into its constituent parts and determine how the parts relate to one another and to the overall structure or purpose.	• See patterns • Organise parts • Ability to select, explain, analyse, connect, compare, etc.
Evaluate	Make judgment based on criteria.	• Verify value of evidence • Recognise subjectivity • Make choice based on reasoned argument • Ability to assess, decide, select, discriminate, compare, rank, grade, etc.
Create	Put elements together to form a coherent or functional whole, recognise elements in a new pattern or structure	• Use old ideas to create new ones • Relate knowledge from several areas • Generalise from given facts • Ability to integrate, modify, design, create, compose, formulate, etc.

Furthermore, L. W. Anderson and Krathwohl (2001) altered the structure of Bloom's taxonomy, changing it from one dimension to two dimensions. The first dimension focuses on the cognitive process, while the second is concerned with knowledge. The cognitive dimension includes the

six stages in Bloom's taxonomy: remember, understand, apply, analyse, evaluate and create. The knowledge dimension contains the following four categories: factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge. The two-dimensional taxonomy enhances the measurement of the learning progress and the testing of hypotheses by adding objectives and activities in relation to the cognitive abilities and knowledge that the researcher or instructor wants to improve, as shown in Table 2.3.

Table 2.3 The two-dimensional version of Bloom's taxonomy (Source: Anderson & Krathwohl, 2001, p. 92)

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyse	5. Evaluate	6. Create
A. Factual Knowledge						
B. Conceptual Knowledge						
C. Procedural Knowledge						
D. Metacogni-tive Knowledge						

The third change should be given special emphasis since the new version can be used acceptably for large-scale populations and for different purposes and because it can be used to generate a curriculum and a methodological plan; furthermore, it may be used as an assessment tool (oz-TeacherNet, 2001). As a result, the new version of Bloom's taxonomy is employed in this research to measure the effects of gaming technology on higher-order thinking. In addition, it will help compare the effects of textbook learning and game-based learning which is dependent on gaming technology. Bloom's taxonomy supports learning experience and this research focuses on critical thinking and problem solving because of their importance in higher learning.

2.4.2.1.2 Problem solving

Problem based-learning is a significant method for learners because it motivates learners and enhances creativity (Schunk, 2012).

Learners face problems when they attempt to reach their goal. Learners are required to think in order to implement an effective strategy to acquire knowledge and to face challenges effectively. Learners can figure out a solution, establish an objective or answer a question (Chi & Glaser, 1985; Schunk, 2012). According to Schunk (2012, p. 299), 'problem solving refers to people's efforts to achieve a goal for which they do not have an automatic solution'. In problem solving based on learners' knowledge and skills, learners set goals that they try to attain, then break the goal down into sub goals and achieve the goal by undertaking cognitive and behavioural activity in order to solve the problem (Schunk, 2012).

There are several methods for utilising problem-solving strategies. Poyla (1957) established a problem-solving method that is based on four steps: (1) understanding the problem by finding information and then supporting problem solving by finding related information; (2) creating a plan based on connecting the information a learner has and unknown information; (3) executing a plan by breaking the problem into sub-problems to use as a strategy in order to find a solution, and (4) checking that the solution solves the problem and examining if it is an effective result.

The IDEAL method created by Bransford and Stein (1984) is similar to Polya's method. IDEAL is based on 'Identify the problem, Define and represent the problem, Explore possible strategies, Act on strategy, and Look back and evaluate the effects of your activities' (Schunk, 2012, pp. 302-303). Alternatively, the CPS model provides a three-step method for problem solving: 'understanding the challenge, generating ideas, preparing for action' (Schunk, 2012, p. 303). From these three methods, one can adopt the following problem-solving process: (1) identify the problem; (2) understand the challenge; (3) create ideas and a strategy from existing experience; (4) implement the strategy; (5) establish the solution, and (6) evaluate the solution.

In brief, higher-order thinking, which is based on critical thinking and problem solving, supports analysing information then evaluating information in order to create an effective knowledge that enhances academic performance.

2.4.2.1.3 Critical thinking

Critical thinking is a significant topic for academic performance in modern learning. Moreover, critical thinking is the main factor and thinking skill that allows students in universities to be successful (Schafersman, 1991). Education has two thinking aspects: the first aspect concerns 'what to think', that is, what makes a learner spend his effort and energy to gain knowledge; the second aspect concerns 'how to think' which concerns critical thinking (Schafersman, 1991). This leads to a definition of critical thinking.

According to Schafersman (1991, p. 3), 'Critical thinking means correct thinking in the pursuit of relevant and reliable knowledge about the world. Another way to describe it is reasonable, reflective, responsible and skilful thinking that is focused on deciding what to believe or do.' Critical learners can ask an appropriate question, collect relevant information and then sort the information effectively to create reasonable, logical, reliable and trustful knowledge that supports the learners in being successful in their life and studies. Critical thinking is about critical search and inquiry. Asking challenging questions to investigate problems and establish novel answers can lead to discovering new information and knowledge which can be used for different and specific purposes (Cottrell, 2005; Schafersman, 1991).

Furthermore, according to Cottrell (2005, p. 1), 'Critical thinking is a cognitive activity associated with using the mind. Learning to think in critically analytical and evaluative ways means using mental processes such as attention, categorisation, selection, and judgment'. Critical thinking is the rational way of discovering evidence by using a particular set of techniques. In addition, it supports identifying apparent and hidden messages accurately as well as providing a clear understanding more accurately and an understanding of the process required to construct an argument (Cottrell, 2005). This led Yeh (2003) to establish a particular measurement for critical thinking levels (Yang & Chang, 2013).

According to Yang and Chang (2013, p. 337), measurement of critical thinking (Yeh, 2003) has five levels:

1. Recognition of assumptions: the ability to identify statements or claims implicit in general premises.
2. Induction: the ability to infer the most likely outcome from known facts.

3. Deduction: the ability to use reason to draw a necessary conclusion from two given premises.

4. Interpretation: the ability to determine which phenomena or causal relationships are implied by given statements.

5. Evaluation of arguments: the ability to assess the strength of an argument.

Effective critical thinking has several benefits: (1) it increases awareness and observation; (2) it makes learners focus their reading and searching; (3) it enhances learners' ability to identify the significant points rather than confusing them with less important aspects; (4) it enhances the ability to react to the suitable aspect in a message; (5) it improves learners' skills to present their points in an effective and efficient way, and (6) it empowers learners' analysis skills and analysis ability in different situations (Cottrell, 2005).

The next section will look at the memory process and how it is used for understanding and learning effectively.

2.4.3 The structure of memory (cognitive load)

There is a significant relationship between learning and psychology which, in turn, affects learning models and theory. According to Wilson and Wilson (2013), '[The] psychology discipline studies how information is proc stored in short-term memory (STM) and long-term memory (LTM), and the conditions that impede learning'. As a result, an understanding of the structure of memory and the cognitive load theory helps in the implementation of an efficient learning theory.

Human memory and the mental processes' system are considered to include three components: sensory memory, short-term memory and long-term memory (Atkinson & Shiffrin, 1968). Sensory memory takes less than one second and primarily works as a buffer for information entering the brain through the senses and organs such as eyes and ears. Attention, which can be focused or separated, is the technique that causes received information to then be processed by the short-term memory (J. R. Anderson, 2000).

2.4.3.1 Short-term memory

'Short-term memory performs two critical functions: maintenance and retrieval. Incoming information is maintained in an active state for a short time and is worked on by being rehearsed

or related to information retrieval from long-term memory' (Schunk, 2012, p. 183; Unsworth & Engle, 2007).

Short-term memory has two main processes and is controlled by a third. The first is the visuospatial sketchpad that processes visual information such as shapes and spaces. The second process is the phonological loop, attention, which processes language and speech. Then, a central executive control applies the previous two processes and swaps between them. Baddeley (2000) added a fourth process, the episodic buffer, which merges new information from sense memory with constructs from long-term memory.

However, short-term memory has two main problems: firstly, short-term memory holds only a limited quantity of information at a time and, secondly, information can be lost quickly from short-term memory (Hattie & Yates, 2014).

Using gaming technology may affect short-term memory and may help to improve short-term memory's capacity to perform well during learning.

Cognitive load measurement takes place in the short-term memory and will be measured based on evaluating effort, difficulties and performance (this is explained in section 2.3.8).

2.4.3.2 Long-term memory

Long-term memory works as an archival library where data are stored for retrieval (Schunk, 2012). Long-term memory recognises links between new information and available information (which has already been learned) to create a frame of information that can be retrieved from the long-term memory (Wilson & Wilson, 2013).

Long-term memory has some problems. According to Hattie and Yates (2014, p. 122), 'The major problems of the long-term memory system hinge around three aspects: (a) the sheer difficulty of loading information into the system, (b) the need to develop efficient encoding strategies that enable inputs to be fully processed and interpreted in such a way as to relate to what the head already knows, and (c) the need to use retrieval strategies which enable ease in accessing stored memories'.

Research can discover if gaming technology can support long-term memory through affecting cognitive load and thus help to solve long-term memory problems.

In conclusion, memory structure and its factors influence learning. It is important to support the memory with effective and suitable tools that can enhance acquiring and creating knowledge in order to assist students to perform well during their academic life. Technologies can play a significant role in supporting and enhancing learning.

A learning-through-gaming environment would be incomplete without some explanation of human-computer interaction (HCI) to explain participants' interaction with gaming technology. The next section does this and then reviews and defines the learning theories that are appropriate for learning though gaming technology.

2.5   Human-Computer Interaction (HCI)

According to Hewett et al. (1992), 'Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them'.

Human-computer interaction (HCI) research has had a significant effect on enhancing the use of new technologies and network systems in learning and training (Churchill et al., 2013).

HCI has a main role in creating and developing products to foster the everyday technologies that people use (Grudin, 2005). HCI is concerned with the role of technology that can be used as a learning tool if it is valuable, consistent, ideal, useful, usable and ethical (Churchill et al., 2013). It is within the realm of this research to discover if gaming technology can support learners in acquiring knowledge, in improving skills and in enhancing attitudes to learning effectively.

Although HCI focuses on usability, HCI research drives and expands its growth by developing systems and applications that meet users' needs by providing emotionally appealing, attractive and suitable challenges and content for users (Churchill et al., 2013).

Researchers, psychologists and sociologists have all worked to discover the effects of technologies on users' human characteristics, capabilities and traits. Moreover, researchers want to explore the helpful technologies that bring advantages for users and avoid those technologies that have disadvantages for users. Researchers are looking to provide successful paths for using technologies for different purposes by discovering effective interaction scenarios and developing new technologies that enhance users' capabilities. HCI research has played a

significant role in education by using HCI to establish educational programmes as required by using technologies such as gaming technology and e-books (Churchill et al., 2013).

Most HCI research is based on quantitative methods that use experiments which have shown the effect of technology and independent variables on learners by using dependent variables. HCI research can also use a qualitative method and interviews can be conducted to collect data. The majority of HCI research measures the time taken to achieve a task as well as using subjective and objective measurements (MacKenzie, 2013). This research has measured time, has used interviews with observation techniques for subjective measurement and has supported both these by using the face reader system for objective measurement in order to measure learners' emotions.

2.5.1 Human factor

HCI research includes looking at the human factor. The human factor has three elements: sensors, responders and a brain.
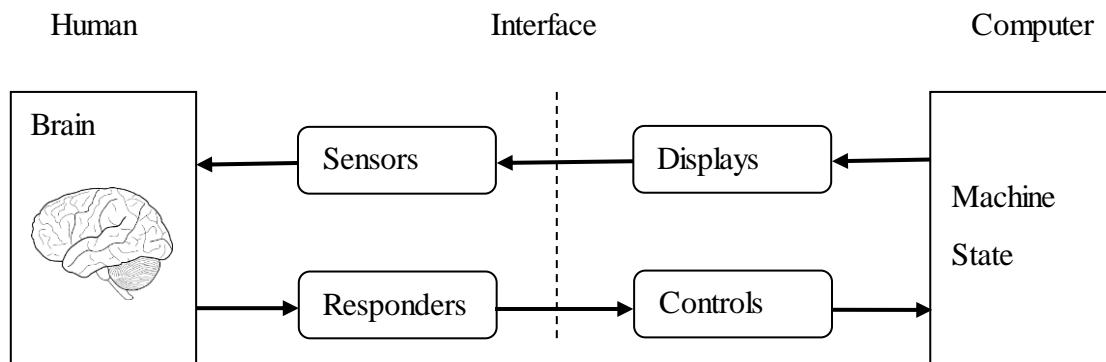
Figure 2.4 Human factor: view of the human operator in a work environment (Source: Mackenzie, 2013, p. 30)

2.5.1.1 Sensors

Sensors are the five human senses (vision, hearing, taste, smell and touch). Sensors help to transfer information to the brain which then acts by responding to the information and interacting with the system (MacKenzie, 2013). The first sense is vision which uses eyes to process information which is given to the brain. It is the most important sensor because most learners gain 80% of information and knowledge through vision. Vision transfers information via neurological signals to the brain through the optic nerve (MacKenzie, 2013).

The second sense is hearing which comprises the response to sound and the discovery of sound types and their sources. Hearing has several steps and process: (1) sound is transmitted via the surroundings as a sound wave; (2) sound waves arrive at the human ear/the ear drum; (3) the drum then creates nerve impulses, and (4) impulses are sent to the brain.

The third sense is touch which uses sensory receptors in the skin, muscles, bones and joints (as well as feeling temperature and pain) to provide information and send it to the brain to respond to phenomena. In HCI, touch is used when using tools and physical objects; for example, fingers use a keyboard, mouse and touch screen to interact with a system such as a computer, mobile or tablet (MacKenzie, 2013).

The fourth sensor is smell which is the ability to recognise odours and aromas.

The final sensor is taste which relates to the ability to identify flavours as sweet, sour, salty and bitter.

Most of these sensors work together when learning is undertaken through computers and similar devices.

2.5.1.2   Responders

While using computers and playing games, learners use their responders to control and empower the learning environment. Learners can use their limbs, such as fingers, to click on a mouse and type on a keyboard. They use their eyes to obtain information by moving their eyes around and focusing on some important parts of screen, and they can use their voice to talk about what they have learned through playing the game and also for communication (MacKenzie, 2013).

2.5.1.3   The brain

Brains have billions of neurons that help to process information and respond to performing tasks. According to MacKenzie (2013, p. 44), 'The brain provides humans with a multitude of capacities and resources, including pondering, remembering, recalling, reasoning, deciding and communicating'. Human sensors work as inputs regarding information and the responding work provides outputs of action and interaction with the computer system.

The first step in perception is processing information via the senses from the environment to the brain as input information, then analysing the information by using previous knowledge to

produce new knowledge that is stored in long-term memory for future use. Thinking, reasoning, analysing and deciding in the brain leads to cognition which includes achieving goals, for instance, using the brain's problem-solving ability to perform tasks and reach goals. Cognition can also include the social process to obtain knowledge (MacKenzie, 2013), for example, a learner presses keys on a computer keyboard to achieve a learning task through gaming technology.

Cognitive abilities are related to memory processes after interacting with the computer system and transferring knowledge to the brain via senses and memories to acquire understanding.

According to MacKenzie (2013, p. 48), 'The memory is the human ability to store, retain and recall information'. Memory has several kinds of memory within it, but the two effective ones are long-term memory and short-term memory which support each other in understanding and creating new knowledge. Long-term memory is the repository for information that is stored to support short-term memory. According to MacKenzie (2013, p. 48), 'Long-term memory is an active area for short-term memory or working-memory. The contents of working memory are active and readily available for access'. This means short-term memory works to merge previous information and experience with new information, to obtain this information/experience from the human sensors in order to understand, and then to create new information to store in long-term memory.

As a result, when learners use their sensors, responders and brain and respond to a computer system, such as gaming technology or e-books, this may indicate they are performing learning goals effectively and increasing academic performance.

2.6   Online learning (e-learning)

In the new digital world, students need to be prepared to face new world challenges by gaining knowledge effectively which can help them to achieve in their academic lives (Cobb, 2013). For example, online education has become an important learning tool. E-learning has increased within organisations and institutions in order to enhance worker and staff knowledge as well as their skills. Organisations use e-learning as a part of their training. According to Cobb (2013, p. 3), 'More than 70% of trade and professional associations deliver at least some of their continuing education offerings online'. Moreover, in the information age, 93% of teenagers have

a computer and Internet access at home (Entertainment Software Association, 2011; Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013). E-learning has increased from 48.8% in 2002 to 70.8% in 2014 (Allen & Seaman, 2015). For example, Harvard and MIT offer free online college-level courses (Cobb, 2013). Open education has become one of the most important ways of getting an education. Cobb (2013, p. 3) stated, 'Online education is now a juggernaut; more than 6.1 million current college students took a web-based course in fall 2010'.

Students prefer online learning because it is flexible and it gives students the opportunity to choose a convenient time and place for learning (Holliday, 2016). The use of e-learning for learning has become important in meeting learning requirements in the 21st century and will do so on into the future. In addition, online learning requires effective tools and resources to grow (Holliday, 2016). E-learning also needs new resources that can support previous resources in order to develop and to support learning by making it flexible, interesting and engaging, and this could be done by implementing gaming technology (Holliday, 2016).

Online education has become one of the most important learning tools. E-learning has increased in universities, organisations and institutions in order to enhance students, faculties and staff knowledge as well as their skills. Organisations use e-learning as a part of their learning and training departments.

The government of Malaysia is occupied with using online learning and developments in technology and planned to convert 50% of educational and learning material into e-content by 2015 (Subramaniam, Nordin, & Krishnan, 2013). Malaysia's government provides online learning for engineering students, an example of which is that 46 students attended the online learning management system (PowerPoint presentations) and exchanged articles with their online classmates (Subramaniam et al., 2013). Subramaniam et al. (2013) found significant performance output in terms of using online learning, for example, 50% of students used their mobile phones to access online learning, 87% of students preferred to attend an online classroom and 70% of users emphasised that online learning enhanced their knowledge.

The University of Alabama in Birmingham (UAB), USA, used online learning for the first time in 2007. Their target was to create complete online platform courses for environmental public health (EPH) doctors (McCormick & Pevear, 2013). The online classes were named 'Environmental Public Health Online Courses (EPHOC)' (McCormick & Pevear, 2013, p. 52).

The result from 355 surveys made of the students on these courses showed that 60% mentioned that their online class had increased their knowledge and improved their performance. Moreover, 90% of students passed their exams after using online courses (McCormick & Pevear, 2013, p. 53). Online materials encourage analysis and synthesis which relate to higher levels of thinking skills (King, Goodson, & Rohani, 2009, p. 12).

The use of online learning leads to finding tools and resources that can be used effectively for learning in order to make learning fruitful and efficient.

2.6.1 Technological tools and resources for e-learning

New technologies will become the main tools that enhance learning (Goodyear & Retalis, 2010). New technology makes the learning environment flexible in terms of size and arrangement and this has a significant influence in the transfer of learning from halls and lecture rooms to a technological environment. Moreover, new technology is concerned with the creation of a flexible and multi-method environment in order to build an authentic learning experience (Valenti, 2015).

Technology designers for higher education work to find solutions for managing some important concepts for learning through using technology, such as personalisation, involvement and feedback which students need for their learning experience (Valenti, 2015).

There are various types of technologies which can be used to support learning concepts. For example, e-books can make reading resources available for students in any place and at any time. Additionally, gaming technology can play a major role in improving learners' knowledge and performance during learning.

2.6.1.1 E-books

E-books are digital forms of textbooks that can be used and read on different types of electronic devices and platforms, such as PCs, tablets and mobiles. E-books have some features and benefits that make them attractive tools; for example, e-books include related links and search options; they use multimedia; they include an online dictionary and they have citation functions (Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013; Schomisch, Zens, & Mayr, 2013). All these features make e-books very effective learning tools.

E-books have become usable tools in universities. According to Mulholland and Bates (2014), 80% of students at the University of Liverpool use e-books through the library system which means that e-books have become essential sources of information in learning. Clay (2012) has pointed out that, in the recent years, e-books, rather than printed books, have been used efficiently by students and faculty members in universities through the academic libraries' systems.

E-books have certain benefits that make them acceptable in the learning environment. These benefits are: (1) e-book availability: it is possible to have 24/7 access to a library system and to read e-books; (2) they can present the reader with related findings and similar subjects; (3) they provide users with citations; (4) they can help users search by using keywords (Mulholland & Bates, 2014; Renner, 2007); (5) e-books provide a wider selection for learners at a low cost (and are sometimes free); (6) e-books can enhance user information and the research experience by using technology and an e-book reader; (7) e-books give students the opportunity to access the same book without any problem (Renner, 2007); (8) e-books are easy to carry, easy to download and easy to use by taking advantage of features such as searching for a word or phrase via a search tool and using a touch screen, and (9) learners have the opportunity to highlight and write notes in an e-book and this increases its usability and allows student to interact with the screen of the device thus making learning more interesting (Y.-L. Chen, Fan, & He, 2012; Cumaoglu, Sacici, & Torun, 2013; Denoyelles, Raible, & Seilhamer, 2015; Hanover, 2103; Waller, 2013). In brief, for these reasons, e-books are acceptable to learners and they can be further improved by using links to audio, video and chatting tools in order to discuss ideas and concepts.

If they can be linked with new technology, e-books can be even more useful. According to Rickman, Von Holzen, Klute, and Tobin (2009), 'Any textbook can be a more powerful learning resource if augmented with review quizzes, recommended and targeted review reading, interactive learning activities, or video segments to reinforce important instruction concepts. These enhance learning resources, which are much easier to integrate and deliver in the e-textbook format, and have the potential to accelerate student learning'. Denoyelles et al. (2015) suggested that e-books should be made more interactive by adding some features such as quizzes. Waller (2013) pointed out that e-books can be linked to educational websites and interactive websites to encourage student participation, collaboration and engagement. Such

suggestions (and others similar) will lead to work on developing learning environments by improving e-books and making them a more interactive tool by adding links to other technology tools and resources or adding new technological resources that have an effective influence on learners, such as an audio book, YouTube or gaming technology.

There are, however, some disadvantages of e-books. For example, an e-book can be expensive (Y.-L. Chen et al., 2012) but this problem can solved because there are free e-books that can be read through the academic library system. Moreover, e-books have an impact on users' eyes if used for a long time (Y.-L. Chen et al., 2012; Renner, 2007; Waller, 2013). Furthermore, there have been some technical problems, such as a limited battery life (but this particular problem has been solved by creating new long-life batteries that can work for several days). There have also been connection problems, but now the Internet is available just about everywhere (Waller, 2013). Overall, e-books can be developed to meet learners' needs and abilities and they can be supported by the new technologies.

As a result, e-books have an important role in improving learning in education by being an available information resource for academic purposes. While using new technology in learning is important in order to meet students' expectations, the e-learning environment needs to improve its resources by using effective technology, such as gaming technology.

2.7   Gamification

Gamification supports using gaming technology for serious approaches, such as in business, learning and training (Van Eck, 2015). According to Prince (2013, p. 162), 'Gamification is a new technology that incorporates elements of game play in nongame situations. It is used to engage customers, students and users in the accomplishment of quotidian tasks with rewards and other motivators'. Moreover, gamification is about using games in learning to make learning interesting and fun, as well as providing an environment that is encouraging and engaging, providing stories for concepts to make learning simple and easy, and providing opportunities for autonomous learning (Kapp, 2012).

Gamification can make a revelation in learning. According to Van Eck (2015, p. 22), 'Gamification can make significant improvements in education quality by adopting the effective synthesis of learning strategies used by digital games'. Nevertheless, there is a need for well-

designed games to avoid confusion, and the need for excellence in implementation and system availability (Van Eck, 2015). Hence, gamification will play a significant role in learning in the future due to the benefits of gamification.

For example, gamification can give meaning to experiences by making participants test their knowledge and skill in a safe environment and this supports not only participants' motivation, but also successful and effective learning (Kapp, 2012). In addition, gamification can help learners think out-of-the-box which supports creativity. Also, gamification arouses curiosity by encouraging participants to believe that their knowledge is incomplete and needs to be enhanced (Kapp, 2012). Gamification is a way of using gaming technology in learning to make learning more effective.

The use of gaming technology in learning has been growing rapidly thanks to the discovery of the effects of gaming on the learning process and on learners' attitudes (Deterding, Björk, Nacke, Dixon, & Lawley, 2013). Universities and higher education institutions have embraced gamification for teaching and learning. As 'students are expected to think critically in order to solve problems, gaming technology can be leveraged in any discipline to reinforce the real-world applications of concepts' (Johnson et al., 2013, p. 21).

Accordingly, gamification used in a library encourages students to engage with the library, and this has a positive influence on academic achievement: the more a library is used, the more its resources and services enhance students' knowledge (Walsh, 2014). Gaming technology can enhance experience and skills which help to practice knowledge and can increase engagement. Overall, gaming technology has had an influence on learning and the impact of gaming technology in learning needs further research.

In brief, gamification has become important for learning, especially online learning. Moreover, an academic library can play a significant role by providing gamification services for e-learning and gaming technology as an e-resource in the library. Gaming technology has its advantages and disadvantages when it comes to the impact it has on learning and it has been shown to have an influence on learners' attitude, cognition and memory during learning.

Furthermore, gamification can be used in an academic library to support academic performance beyond e-books and other technologies. Gamification can be provided in libraries to increase

fruitful activity and enhance effective learning. The following section uses previous research to explain this impact.

2.7.1 Gaming technology

Gaming technology has become a new-generation tool for entertainment and can be an effective learning tool. The main factors of a gaming technology environment are interest, enjoyment and fun which can be used to measure learner engagement and performance in achieving learning objectives in an interactive environment (K. Kiili et al., 2014; Squire, 2011). Having a learning objective in a game environment requires a designer to utilise challenges as well as enhance engagement and interaction with the game in order to achieve learning goals.

Statistics show that 72% of people in the United States of America play computer and video games at home. Furthermore, according to the Entertainment Software Association (2011), 68% of parents in the United States of America found gaming technology supported mental stimulation and 57% of parents found playing games strengthened family relationships by family members spending more time together. Cognition is needed to explore and observe game strategy and this can be especially useful for learning. Games can be adapted for learning and become an effective tool for e-learning.

Gaming technology includes several types of games such as video games, simulation games and 3D environments. These can be used in a learning environment to support and enhance learning. Gaming technology can have an impact on learning in that it can be an effective tool and e-resource in the future.

Gaming technology can have some disadvantages, such as causing confusion for participants and distracting them from their learning target (Gee, 2005). In addition, gaming technology can waste time (K. Kiili et al., 2014). Moreover, gaming technology needs to be well-designed in order to avoid boredom or anxiety. In addition, Van Eck (2015) found that gaming technology needs more development because he found, in his research, that learning through games is not suitable for all participants. Sometimes learners obtain better results when they get their information from lecturers and books.

On the other hand, gaming technology has many benefits, such as providing an opportunity to undertake an event or phenomenon and creating an interactive environment between the system

and the user that is interesting due to the game's simulation. In addition, users play games for a challenge, for immersion and for the connection with the system and with other users (Buchanan & Vanden Elzen, 2012). Although gaming technology focuses on activity, gaming technology can also be used to support experience (Becker, 2013) when users practice their skills and knowledge in a gaming environment.

Gaming technology has a significant effect on a player and has various uses (Beck, 2004). Gaming technology can play a significant role in learning because 79% of teenagers between the ages of 12 and 17 have used gaming technology (Lenhart et al., 2008). This finding is significant because it indicates that future users will have grown up with gaming technology. New generations have embraced technologies, including gaming technology, thus making it important to implement gaming technology in order to enhance and support learning in the future (Friedl & O'Neil, 2013). The Pew Report (Lenhart et al., 2008) recommended using gaming technology within education to improve the worth of learning.

Gaming technology can use 3D to create a virtual interactive environment that allows users to be involved in the system and to achieve a specific task. Using 3D technology for learning encourages learners to engage and interact with the learning environment to build knowledge, skills and experiences (Richards & Taylor, 2015).

The 3D environment has become popular and is used by many people, especially in learning (Chittaro & Ranon, 2007; John, 2007; Monahan, McArdle, & Bertolotto, 2008; Pan, Cheok, Yang, Zhu, & Shi, 2006; Rauch, 2007). There are several advantages in using a 3D environment in learning. The first advantage is that it gives learners the opportunity to be involved in activities which improve their knowledge and experience (Hanson & Shelton, 2008). The second advantage is that a 3D environment uses real-time interaction which means that the system responds to any action immediately. Learners can also cause changes in the system depending on their commands and actions (Huang et al., 2010). A 3D environment also gives users the opportunity to utilise nearly all the human senses (Burdea, 1999). A 3D environment helps users solve problems and provides a solution for training and for teaching concepts and skills to any student. Furthermore, it supports creativity which leads to a high level of problem solving and thinking. Technology provides tools, such as a 3D environment, that can improve cognitive learning by engaging learners (Jonassen, 2000).

According to research, gaming technology has a significant influence on how users learn. For example, gaming technology used in medical learning has had an effective impact on learning concepts and improved medical skills (Heather, 2010; Jeffries, 2005; Rieber et al., 2009). The Al-Ahsa College of Medicine in Saudi Arabia used simulation to improve surgical skills and found it more effective than books and texts (Abou-Elhamd, Al-Sultan, & Rashad, 2010). Moreover, using gaming technology for training military pilots has proven to be an effective tool in improving pilot skills (Bell & Waag, 1998). Gaming technology involving movement can also be used in sport training in colleges and universities (Neely & Tucker, 2013). Gaming technology can provide activities and can mimic real action or event scenarios. It has become one of the most effective factors in teaching and building skills (Neely & Tucker, 2013). Thus, gaming technology enhances learners' experience and skill levels; this is the important advantage of gaming technology.

Gaming technology in academic libraries gives individuals an opportunity to try out scenarios that cannot be used in real life (Friedl & O'Neil, 2013). Virtual simulation games can evaluate student learning outcomes by measuring their achievement through the system (Neely & Tucker, 2013). As a result, a 3D environment can be implemented as a learning tool to improve knowledge, skills and experience.

Although gaming technology within teaching may be fun for users, its main target is to support the understanding of tasks and improve cognition. Gee (2003) has recognised that teaching and learning objectives can be achieved by using gaming technology to complete some long, composite and hard tasks. Moreover, using gaming technology, Gee discovered the principle that games can support successful learning and develop effective experiences (Gee, 2003). Furthermore, games enhance desirable attitudes through emotional and cognitive reactions from interacting and getting feedback from a game. In addition, Gee (2005) noted that gaming has three benefits which are empowered learners, problem solving and understanding.

The benefit of gaming technology, according to Gee, is an empowered learner. Games give users experience by offering them an interactive system in which to make decisions and perform various tasks. This promotes ownership within the users and motivates them to face the game's challenges in a flexible environment. Players learn the game's processes and methods to resist obstacles and solve problems in multiple ways which, in turn, empowers the users. According

to Gee (2005), using gaming technology successfully results in role and game characteristics that are influenced by social science, psychology and learning theory.

2.7.1.1 Influence of gaming technology on learning

In this section, the influence of gaming technology on learning will be further explained based on average behaviours that arouse learners' desires to learn as well as their cognitive needs for success in learning and the impact of gaming technology on memory.

Gaming technology supports independent learning. According to McBride (2014, p. 133), 'learning-by-doing or an active learning environment fostered by computer/video games makes the learning experience much more exciting, rich and ongoing'. Furthermore, gaming technology gives participants opportunities to solve gaming challenges in multiple ways that make the game flexible and to perform tasks for different levels of skills. Gaming technology supports learners who have a low level of achieving tasks in enhancing their skills (Van Eck, 2015). Thus gaming technology enhances attitudes such as independent learning and the motivation to learn. Furthermore, the availability of the Wi-Fi network also encourages developing learning experiences because it widens access to technology (such as gaming technology) (Huer, 2015; Valenti, 2015).

Moreover, gaming technology is fun and interesting and this enhances ability and motivation based on interacting with a game and making information and knowledge clear and coherent. It also gives learners opportunities to repeat the game context (Pivec & Dziabenko, 2004).

Annetta (2008) found that educational gaming technology enhances learner motivation, supports engagement with a learning environment, increases interest to an enjoyable level during learning and, in particular, enhances intrinsic motivation. K. Kiili (2005, p. 192) found that game-based learning 'arouse[d] intrinsic motivation' which has an important impact on learners in learning and in enhancing their knowledge, skills and experiences. Also, game based learning encourages learners to learn and improve knowledge, skills and experience independently. Furthermore, Ciampa (2014) and Mozelius (2014) found that gaming technology enhances intrinsic motivation. Moreover, gaming technology has an external effect in increasing extrinsic motivation because it has challenges and provide scores (Kapp, 2012; Nicholson, 2012; Zichermann & Cunningham, 2011). However, Nicholson (2012) suggested that gaming

technology can reduce intrinsic motivation because it is replaced by extrinsic motivation. This supports the need to have well-designed and effective games that relate to the needs of the users.

Well-designed games motivate participants to learn. Mayo (2009) found that a well-designed game enhanced learning between 7% and 40% over traditional learning (such as lectures) and helped participants to develop their understanding and improve their grades. Moreover, gaming technology also has an effect on cognition and helps to enhance understanding, critical thinking and problem-solving ability.

Gaming technology can enhance understanding. Players can use and apply the experiences and skills that they have gained in developing a plan to overcome challenges and difficulties (Gee, 2005; Mayo, 2009; Tobias, Fletcher, Dai, & Wind, 2011). Accordingly, they build a better understanding by using their imaginations and skills within the rules in order to achieve the task and reach a specific target. Tobias et al. (2011) pointed out that gaming technology stimulates participants' educational skills based on cognitive abilities such as mathematics, spelling and reading, physics, health and medicine, and computer science. Also using visual aids such as pictures and animation can enhance attention as well as helping to organise and map knowledge.

Previous research demonstrates the significant advantage of gaming technology in enhancing and promoting the higher-order thinking which is important for 21st-century learning, such as critical thinking and problem solving (Hays, 2005). Moreover, Clark, Tanner-Smith, and Killingsworth (2014) found that game-based learning is better than conventional instruction in supporting cognition and in improving understanding.

Furthermore, one of the important benefits of game-based learning is problem solving. Games are based on problems that users face while playing the game. These problems require the players to learn the rules of the game. In addition, the games challenge players to create an effective strategy for solving the problems as well as increasing their proficiency in performing the task efficiently. As a result, game-based learning enhances a player's problem-solving abilities (Gee, 2005, p. 10).

Games offer a wealth of experiences for learners when synthesising information to learn and solve problems, and they also support the cognitive process (McBride, 2014).

Rosas et al. (2003) discovered playing computer/video games improves learners' performance and enhances cognitive abilities and higher-order thinking skills, such as critical thinking and problem solving. Moreover, playing computer/video game increases motivation and a higher level of curiosity towards learning. It also increases attention and concentration. Additionally, gaming technology can provide a better understanding if the cognitive load is low, which supports learning.

According to K. Kiili et al. (2014), gaming technology can minimise the cognitive process which can help to improve participants' performance and help them to understand and gain knowledge effectively.

Thus, games can be used to improve learners' knowledge and attitude. They can be used effectively and successfully in formal education, such as within the military, in health care, medicine and physics, as well as in a training setting (Pivec & Dziabenko, 2004). In addition, games can be used in higher education in universities to support academic performance.

2.8   Academic Libraries' role

The library is one of the most important institutions both in education and in terms of the enhancement of people's skills in the information age. It is an important destination for people who are seeking critical and accurate information. Libraries improve people's information and knowledge. People use new technologies in order to access information by using the Internet, mobile phone applications, Web 2.0 and social media. For instance, mobile applications and the Internet can be used to access a library's resources and services at any time from any location. Furthermore, social media can be used to ask and answer questions and contribute to discussions. An academic library provides services via technology.

The next paragraphs explain some of the academic libraries' services.

2.8.1   Academic libraries' services

The advanced/advancing development of computers, technology and communication enhances the reform of academic libraries' services and collections which, in turn, affects the way that learning is undertaken in schools and universities.

Academic libraries are influenced by new technologies. Information science researchers employ new technologies and networks within academic library information systems in order to provide and/or improve library services so as to meet users' expectations and their requirements. As a result, academic libraries use technologies such as the Internet, mobile phone applications, cloud computing, Web 2.0 and social media. They are continuously improving their systems in order to meet users' needs and expectations.

Academic libraries are required to serve the majority of people in the academic community who are seeking information. Technology can be used to build an interactive relationship between users in academic communities and academic libraries by using an efficient information system that supports learning. According to the The Society of College National and University Libraries (2014) Report 'The library is not just a repository, or a service like any other, or a place for study: *it is all these things*. It can also be a partner in research and in teaching, and institutions which fail to capitalise fully on this asset will find it harder to compete in the future'. Academic libraries in the future will be different with regard to their services, goals and information systems. Academic library information systems in the future will help to increase the library's role in learning and education. Moreover, academic library systems will support online learning. Technology in future academic library information systems will provide opportunities to improve and develop learning resources and tools for academic communities. For example, virtual reality will play an important role in improving academic library services.

2.8.1.1 Virtual reality in academic libraries

Technology has had an undeniable impact on libraries and, as such, libraries work to improve their role by implementing different kinds of technology. Academic libraries use virtual environments to support their services. Libraries use virtual reality for several purposes, such as for collaboration among groups in different locations so that they can discuss and negotiate important issues and concepts in addition to submitting group members' agendas. This has helped to increase face-to-face meetings through virtual environments (Cocciolo, 2010; Gantt & Woodland, 2013). Moreover, virtual reality is used to access collections and resources such as law, medical studies and health within libraries (Gantt & Woodland, 2013). Furthermore, virtual reality in libraries supports discussion groups and social gatherings that can empower a community to improve their knowledge and their use of library collections and services (Gantt

& Woodland, 2013). The virtual reality environment can provide libraries with the opportunity to use an avatar for their reference services. The avatar will meet people face-to-face in a virtual environment in order to answer their queries (Buckland & Godfrey, 2009). In addition, libraries can apply virtual reality to enhance experiences with regard to, for example, some fiction and stories from past (such as information on the 19th century) which can help users understand how communities lived and were socially structured during that time (Gantt & Woodland, 2013). Such experiences will contribute to building effective understanding and support the cognition of the library user.

Gantt and Woodland (2013) raised important questions on how libraries can provide information in a virtual reality environment to help their users. High-quality technology and its features will encourage e-learning as part of an academic library system alongside a variety of e-resources that support learners' needs and interests in order to for them better achieve in the academic world.

The next section focuses on e-learning services in academic libraries.

2.8.2   Academic libraries' online learning services

The advanced development of computers, technology and communication enhances the reform of library services and collections which, in turn, affect the ways learning is accomplished in schools and universities. Digital libraries have become concerned with learning models in the library in order to support education and research needs (Uzoka & Ijatuyi, 2005).

The new era for academic libraries will probably see changes from libraries in a physical location with traditional services to online-environment libraries that implement online courses and classes to fulfil future knowledge requirements and learning objectives (Duncan, 2008; Uzwyshyn, Smith, Coulter, Stevens, & Hyland, 2013). For example, the American Public University System (AUPS) has created a virtual academic library to serve their users effectively. They provide traditional services plus online classrooms. They also provide online tutorials in addition to a physical student studies' centre to serve current and future users' needs and expectations (Uzwyshyn et al., 2013).
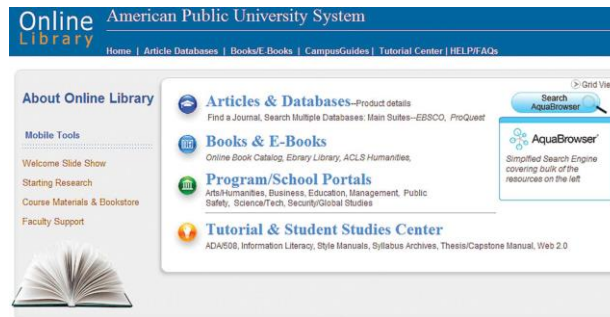
Figure 2.5 American Public University System online library's main portal, 2012 (Uzwyshyn et al., 2013).

The role of academic libraries has been developed to support learning objectives which will increase library usability and the use of both old and new services. For instance, the American Public University system's usage has grown from 18 students in 1993 to more than 120,000 students in 2012 (Uzwyshyn et al., 2013).
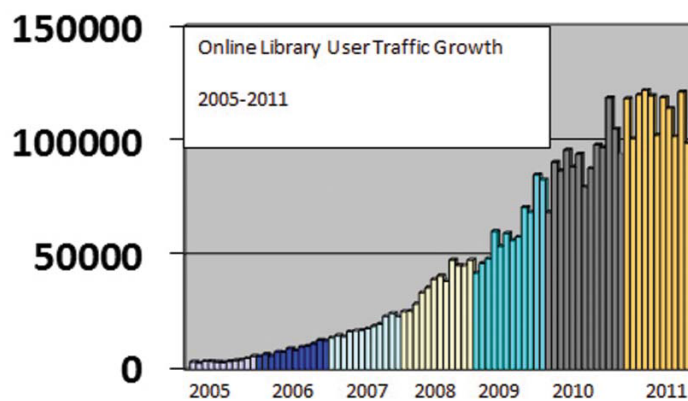
Figure 2.6 American Public University System online library user traffic: 2005–2012 (Uzwyshyn et al., 2013).

Academic libraries in the future will provide a new model for the 21st century by applying technology to serve learning by supporting faculty, staff, teachers, students and researchers via virtual environments, and by supporting online learning. Libraries need to recognise useful technology in order to provide effective learning and to successfully run practical library systems. Libraries have the opportunity to provide a massive number of resources for online learning that cannot be found in physical classrooms (Uzwyshyn et al., 2013). Although libraries use technology to retrieve information and resources, libraries can also employ technology for learning, for example, cloud-computing technology uses infrastructures for a variety of applications and also saves online class material. Furthermore, Web 2.0 and social media such

as Facebook, Twitter, LinkedIn and YouTube are used to answer questions and provide discussions and can affect learning achievement by enhancing a high level of thinking (Daluba & Maxwell, 2013).

Technology can lead libraries towards developed digital resources and tools and to thus further serve academic communities by making such information and resources readily available. Such a service can be more flexible and fulfilling than traditional library systems. Technology can also serve learning objectives by providing access to an academic library's system. This could lead to the use of gaming technology in academic library systems to enhance learning services via e-learning so as to support students as they learn in a university setting.

Hence, academic libraries can use different types of technology for learning purposes; however, the main e-resource is e-text and the e-book. Gaming technology can be applied through academic library systems to support e-learning (by using attractive tools and sources) in order to enhance learning as knowledge is acquired effectively.

The next sections focus on e-resources such as e-books and, especially, on the impact of gaming technology in learning.

2.8.3   Using gaming technology in academic libraries

According to Becker (2013, p. 201), 'Reference and instructional librarians should already be familiar with some of the learning principles that Gee describes'. Moreover, libraries can use gaming technology to support learning and teaching objectives. For example, an academic library can use a game to teach research skills by requiring users to go to the topic of interest. Then the game could teach users how to control field vocabulary which helps in searching the database. The game could also address how to minimise the problem of excessive resources in order to focus on the main subject. Finally, the game could help users understand what they need for the research topic. The use of games in different types of libraries has increased since 2008 (R. T. Brown, 2014; Levine, 2008). Technology plays an important role in improving and growing the use of games. Gaming technology enhances communication and interaction between learners and libraries. All in all, gaming technology can provide an effective learning resource for learning.

2.8.4   Using gaming technology as an e-resource

Games play an important role in libraries. They can entice users to visit libraries and induce patrons to use effective resources and services in addition to enhancing engagement between library users (Nicholson, 2013). Games have been used in libraries by organisations such as chess clubs since the 19th century (Nicholson, 2013). According to Nicholson (2013), many libraries provide puzzles, quizzes, toys and collections of games to support courses, sessions, classes and research needs, as well as assisting teachers (Nicholson, 2013). An academic library should pay attention to providing digital games in order to improve technological skills and enhance users' experience (Nicholson, 2013). Nielsen (2014) suggested that gaming technology can support distance learning and e-learning through an academic library system to make online learning useful and helpful in understanding concepts. This supports the view that gaming technology can play an effective role in academic libraries to support learning.

Indeed, an academic library has a mission to provide services such as online learning and to provide resources such as e-books. An academic library has a significant role in using gaming technology for e-learning (Miltenoff, 2015) and it can be an e-resource for online learning. There are several reasons for an academic library to develop and provide gaming technology for education. Among these are: (1) an academic library serves students, faculty members and staff in a university which indicates that the library has an influence on learning; (2) an academic library provides short courses that can be supported by interactive environments, such as gaming technology which supports the curriculum process; (3) the librarian(s) can be consulted by academics when developing gaming technology in order to support the curriculum and enhance academic performance (Miltenoff, 2015).

Academic libraries can improve their learning services by using gaming technology resources in engaging learners in improving their knowledge and thus, by so doing, empower and enhance their learning behaviour and higher-order thinking (Gantt & Woodland, 2013).

With influences from both learning theories and psychology, there is a need to implement a gaming technology environment in libraries to serve learning concepts and to enhance users' behaviour and thinking in order to support their academic performance.

2.9   Summary

This chapter has provided definitions for learning and the learning process which enhances knowledge, skills and experiences. It has reviewed the learning theories that help to explain the learning process and to assess the learning outcome. The chapter looked at the constructivism theory and the cognitive load theory that will be used to measure the use of gaming technology and e-books in learning. This led to defining the learning factors that need to be tested and investigated through this research. Moreover, this chapter reviewed online learning, its tools and resources such as e-books and gaming technology. It defined gamification concepts and discussed research work on the impact of gaming technology in learning. Furthermore, this chapter reviewed the role of academic libraries and their services. The chapter also looked at the impact of technology on the role of academic libraries and their services. Additionally, the chapter explained the technologies that are used in academic libraries (such as virtual reality and gaming technology) which can be used as an e-resource for learning and for academic purposes in order to develop the library services and resources for future learning.

The next chapters will explain the methodology, the research design, the conceptual framework and the game design that helped to accomplish the research aim.

Chapter 3. Research Methodology

The purpose of this chapter is to explain the research methodology that was used to undertake this research. The research onion model was used for the main approach. The chapter also presents details of the research methodology steps and process.

Methodology describes the path that is used to accomplish research. The methodology for this research is built on the Onion Model (Saunders, Lewis, & Thornhill, 2012) which contains several layers. The first layer, the fundamental one, incorporates the main philosophy for undertaking the research. Next, the approach layer shows the way to accomplish the research which includes the deductive, inductive and abductive approaches. The methodological layer comprises the quantitative, qualitative and mixed methods. This leads to the selection of the appropriate strategies to perform the research and to choosing suitable data collection methods and a data analysis strategy. Then, the time horizon and techniques are determined.
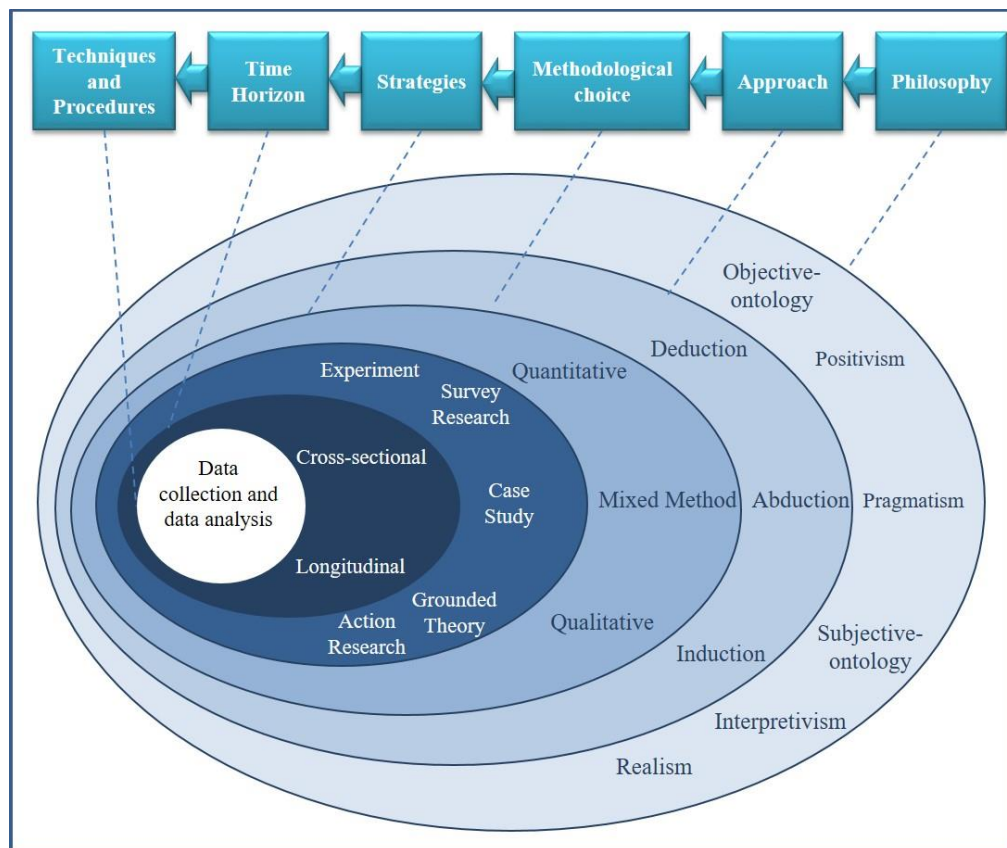
Figure 3.1 The Research Onion Model (Saunders et al., 2012).

3.1   Philosophy

Research philosophy focuses on the 'development of knowledge and the nature of knowledge' (Saunders et al., 2012, p. 127). Research philosophy covers significant assumptions about how the researcher views and assesses the world and reality (Saunders et al., 2012). Hence, research philosophy is about 'how a researcher views the world; his or her taken-for-granted assumptions about human knowledge and about the nature of the realities encountered, inevitably shape how the research question is understood and the associated research design' (Saunders & Tosey, 2013). There are numerous types of philosophical approaches, including ontology which concerns objectivism and subjectivism reality, as well as epistemology that includes pragmatism, realism, interpretivism and positivism. In addition, axiology shows the researcher's judgements about value within the research. Each of these philosophies is used for special purposes and the choice of philosophy depends on the research target (Saunders et al., 2012). To define the research philosophy, there are three questions that need to be asked. 'The three questions are: (1) What is the nature of reality? This is the ontological question concerning the nature and form of reality; (2) What is the relationship between the knower and the known? This is the epistemological question; (3) How can we come to know it? This the methodological question.' (Pickard, 2013, p. 6). The research philosophy is important for several reasons: (1) it supports the design of the research successfully and coherently; (2) it helps to choose an effective research design that is related to the research observations; (3) it enhances the research designer's ability by using a new research design that has not been used and is outside the researcher's previous experience (Esterby-Smith, Thorpe, & Lowe, 2002). In conclusion, research philosophy is based on ontology, epistemology, and axiology in order to define the research methodology steps, process, and layers. In the next section, the ontology, epistemology and axiology for this research will be defined.

3.1.1   Ontology

'Ontology is the nature of reality' (Bryman & Bell, 2011; Pickard, 2013; Saunders et al., 2012). It involves the researcher creating assumptions and questions about the manner in which the world functions and the obligation of a specific assessment for context (Saunders et al., 2012). There are two types of ontology: objectivism and subjectivism.

3.1.1.1 Objectivism

Saunders et al. (2012, p. 131) stated that 'objectivism represents the position that social entities exist in a reality external to and independent of social actors'. Objectivism is suitable for use with positivism to explain and test theories (Saunders et al., 2012). Bryman and Bell (2011, p. 21) stated that objectivism 'is an ontological position that asserts that social phenomena and their meanings have an existence that is independent of social actors'. As a result, objectivism focuses on realism which is 'a commonly experienced external reality with a predetermined nature and structure' (Sexton, 2003).

3.1.1.2 Subjectivism

Subjectivism focuses on social events that involve social activity. It is about the interaction between user, phenomenon and process, and it is used to understand situations, the influence of phenomena, and the reasons behind this influence (Saunders et al., 2012). Subjectivism is most effective when used with interpretivism (Saunders et al., 2012). In conclusion, subjectivism focuses on idealism, which is 'an unknowable reality perceived in different ways by individuals' (Sexton, 2003).

In this research, the researcher used two types of ontology. Subjective reality was observed by investigating learners' attitudes while using gaming technology and e-books in learning. In addition, objective reality was discerned by observing some statistical realities about the effect of using gaming technology and e-books on learning, such as measuring cognitive load and measuring the increase in curiosity by using a questionnaire that also measures learning factors by using close-ended questions in an interview. As a result, a suitable epistemology that can work with these two types of ontology was determined.

3.1.2 Epistemology: pragmatism

Epistemology is 'the philosophy of how we can know reality' (Pickard, 2013, p. 6). It focuses on satisfactory knowledge and information in the research field (Saunders et al., 2012). 'Epistemology as a branch of philosophy deals with the sources of knowledge. Specifically, epistemology is concerned with possibilities, nature, sources, and limitations of knowledge.' (Dudovskiy, 2011). There are several types of epistemology:

(1) positivism: which is used to achieve research based on logical reasoning and empirical methods. Positivism focuses on the nature of science, truth, meaning and general explanation. Positivism focuses on logical reasoning and ignores any relationship of interest to the participants and any behaviour and experience (Saunders et al., 2012);

(2) interpretivism: according to Pickard (2013, p. 13) 'interpretivism can offer an understanding of the meanings behind the action of individuals.' Moreover, Dey (1993, p. 110) stated 'from this perspective, meaning, depending upon context, and the interpretation of action or opinion must take account of the setting in which it is produced'. Interpretivism is concerned with social science and subjects because people are the subject matter of social science and social action;

(3) pragmatism: which is used to explain action and can combine positivism and interpretivism (Saunders et al., 2012). Pragmatism is the preferred method for research that utilises mixed methods (John W Creswell & Clark, 2011; Kelemen & Rumens, 2008)

Pragmatism was the preferred epistemology for this research because it is used for research pertaining to the support of actions, and this research is built on using gaming technology and e-books as actions in learning. Research questions are the main reason for choosing the pragmatism philosophy (Kelemen & Rumens, 2008) and the research question focused on the impact of learning through using gaming technology on learners' attitudes and cognition and this was compared with using e-books in learning. Pragmatism can be used effectively with multiple philosophical positions (Saunders et al., 2012, p. 127). This research has multiple philosophical positions regarding certain aspects of the research relating to positivism (such as cognitive load measurement) and other aspects relating to interpretivism (such as attitude). Furthermore, pragmatism focuses on practical results and findings when researchers believe, for example, that there are several ways of explaining a phenomenon and completing the research. This research tested learning theories such as constructivism and the cognitive load theory and, as such, this research used hypotheses and variables in addition to interviews to obtain a coherent and accurate explanation for phenomena. Pragmatism can make use of multiple methods or a single method to collect data and conduct research (Kelemen & Rumens, 2008) which supports the mixed methods' approach used in this research.

3.1.3 Axiology

Saunders et al. (2012) stated that 'axiology is a branch of philosophy that studies judgments about value'. It explores the role of the research process at different stages and how researcher value affects the accuracy of results (Saunders et al., 2012). The use of the pragmatism epistemology and the subjectivism type of ontology adds value to the research because the researcher interacts with participants while collecting and analysing (the data are value-laden). In addition, the use of the pragmatism epistemology and the objective type of ontology does not add any value to research and makes it value-free because, for example, when using a questionnaire there is no value to the participant while collecting and analysing data. Table 3.1 shows the research philosophy that was used for this thesis.

Table 3.1 Research Philosophies (Saunders et al., 2012, p. 140)

Philosophy	Pragmatism
Ontology The nature of reality	An external, multiple view chosen to help answer research questions.
Epistemology What constitutes acceptable knowledge	Either or both observable phenomena and subjective meanings can provide acceptable knowledge, depending on the research question. The focus is on applied research, integrating different perspectives to help interpret the data.
Axiology The role of value in research	Values play a large role in interpreting results and the researcher adopts both objective and subjective points of view which have both types of axiology: value-laden and value-free.
Data collection	Mixed or multiple method designs, both qualitative and quantitative.

Based on the above discussion, the research philosophy used for this research was objective and subjective ontology which led to the choice of pragmatism epistemology with the both value-laden axiology and value-free axiology. Figure 3.2 shows the research philosophy aspects of this research.
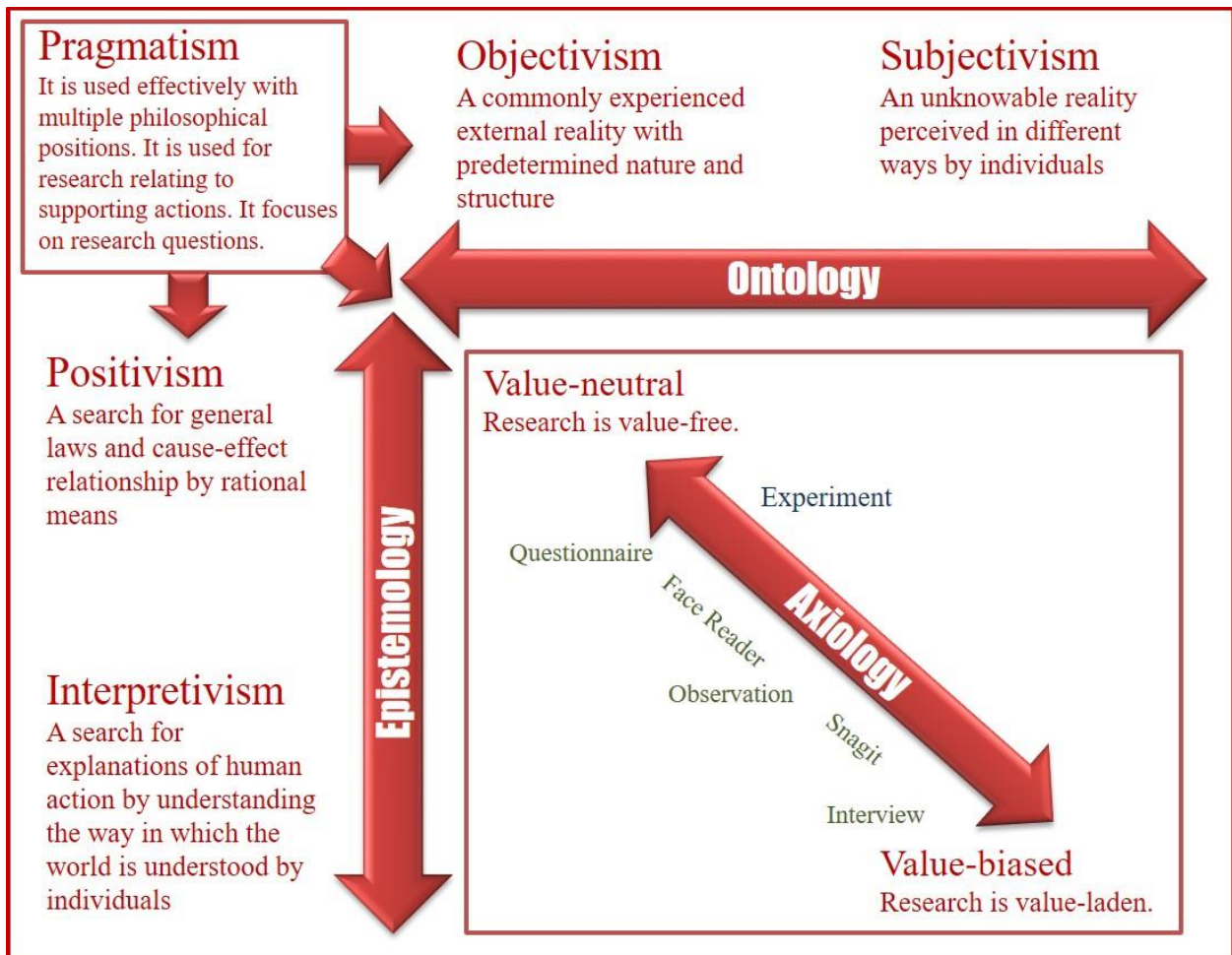
Figure 3.2 Relationship of research philosophy to methodology. This figure illustrates the relationship of the research philosophy to the methodology used for this research.

In conclusion, the choice of research philosophy had an initial impact on designing and creating the research methodology (Dawood & Underwood, 2010; Sexton, 2003) which led to decisions regarding the other research methodology layers. The next section discusses the research approach.

3.2   Approach

According to Saunders et al. (2012), there are three types of approach: deduction, induction and abduction. Each type of approach can work with different philosophical types, for example, deduction works very well with positivism and induction works effectively with interpretivism.

However, abductive can cover both the deductive and inductive approaches which can work with several types of philosophy.

3.2.1 Deduction

Deduction involves 'moving from theory to data' (Saunders et al., 2012, p. 147). This research moved from examining learning theories to exploring the impact of gaming technology on learners and comparing that with the impact of e-books on learners. Blaikie (2010) noted several steps for deduction. First, the researcher must set the idea, premise and factors to examine the relationships between the concepts to compose a theory. Then, based on the literature review and theory, the researcher defines factors and tests the factors and premise. Next, the researcher must test the premise and the literature review arguments that have produced variables and factors, then compare the results with the theory to check if it builds a clear understanding. After this, the researcher must examine the premise and factors to measure and analyse them. If the outcome is not consistent with the premise, the test has failed and the theory does not meet the research concepts. If, however, the results of the analysis succeed by meeting the theory concepts, the theory is confirmed. Deduction is used with quantitative research; it requires not only a highly structured methodology, but also a large sample to test a theory (Gill & Johnson, 2010).
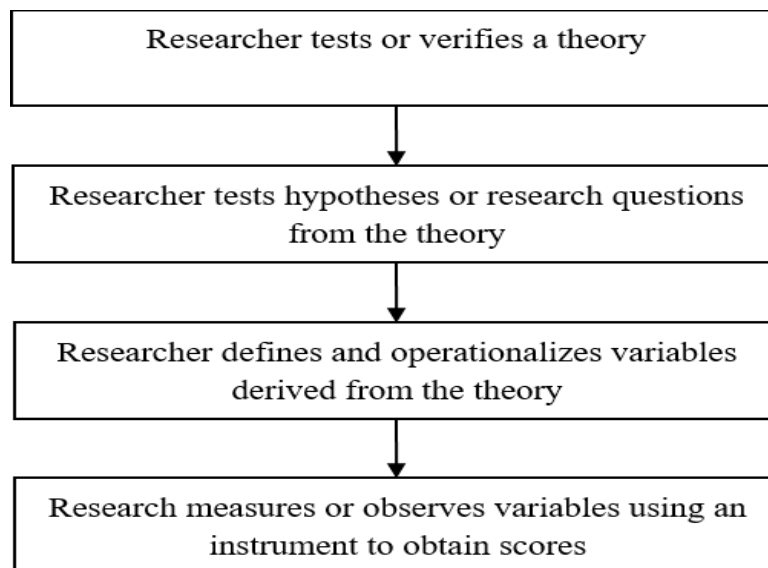
Figure 3.3 Deduction approach. This figure outlines the deduction approach (John W. Creswell, 2011, p. 57).

3.2.2 Induction

Induction involves 'moving from data to theory' (Saunders et al., 2012, p. 147). Induction is based on collecting data from specific phenomena to get a clear understanding of the problem; then, analysis of the data leads to the formulation of a theory (Saunders et al., 2012). Induction moves from the general to the specific. Induction is used with qualitative research. It does not require a highly structured methodology; accordingly, it requires only a small sample for data collection (Saunders et al., 2012). This research also collected data through interviews about the effects of gaming technology and e-books on learning and formulated the conceptual framework with factors that explained the process and the impact on learning.
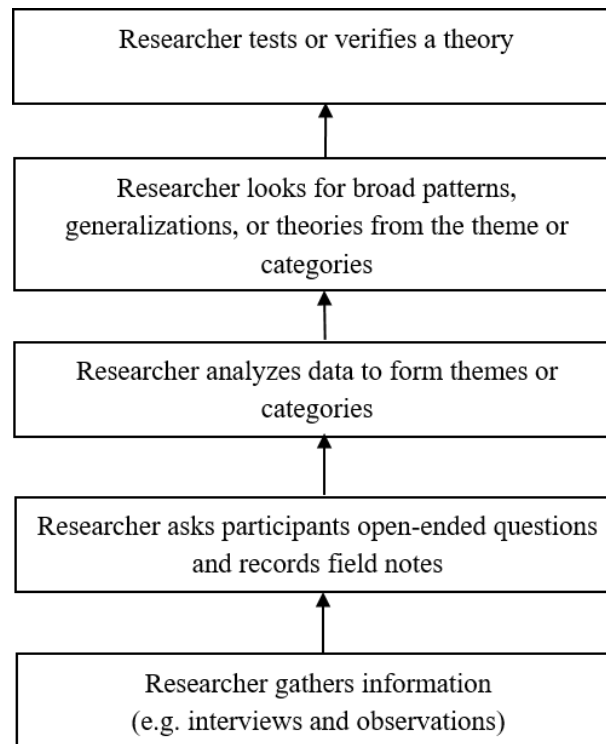
Figure 3.4 Induction approach. This figure outlines the induction approach (John W. Creswell, 2011, p. 63).

3.2.3 Abduction

According to Suddaby (2006), 'an abduction approach moves back and forth, in effect combining deduction and induction'. Abduction is used to observe the fact of either phenomena by using theories' concepts to test and observe the phenomena; then, results are used to build an

effective theory or model that can accurately explain real phenomena or events. According to Easterby-Smith, Thorpe, Jackson, and Lowe (2008), there are three reasons to use abduction:

1) It provides the researcher with an opportunity to make effective decisions about the research design, particularly with regard to data collection, data analysis techniques, research questions, and evidence.

2) It helps to find a research strategy and a research methodology that work effectively within the research study, and it helps to understand concepts relating to the phenomena.

3) It helps to establish hypotheses because it gives a complete understanding about research concepts and context; this is different from other approaches that require a one-way approach, such as from theory to fact (deductive) or from facts to theory (inductive).

The approach used in this research was abduction because it is based on testing theories and supporting them with new factors that are discovered by interview. The data was then collected and analysed to find suitable characteristics for use in game-based learning and text-based learning for university students. Figure 3.5 explains the research approach that was utilised in this research.
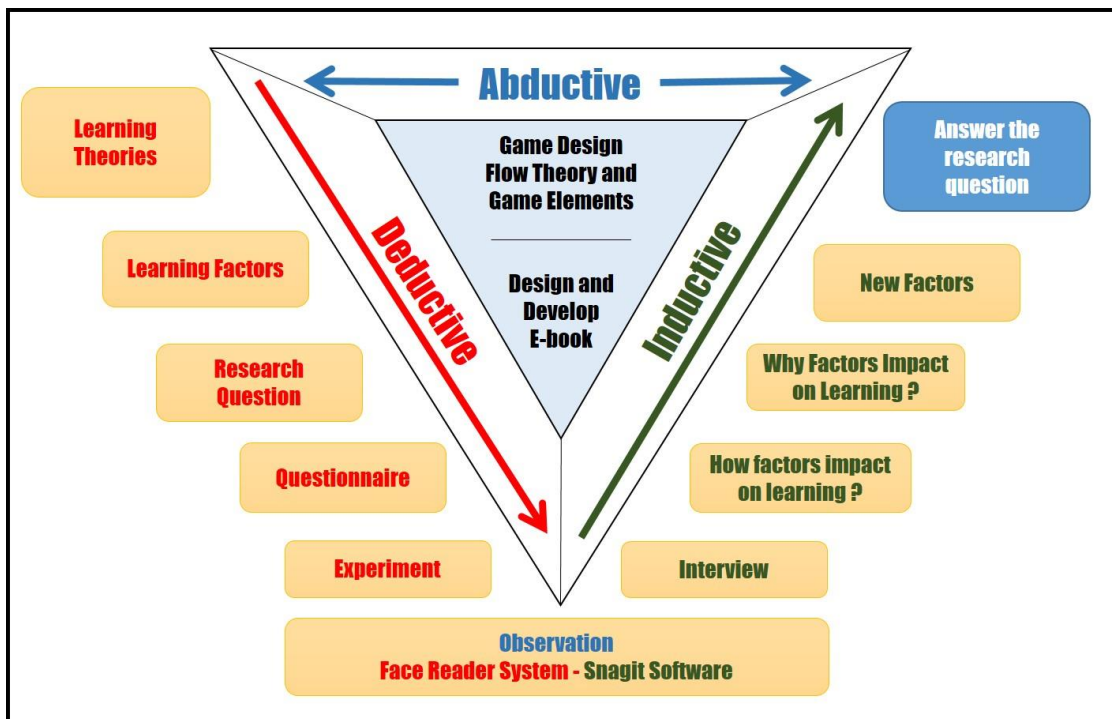
Figure 3.5 The research approach. This figure outlines the research approach used.

3.3   Methodological Choice

There are three major research methods: qualitative, quantitative, and mixed methods. Each method is used for a specific kind of research in order to meet the research targets and objectives (Saunders et al., 2012).

3.3.1   Quantitative

Quantitative research investigates the connection between research variables. Quantitative research is based on measuring numerical data and uses statistical techniques to analyse the data (Saunders et al., 2012). It is based on a theoretical framework derived from a literature review; the literature review helps the researcher to find the aims and objectives and to develop the research hypotheses (Dawson, 2013; Pickard, 2013). Quantitative research is used with positivism and a deductive approach to test theories. It can also use the inductive approach when creating a theory (Saunders et al., 2012).

3.3.2   Qualitative

Qualitative research is used to investigate behaviour, attitudes and experiences using data collection techniques such as interviews and focus groups (Dawson, 2013). According to Saunders et al. (2012, p. 163), 'qualitative research studies participants' meaning and the relationships between them, using a variety of data collection techniques and analytical procedures, to develop a conceptual framework'. Qualitative research uses interpretivism and the inductive approach to establish a theory or model (Saunders et al., 2012).

3.3.3   Mixed Methods

Research can adopt a 'mixed methods' approach. Research using mixed methods combines qualitative and quantitative methods in the research design to get a clear understanding of research concepts and exploration (John W Creswell, 2007; John W Creswell & Clark, 2011; Saunders et al., 2012). Moreover, the mixed methods approach uses more than one data collection technique because it needs both qualitative and quantitative data (John W. Creswell, 2011; Saunders et al., 2012).

This method has advantages and disadvantages. John W Creswell and Clark (2011) suggested the advantages in using mixed methods are:

1) A mixed methods approach offsets any research weakness and provides strengths for both quantitative and qualitative approaches.

2) Mixed methods support research by providing more evidence in the study of the research problem.

3) A mixed methods approach helps to explore and find answers for a research question that cannot be explored by a single approach, either quantitatively or qualitatively.

4) A mixed methods approach can connect and link the quantitative and qualitative approaches to bridge adversarial divides.

5) A mixed method research approach incites the use of a multiple world view rather than one view.

6) A mixed method research approach provides number and word explanations for the results and research findings; it is a practical method.

A mixed methods approach also has disadvantages which should be avoided when carrying out research. John W Creswell and Clark (2011) pointed out these disadvantages: A mixed methods research approach require some skills:

1) The researcher needs to have experience of both quantitative and qualitative methods.

2) The researcher needs to have a good understanding concerning data collection and data analysis techniques for both quantitative and qualitative methods.

3) The researcher requires an understanding of the quantitative fundamental issues of rigour in quantitative research, such as reliability, validity, experiment control, and generalisability. Additionally, the researcher also needs to understand the qualitative essentials, such as defining the phenomenon and identifying the research question.

4) A mixed methods researcher needs to manage time effectively. The researcher should be be acutely aware of the time required for collecting and analysing the data in both the quantitative and qualitative methods.

5) A mixed method approach requires having sufficient resources to support the research. The researcher needs to be concerned about the resources that help to collect and analyse data for both quantitative and qualitative research.

6) A mixed method approach may cost the researcher money. The researcher needs to be aware that expense can form part of the study; for example, these expenses could include printing, recording, transcription, and software costs.

Based on the previous advantages and disadvantages, a mixed methods approach was used because mixed methods could provide a clear understanding of the impact of using gaming technology on learning. John W Creswell (2015) suggested that a mixed methods approach can provide a clear explanation for a phenomenon and both the quantitative method and the qualitative method can support each other and overcome each other's weaknesses. Also, the mixed method approach helps to support the statistical results concerning the impact of gaming technology with explanations for people's emotions and behaviour, and it provides new factors and elements that can support the research results. A mixed methods approach was required because some themes and factors in the conceptual framework related to participants' behaviour and emotions which called for further explanation. On the contrary, however, cognitive load, the level of curiosity, autonomous learning and the level of understanding required statistical results for the best results. In general, a mixed methods approach was required to answer this research's questions accurately and coherently.

According to Saunders et al. (2012), using a mixed methods approach strengthens research because it delivers a rich view and approach to data collection and data analysis which, in turn, influences the findings and results and helps to answer the research questions. The mixed methods approach often has two phases of data collection and analysis: one phase relates to qualitative methods, while the second phase relates to quantitative methods (John W. Creswell, 2011; Saunders et al., 2012).

Mixed methods has two levels of design: the basic design which includes three types of design (convergent design, explanatory sequential design, and exploratory sequential design), and three advanced types of design (intervention design, social justice design, and multistage evaluation design). This research used the intervention design from the advanced level alongside explanatory sequential basic design because it was more appropriate for answering research questions as it merges quantitative with qualitative results to explain the impact of gaming technology and e-books on each of the theme's factors and to discover elements for the learning factors in the conceptual framework. It used experimentation as a quantitative method as well

as a questionnaire. Moreover, the research used interviews as a qualitative method. As John W Creswell (2015, p. 43) stated, 'The intervention design adds to one of the basic designs. The intent is to study a problem by conducting an experiment or an intervention trail and adding qualitative data into it'. Figure 3.6 explains the intervention with explanatory design that was utilised in this research.
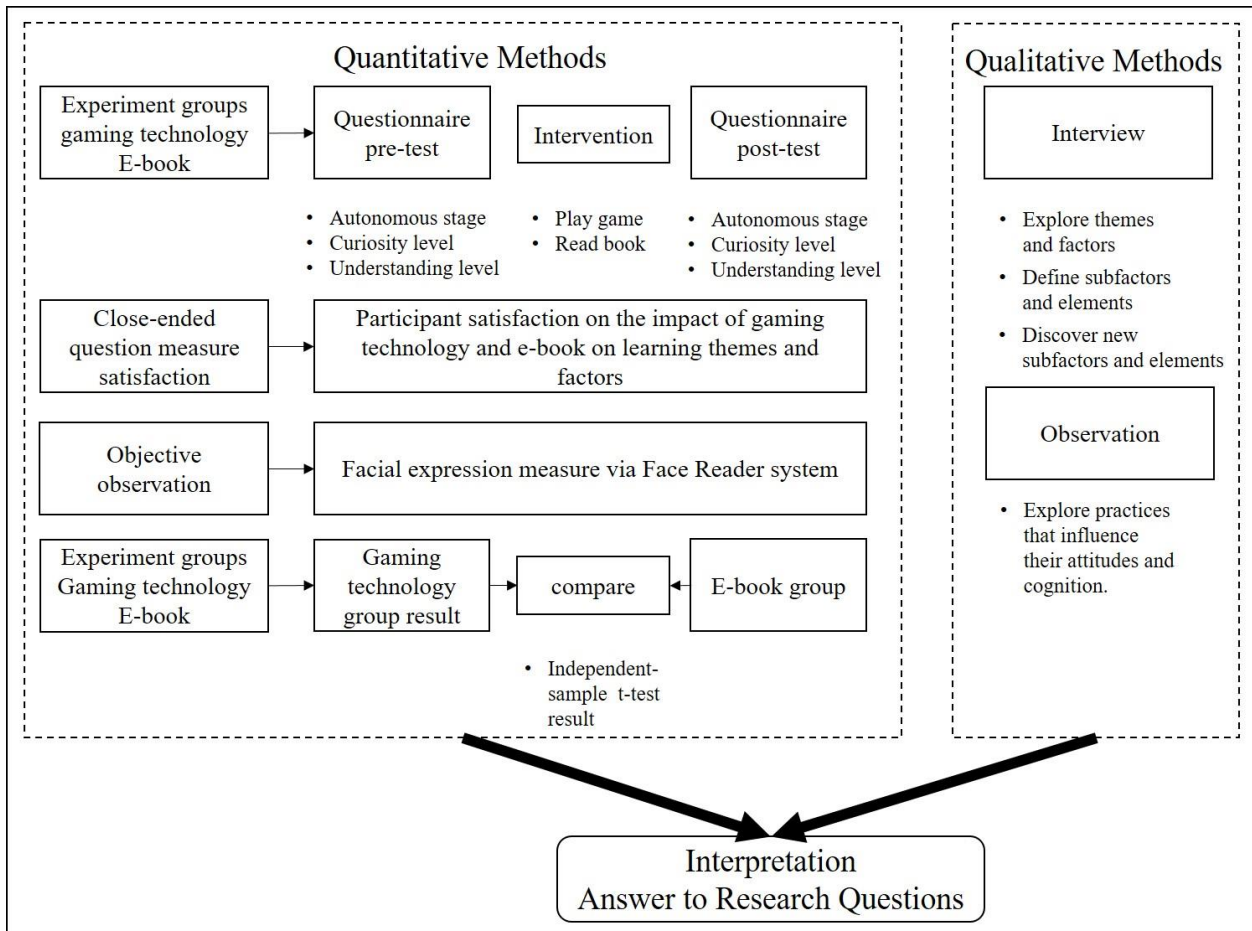
Figure 3.6 Intervention with explanatory mixed method design. This figure illustrates the intervention with explanatory design that was utilised in this research.

This research used a mixed methods approach. Data was collected by using quantitative experimental procedures in addition to individual interviews with the participants in the experiment which helped to explain the experiment outcomes and provide a complete understanding of the research problem (John W Creswell & Clark, 2011). As a result, a convergent mixed method approach was conducted to measure the impact of gaming technology on learning compared with the impact of e-books on learning. This led to the definition of the research strategy.

3.4   Research Strategies

Saunders et al. (2012, p. 173) stated that 'strategy is a plan of how a researcher will go about answering her or his research question'; it is a methodological path between the philosophy, the method, the data collection, and the data analysis to achieve the research aim and objectives (Denzin & Lincoln, 2005). The research strategy is selected based on the philosophy, approach, and methods used to answer the research question and in order to coherently meet the research objectives. Moreover, it is based on existing knowledge as presented in the literature review (Saunders et al., 2012). There are many types of strategy, such as experiments, surveys, archival research, case studies, ethnography, action research, grounded theory, and narrative inquiry (Saunders et al., 2012).

3.4.1   Experiment Research

According to Saunders et al. (2012, p. 174), an 'experiment is a form of research that owes much to the natural sciences, although it features strongly in psychological and social science research'. An experiment that requires measuring the change for an independent variable causes change for a dependent variable.

There are several kinds of variables:

- An independent variable (IV) 'is manipulated or changed to measure its impact on a dependant variable' (Saunders et al., 2012, p. 174). This means 'the phenomenon or situation is manipulated by the researcher' (Pickard, 2013, p. 120).

- The dependent variable (DV) 'may change in response to change on other variables, observed outcomes or results from the manipulation of another variable' (Saunders et al., 2012, p. 174). This means 'the behaviour or effect that is measured by the research as a result of manipulation' (Pickard, 2013, p. 120).

- The mediating variable is 'located between the independent and dependent variables, which explains the relationship between them' (Saunders et al., 2012, p. 174).

- The moderator variable is 'a new variable that when introduced which will affect the nature of the relationship between the independent variable and dependent variable' (Saunders et al., 2012, p. 174).

- The control variable is an 'additional observable and measurable variable that needs to be kept constant to avoid it influencing the effect of the independent variable on the dependent variable' (Saunders et al., 2012, p. 174).
- The confounding variable is an 'extraneous but difficult to observe or measure variable that can potentially undermine the inferences drawn between the independent variable and dependent variable. It needs to be considered when discussing results, to avoid spurious conclusions' (Saunders et al., 2012, p. 174).

An experiment tests research factors in order to examine theories rather than using a research question (Saunders et al., 2012).

Experimental research includes different designs, such as classic experiments, quasi-experiments, and within-subject designs. The classic experiment uses an experiment group and a control group. The two groups are similar, but the intervention is different, which allows the researcher to test and compare the experimental group to the control group in order to measure the research variables. The quasi-experiment also uses an experiment group and a control group, but the groups are different in some aspects which allows for the measurement of different aspects, such as age, gender, or profession. The within-subject design, however, requires only a single group (Saunders et al., 2012).

This study will use the classic experiment, creating an experiment group that uses game-based learning to test constructivism and the cognitive load theory. The control group will engage in textbook learning. Furthermore, the research will use a quasi-experiment to determine the influence of gender.

3.4.2 Experimental Design

This research will use the experiment strategy to discover and compare two types of learning, which are text-based learning and game-based learning, in order to find out the influence of gaming technologies on learning and on learners in the future when they pursue learning independently through an academic library system. The experiment will determine the influence of game-based learning on learners and ascertain if it will enhance their future autonomous learning via an improved learner attitude in order to enhance their cognition.

This research uses the experiment strategy for several reasons. The experiment strategy allows the discovery of the effects of independent variables on dependent variables, which is the purpose of this observation (C. J. Wu & Hamada, 2009). Moreover, the experiment strategy is used to improve systems such as product and process. Process can either be a physical phenomenon or a non-physical one, such as improving services and administration; it can be used in business, medicine, and social and psychological research (C. J. Wu & Hamada, 2009). The experiment strategy can examine the effect of gaming technology on learning by studying its impact on learners' attitudes, cognition, and memory and compare that impact with the effect of using e-books.

Experiment research requires four components: participants, materials, procedures, and measures (John W. Creswell, 2011). Each of these components is described in the following sections.

3.4.3   Sampling

This research used several subjective types of data collection which were experiment, interview, questionnaire, and observation. Additionally, an objective measurement based on the FaceReader system was undertaken. This collection of data was used to explore the effect of gaming technology on university learners' attitudes, cognition, and memory and to determine if it enhances learners' higher-order thinking. This data will be compared with the data collected from participants who used an e-book textbook instead of gaming technology.

Appropriate sampling is very important to accurately accomplish research data collection and analysis. Moreover, the purpose of sampling is to use the opportunity of utilising a small number of participants which will enhance obtaining the results quickly and in a specific manner (Saunders et al., 2012).

'The purpose of sampling theory is to make sampling more efficient. It attempts to develop methods of sample selection and estimation that provide, at the lowest possible cost, estimates that are precise enough for our purpose. This principle of specified precision at minimum cost recurs repeatedly in the presentation of theory' (Cochran, 1977, p. 8).

According to Dawson (2013), 'The number of participants depends on the type of research. For a large scale quantitative survey, you will need to contact many more people than you would

for a small qualitative piece of research. The sample size will also depend on what you want to do with your result. If you intend to produce large amounts of cross tabulation, the more people you contact the better. It tends to be a general rule in quantitative research that the larger the sample the more accurate your result. However, you have to remember that you are probably restricted by time and money; you have to make sure that you construct a sample which will be manageable.'

Moreover, according to Saunders et al. (2012), there is a 5% margin of error for the use of participants in a research study.

For the purposes of this research, 30 learners were needed to participate in the experiment and interviews and for the observation: 15 used the e-book and 15 used the gaming technology. The number of estimated participants was based on the t-test method because this research tested the independent variables that affect the dependent variables (Hulley, Cummings, Browner, Grady, & Newman, 2013). Moreover, the t-test method was used for estimating the effective sample size for the two groups, the experiment group and the control group. t-test is used to work with extremely small samples (Winter, 2013). Winter (2013, p. 1) pointed, out 'there are no principle objections to using a t-test with numbers as small as 2.'

The choice to use a small sample of participants may be made for several reasons. One relates to constraints of budget and time (Winter, 2013; Saunders et al., 2012). The research described herein involved experiments requiring at least 30 minutes with each participant while they completed a task, a questionnaire and an interview. Working with a larger sample would have meant taking an impractically long amount of time to collect and analyse the data, which would have been beyond the scope of this PhD programme.

Quantitative methods can be used in research to help define small samples. Herein, the *t*-test was selected as the method used to compare gaming technology and e-book technology. The *t*-test can reportedly be utilized with extremely small sample sizes (Winter, 2013). Winter (2013) investigated sample sizes ranging from 2–5 participants, and reported that acceptable power (80%) was generally reached, provided the effect size was very large. Thus, the *t*-test can be used to analyse data derived from small samples.

Notably, the two groups in the current study had similar participant roles and attributes (PhD students at the University of Salford). The data derived from each group was normally distributed and both groups exhibited equal variance. In addition, the same number of participants was used in each group, and the data were obtained from both groups in the same environment via the same research methodology. Collectively, these considerations support the use of the *t*-test to analyse the data derived from these small samples (Winter, 2013). Moreover, the data sets derived from both groups were normally distributed, and there were no statistical outliers.

Previously reported research methods were reviewed, and recommended methods of predetermining the required sample size for analysis via the *t*-test were identified (Winter, 2013; Hulley et al., 2013; Scott, 2013). Based on these recommendations, in the current study the required sample size was estimated via 'Power Sample' software which calculates the sample size required to achieve the predefined aims of the research, as explained below:

Previous research has used t-test used type 1 error with Power between 0.8-1 and has used t-test for a single group and two groups (Winter, 2013).

The t-test method uses certain factors to assist in identifying the appropriate number of participants (Hulley et al., 2013; Scott, 2013). These factors are:

1) Type of error: Type I errors refuse the null hypothesis and Type II errors do not reject null hypothesis (α)
2) Standard deviation (SD) (σ)
3) Power: the possibility of correctly refusing the null hypothesis in the sample if the population is equal to, or more than, the effect size
4) The rate of controlling the experiment participants
5) The difference in the participants' means (m)

Power and sample size (PS) software was used to calculate the sample size by entering all the factors required to estimate the number of experiment participants.

The researcher estimated the type of error to be 0.1, SD 0.9, power 0.9, the rate of controlling the experiment is 1 and the difference in the participants' means to be 1 to give the result below which indicated that there should be 15 participants for each group, thus 30 participants in total.

'We are planning a study of a continuous response variable from independent control and experimental subjects with 1 control (s) per experimental subject. In a previous study the response within each subject group was normally distributed with standard deviation 0.9. If the true difference in the experimental and control means is 1, we will need to study 15 experimental subjects and 15 compare subjects to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) 0.9. The Type I error probability associated with this test of this null hypothesis is 0.1' (PS software).

3.4.4 Participants

The appropriate type of research participants is essential in establishing a successful experiment, and it is the main component in deciding the experiment procedure (John W. Creswell, 2011).

This research utilised a convenient sample for the research. The researcher invited 30 Ph.D. students from different departments within the University of Salford to participate in the experiment: 15 learners for the experiment group using gaming technology and 15 learners for the comparison group, the e-book group. Each group went through steps to perform tasks in the experiment.

3.4.5 Variables

The experiment strategy requires independent variables to decide influence on dependent variables (Bryman & Bell, 2011). Moreover, the experiment group and the control group represented the effect of independent variables on dependent variables and, when the results were compared, the differentiation was discovered between the groups responding to the dependent variables. This research had both independent and dependent variables. The independent variables included text-based learning by using an e-book and game-based learning by using gaming technology. The dependent variables included attitude (autonomous learning, curiosity, and motivation); cognition that included higher-order thinking (problem solving and critical thinking), and the memory process which focuses on cognitive load and brain activities. Moreover, there were two control variables: curiosity level and autonomous level.
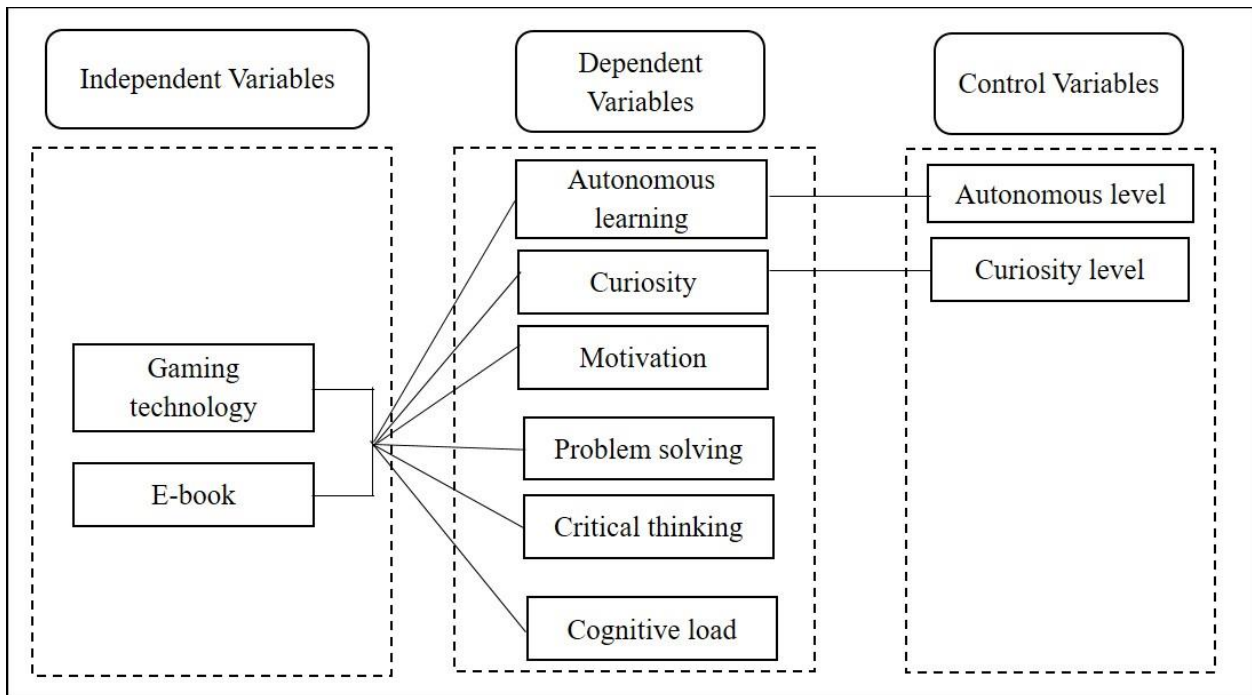
Figure 3.7 Independent, dependent and control variables. This figure illustrates the independent and dependent variables and the control variables of this research.

3.4.6 Instrumentation and Materials

Several types of experiment materials, including hardware and software materials, were used in this research. For instance, a computer was used in order to use a gaming technology platform and an e-book platform to perform the experiment's tasks. The research used Snagit software to observe learners' accomplishments during the experiment. Furthermore, the research adopted the FaceReader system for measuring learners' emotions during the tasks. All these materials support the validity and the reliability of the results (John W. Creswell, 2011).

3.4.6.1 Gaming technology platform

The author used a 'research methodology game' that explained the steps, layers, and processes involved in research methodology. Learners could acquire knowledge about research methodology through the game and they could practise to gain needed knowledge in the learning mode. Then, participants practised and tested their knowledge by using the playing mode to complete the game successfully. Moreover, learners obtained feedback from the game about their performance. In addition, participants needed to justify each step by filling in a justification

form. Finally, the game provided participants with a report about their performance. The research methodology game can help a learner discover the steps, layers and processes involved in research methodology, and explains the relationship between the layers. The game environment helps learners to explore research methodology by undertaking the game and interacting with the system. A learner can decide if the game helps in enhancing their knowledge, experience and skills.

3.4.6.2 E-book platform

The e-book is a PDF file that explains various aspects of research methodology. Within this research the e-book group participants read the PDF file that explains research methodology concepts via a computer. After reading the research methodology document, participants should have been aware of the different types of research methodology and should have been able to demonstrate research methodology layers, steps and processes. Subsequently, these participants should be able to accomplish tasks by creating and developing suitable and appropriate research methodologies for three different scenarios. The research compares the results from the text-based learning with those of the game-based learning.

3.4.6.3 Snagit software

Snagit software was used to observe the learners while they undertook and accomplished tasks on the gaming platform and on the e-book platform. It also recorded video and audio recordings of the learners during learning. Additionally, it stored pictures and videos of the computer screens. As a result, the Snagit software helped to measure time, the learners' steps and strategies on the system, and the learners' performances.

3.4.6.4 FaceReader system

FaceReader is a highly developed tool for the automatic measuring and analysis of facial expressions, providing a researcher with an objective evaluation of a participant's emotions, such as whether he/she was interested, happy, sad, angry, amazed, afraid, shocked, contemptuous, bored, or neutral. According to Langner et al. (2010), 'Face processing may well be one of the most complex tasks that human beings accomplish. Faces carry a wealth of social information, including information about identity, emotional and motivational status, lip speech, and focus of attention as indicated by eye gaze, all of which are important for successful

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communication.' Thus, face processing can help a researcher in observing participants' emotions and assists in identifying the best tools and situations for learning.

FaceReader uses a camera to capture facial expressions. FaceReader software analyses facial expression and provides several types of data analysis such as 'bar graphs, in a pie chart, and as a continuous signal' (http://www.noldus.com/facereader/facial-expression-analysis). This helps to show the range of participants' emotions that occur during the accomplishment of a learning task. It helps to measure autonomous learning, curiosity, and motivation by measuring participants' emotions.
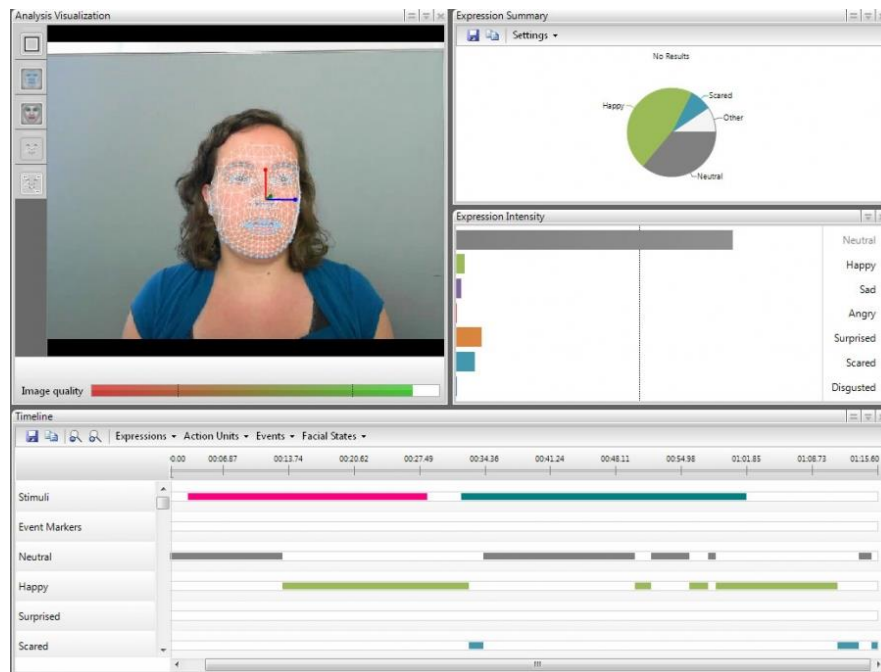
Figure 3.8 The FaceReader system. This figure shows a screenshot of the FaceReader system.

3.4.7 Experimental Procedures

There are several procedures for experiment design, such as pre-experiment, quasi-experiment, true experiment, and single subject design (John W. Creswell, 2011). Each design has rules concerning the groups, the sample, or the participants within the experiment. Pre-experiment design uses a single group to test the variable. However, the quasi-experiment and the true

experiment design use two groups, the experiment group and the control group. The quasi-experiment uses a non-random sample (convenient sample) and the true experiment uses a random sample (John W. Creswell, 2011). A single-subject design uses observation of a single individual's behaviour or the behaviour of a number of individuals over time (John W. Creswell, 2011).

This research used the quasi-experiment design for two reasons. Firstly, two groups were utilised for the research: the experiment group and the comparison group. Secondly, the experiment was carried out with a specific group of participants, namely post-graduate students (Ph.D. candidates).

3.4.8   Data collection and experiment steps

The experiment had several steps that were carried out in order to achieve a successful outcome. These steps are shown in Table 3.2.

Table 3.2 Data collection and experiment steps

Experiment groups Game-based learning (gaming technologies) group and Comparison group: Text-based learning (e-book)	Purpose	References
Define learner information and autonomous stage by having participants complete a profile form	To measure how autonomous learning is affected before and after using gaming technology or the e-book	Warring, S. (2013). Model of Independent Learning Applied to the Online Context. *Quarterly Review of Distance Education*, *14*(1), 25-34.
Define the level of curiosity by completing the Melbourne State-Trait Curiosity Inventory form	To define the learner's level of curiosity before using gaming technologies or the e-book	Naylor, F. D. (1981). A state-trait curiosity inventory. *Australian Psychologist*, *16*(2), 172-183.
Explain the experiment to the learner and give him or her the game or the e-book so he/she can study about research methodology	To learn research methodology through gaming technologies or the e-book	
Ask the learner to perform tasks	To measure the learner's critical thinking through problem-solving steps and rules	
Measure curiosity by completing the Melbourne State-Trait Curiosity Inventory form	To measure the effect of gaming technologies/the e-book on learner curiosity.	Naylor, F. D. (1981). A state-trait curiosity inventory. *Australian Psychologist*, *16*(2), 172-183.
Interview	To measure autonomy, curiosity, motivation, problem solving, critical thinking, and cognitive load	
Observation	To measure time, users' steps on the screen, and users' performance by using Snagit software	
Objective measurement	To measure users' emotions via the FaceReader system	

3.5   Time Horizon

The research used cross-sectional studies which investigated a specific phenomenon in a specific time in order to measure the influence of gaming technology on learning. The study examined the influence of game-based learning on Ph.D. students

3.6   Techniques and Procedure

The research used several additional types of techniques to elicit data: (1) a questionnaire based on the curiosity inventory, independent learning level and understanding level. The questionnaire used close-ended questions utilising Likert scales; (2) semi-structured interviews that asked questions directly and recorded the answers (Saunders et al., 2012), and (3) observation (as a means of data collection) to support the questionnaires' data collection. Experimental research uses questionnaires.

The data analysis was used to explain and test the use of gaming technology in learning and to compare this data with the results of using e-books for learning purposes.

3.6.1   Data collection techniques

Several types of data collection techniques were used to explore and test the impact of gaming technology and the impact of an e-book on learning. A comparison was made of the findings and results from both techniques.

3.6.2   Semi-structured interviews

An interview is an effective technique and procedure to collect data. It helps to explain phenomena efficiently and in this research semi-structured interviews were used to discover specific information that helped to compare the two groups' answers (Dawson, 2013; Saunders et al., 2012). Researchers use semi-structured interviews because they provide the advantage of using both open-ended questions and close-ended questions in the interview. Moreover, for qualitative data collection, semi-structured interviews help to create themes and the key structure that is needed to be measured and explained through the interviews. A semi-structured interview helps to gain further information in order to answer the research question and achieve the research objective (Saunders et al., 2012).

This research utilised face-to-face and one-on-one interviews (John W. Creswell, 2011).. This type of interview support the results that have been gained via observation and experiment and can provide a clear description of learners' attitudes and cognition (John W. Creswell, 2011).

The interviews used in this research asked two different types of questions. Firstly, open-ended questions were used in order to gain more information and get a better understanding of the learners' experience in the experiment (Pickard, 2013; Saunders et al., 2012). Secondly, the interviews included close-ended questions to measure specific concepts in the learning theories, constructivism and the cognitive load theory (Pickard, 2013; Saunders et al., 2012). The close-ended questions utilised a Likert scale which 'is a bipolar scaling technique, which allows a respondent to select a choice that best demonstrates their level of agreement with a given statement' (Pickard, 2013, p. 213). By using such a scale, the relationship between the dependent and independent variables was discovered and the learning factors were measured numerically.

3.6.2.1 Questionnaire

This research used two types of questionnaire. The first asked close-ended questions in the interviews. The second questionnaire technique measured curiosity by using the Melbourne State-Trait Curiosity Inventory to discover the natural level of curiosity of a participant by undertaking a trait-form. Then, the effect of gaming technology or using an e-book on a participant's curiosity was measured by undertaking the state-form. By having the participants complete this form, it was then possible to measure the effect of gaming technology or the use of the e-book on a participant's curiosity.

3.6.2.2 Observation

Observation can be undertaken directly, by recording with video or by using software. Research can use all types of observation. Observation helps a researcher to explain the effect of an independent variable on a dependent variable by monitoring the learner (Dawson, 2013). Based on the experiment strategy, observation has a part to play in research because it helps to discover the time that a participant spent on accomplishing a task. Also, observation leads to ascertaining if a participant performs a task correctly. Snagit software was used to monitor participant activity on the screen and the time taken to undertake the experiment. The author also observed the participants directly.

Objective data collection was achieved by using a FaceReader system (see section 3.5.6.4).

Collecting data through several means allows for that data to be analysed within, and categorised into, different areas, some of which relate to the qualitative part, some to theme analysis, and some to the quantitative part and the statistical results.

3.6.3   Data Analysis

Based on the needs of the research and the data collection, several types of data analysis can be conducted to find appropriate results that can answer the research questions and achieve the research aim. Content analysis was used for finding themes, factors, sub-factors, and elements. Statistical analysis was used to compare impact before and after using both technologies. Moreover, participant satisfaction regarding certain research factors was analysed. Finally, the data analysis compared the impact of gaming technology with the impact of the e-book.

3.6.3.1   Content analysis

Content analysis used in this research was based on the themes, factors and sub-factors that were discovered in the literature review. Work was carried out to find more sub-factors and elements that could help to explain the impact of gaming technology and e-books on learning. Ryan and Bernard (2003, p. 85) described the analysis process as 'analysing text involv[ing] several tasks: (1) discovering themes and subthemes; (2) winnowing themes to a manageable few (i.e., deciding which themes are important in any project); (3) building hierarchies of themes or code books; and (4) linking theme to theoretical model'. The theoretical framework for this research was built upon content analysis. Saunders et al. (2012) mentioned that content analysis searches for meaning and the need to organise data and use words to explain phenomena. This research used content analysis to answer why and how gaming technology affected participants and compared that with the influence exerted by the e-book.

NVivo software was used to determine the factors, sub-factors and elements for each theme that was measured and explored in the research. It also provided the research with figures to clarify the results.

Content analysis was used to analyse the responses to the open-ended questions in the interviews and to obtain more explanation of the observations.

3.6.3.2 Statistical analysis

The statistical part of this research used a paired-sample t-test to compare the impact of gaming technology with the impact of the e-book on the participants' autonomous stage, curiosity level, and understanding before and after using both technologies. Moreover, an independent-sample t-test was used to compare the impact of gaming technology with the impact of the e-book. The t-test was used for several reasons: (1) research about cause and effect: the cause and effect of gaming technology and e-book in learning was used and then the results were compared; (2) t-tests work with a small group: t-tests support and can be used with small groups as it was difficult to find a large number of participants to undertake this experiment which was limited to Ph.D. students at the University of Salford); (3) the test is used to compare means: the author used the t-test to compare means to find the difference between the impact of gaming technology and the impact of an e-book on learning, (4) it works very well with experiment results (Field, 2009; Pallant, 2013; Rumsey, 2011).

Furthermore, objective analysis of participants' emotions during learning was used to analyse participants' emotions while learning from the e-book and while learning using gaming technology.

In addition, close-ended questions provided the results that showed participant satisfaction concerning the themes and factors that were influenced by using the e-book and gaming technology. Close-ended questions about satisfaction helped to measure the effect of both technologies on the cognitive load. SPSS software and Excel software were used to undertake the statistical analysis. Overall, the statistical analysis helped to obtain a better understanding concerning the impact of gaming technology and the impact of e-books on learning.

3.7 Validity and reliability

Validity is concerned with measuring and assessing 'what they intended to measure' based on the research question and obtaining the results based on the research aim (Field, 2009; Golafshani, 2003; Heale & Twycross, 2015, p. 114). Validity questions in this research are: (1) Does this research measure and assess the impact of gaming technology in learning? (2) Does this research discover a difference between the impact of the e-book and the gaming technology? and (3) Does this research find any relationship between the e-book and gaming technology?

All these questions validate the research. From the first step of undertaking the research to collecting data about the impact of gaming technology on learning and then providing the conceptual framework, all of the validity questions were concerned with testing and exploring all the themes and factors that support gaming technology in learning, and comparing that with the impact of the e-book on learning.

Validity consists of several types, such as content validity, construct validity, internal validity and external validity (Heale & Twycross, 2015). All these types of validity were used in this research.

Content validity is 'the extent to which a research instrument accurately measure all aspects of construct' (Heale & Twycross, 2015, p. 66); this relates to the instrument covering all variables that have an effect. This research conducted an experiment to explore the impact of gaming technology and the impact of an e-book on participants. It utilised a questionnaire, semi-structured interviews and observation to cover all the variables that had an effect on these technologies covering the impact on (1) attitude (autonomous learning, curiosity and motivation), (2) cognition (critical thinking and problem solving), and (3) memory process and cognitive load. All in all, this research covered and studied all the content needed for this research.

Construct validity depends on the use of several and multiple sources of evidence to establish a chain of evidence, and on the study of previous cases and events to review and assess the information provided (May, 2011). This research used a mixed method approach by using several types of data collection, such as interviews, questionnaire, and observation based on the experiment strategy, to collect primary data. This ensured the best explanation for the research result. Moreover, it supported the research in finding the objective and subjective reality to explain the impact of gaming technology on learning compared with the impact of the e-book on learning to confirm the conceptual framework. In addition, the secondary data used to build the conceptual framework was based on data collected from previous research and evidence, alongside the constructivism and cognitive load learning theories discussed in the literature review chapter. The next chapters provide and explain the results and findings.

Internal validity concerns establishing relationships between factors and measuring the impact of theories (Yin, 2013) as well as measuring the relationship of participant satisfaction with

regard to the factors in the same circumstances (Heale & Twycross, 2015). Participants who had a relationship with the concepts of the research were chosen. The concepts behind the experiment pertained to gaming technology and e-books with a focus on research methodology. Research methodology is a very important concept for Ph.D. students in earning their degrees. In addition, the influence of constructivism and the cognitive load theory provided themes and factors in the conceptual framework that tested participant satisfaction and explored the sub-factors and elements that affected these themes and factors. Finally, both technologies were compared which validated the research method used and information obtained.

External validity is about generalising the results of research, such as information, knowledge, frameworks, and theories (Heale & Twycross, 2015; Yin, 2013). This research was about technology enhancing learning, in particular the impact of gaming technology in supporting learning in universities, and about using games as an e-resource in academic libraries to support academic performance. Ph.D. students in the University of Salford were invited to participate in the research and the results of this research can be used in any university around the world to justify using new technologies in learning to support students' performance. As a result, any information that was found to be unrelated to the research context area was either rejected or preserved as information for awareness purposes only. All the inspection and examination helped to ensure that participants' biases and individual views did not dominate the focus of this research.

Reliability focuses on measurement and assessment performed in the same circumstances (Field, 2009). Moreover, reliability requires that the information provided by the participants and the research results in trustworthiness. (Bryman, 2015). The reliability of this research was based on the selection of an appropriate sample for this research. This research selected Ph.D. students in the University of Salford to study the impact of technologies on learning. Furthermore, the sample number of participants was chosen based on the t-test method for the experiments and the quantitative part, and the same number of participants was chosen for the semi-structured interviews for the qualitative part; this is explained in the 'Sampling' section of this chapter.

Moreover, all the participants undertook their experiment and interview in the same environment and under the same circumstances. All the participants used the same room for the

experiment and used the same equipment. Moreover, the gaming technology group and the e-book group studied the same concepts concerning research methodology within the different technologies in order to ascertain gaming technology's and e-book's impact on the participants and compare the impact of both technologies. In addition, both groups were asked the same questions and used the same process and instrument to measure the impact of both technologies. The reliability of this research was increased as a result, and all this was achieved while conforming to the ethical obligations for this research.

3.8 Ethical considerations

The author was concerned with the ethics of undertaking this research and worked to fully explain all the aspects of the research, concepts, and influences to the participants. The invitation letter was composed with a view to helping students feel welcome in participating in the experiment and interview. Moreover, the information form provided a full explanation about the observation that would be carried out as part of the research. Additionally, information was provided about the devices that would be used during the experiment, such as the FaceReader system and its side effects on participants. These were explained to help improve confidence between the author and the participants. Informed consent was required from each participant. Furthermore, all the collected data was kept secure. Names of the participants were not published nor were any personal information, responses and opinions, in an effort to protect and respect participants' privacy. All videos, records and information have been saved securely so as to do no harm to any participant. Participant dignity was the most important ethical consideration in the success of this research.

In conclusion, the research methodology for this study was based on the Onion Model. It used the objective and subjective realities as well as pragmatism epistemology as the philosophy underlying the research methodology. In terms of approach this study used the abductive approach to conduct the mixed method approach as a methodical choice. The experiment's strategy used several types of data collection such as a questionnaire, interviews and observation. Content and statistical analyses were utilized to perform the research. Figure 3.9 shows the research methodology used, based on the Onion Model.
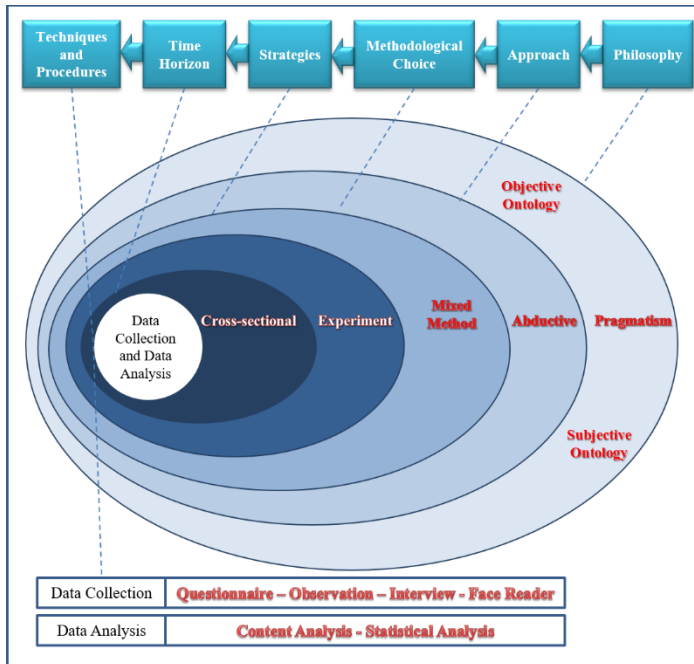
Figure 3.9 Research methodology. This figure shows the methodology utilised in this research based on the Onion Model (Saunders et al., 2012).

3.9   Summary

This chapter provided an outline of the research methodology that was used in this research. This research used the pragmatism philosophy. Pragmatism philosophy is appropriate for this kind of research which is looking for objective and subjective results. An abductive approach was conducted to meet the philosophy requirement. Moreover, a mixed methods approach was deemed the best methodological choice for this research in order to find both quantitative and qualitative results for explaining the impact of gaming technology on learning. An experiment strategy was utilised to find the impact of gaming technology on learning and to compare that with the impact of an e-book on learning. Data was collected from a quasi-experiment on two different groups, the gaming technology group and the e-book group.

This research used several data collection techniques, including a questionnaire, interviews and observation, for data collection. Also, data analysis techniques, such as statistical analysis and content analysis, were used to find the appropriate results and to explain the impact of gaming technology on learning.

Chapter 4. Experimental Platform Design

The purpose of this chapter is to create the conceptual framework that is required to test and explore the effect of gaming technology on learning and to compare that to the e-book's impact on learning. This framework is then used to design and create the gaming technology platform and the e-book platform for the experiment, and for assessing the learning outcomes.

4.1   Conceptual framework

This research created the conceptual framework based on two learning theories which are constructivism and the cognitive load theory. Constructivism was utilised in measuring attitude which concerns:

- Autonomous learning or independent learning
- Curiosity that enhances learners in acquiring knowledge
- Motivation as the main behaviour to improve knowledge, skills, and experience

Moreover, cognition is assessed by focusing on the higher-order thinking that is important for academic performance, such as

- Critical thinking
- Problem solving.

This research excluded the social aspect of constructivism which is an aspect which can be tested in future research.

The cognitive load theory is used to evaluate the workload on memory. Cognitive load was assessed via measuring the effort, difficulty and performance (of the participants using the e-book and gaming technology) which take place in the short-term memory and obtain support from long term-memory in order to perform tasks.

As a result, this research focused on measuring users' attitudes, cognitive (higher-order thinking) and memory processes (cognitive load) when subjected to technology-enhanced learning from the perspective of constructivism and the cognitive load theory.

The conceptual framework led to the design of both a gaming technology platform and an e-book platform to test the learning themes and factors that are influenced by these technologies.

The conceptual framework includes two technologies which can used for learning which are gaming technology and e-book. The conceptual framework outcomes include three themes: attitude, cognition and memory (cognitive load). Attitude includes three important factors which have an effect on learning:

- Autonomous learning: to help students in universities learn independently as a significant function for learning in the 21st century.
- Curiosity: to enhance students in the discovery of new knowledge by interacting with learning environments.
- Motivation: to encourage students to have the willingness to engage in learning environments in order to acquire knowledge.

Thus, the outcome of this research may be that gaming technology enhances autonomous learning, curiosity and motivation, more so than the e-book.

The cognition theme (that focuses on higher-order thinking) has two important factors:

- Problem solving factor: enhances students when going through learning tasks and putting in effort in order to find solutions in order to complete tasks by undertaking some steps and strategies.
- Critical thinking: increases learners' ability to analyse and evaluate the information they have in order to create a new interpretation and create new knowledge which helps to achieve the learning objective.

Hence, the outcome of this research may be that gaming technology supports participants' understanding and cognition more than, or the same as the e-book.

The memory process focuses on the cognitive load that is processed in the short-term memory and receives support from the long-term memory in order to perform the learning tasks and to store the new knowledge in the long-term memory. Cognitive load has a significant impact on a student in terms of learning effectively via reducing cognitive load in the memory.
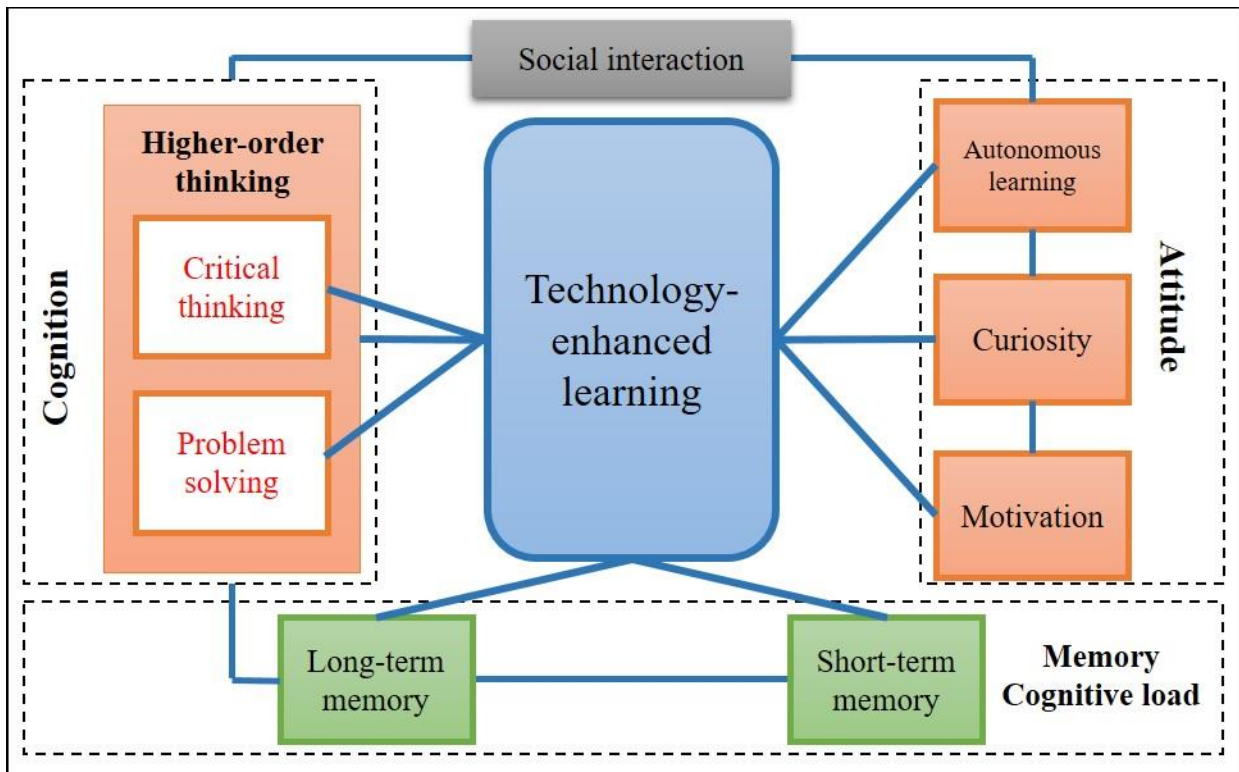
Figure 4.1 The theoretical framework. This figure illustrates the conceptual framework of this research.

4.2 Measurement framework

Measurement points were adopted from the literature review as well as the learning factors and principles for acquiring information and knowledge. These factors were examined and measured through experimentation by using a gaming technology platform and comparing that with an e-book platform based on the learning factors.

This research examined and measured certain factors relating to learners' attitudes and cognition in addition to measuring cognitive load. As part of the research the researcher was trying to define how various factors (such as learners' autonomous levels of learning) should be characterized and whether they can be affected by using gaming technologies or an e-book. In addition, interviews were used to ask about willingness, confidence, the learning process, goals, plans and observation in order to monitor tactics and adaptation. Moreover, curiosity levels were measured by defining the level of curiosity through the Melbourne curiosity inventory trait form, and the effect of gaming technologies were discovered by using the Melbourne curiosity

inventory state form. Furthermore, the research measured curiosity (via the information received in the interviews) by asking participants about their interest in the game and/or e-book and their lack of knowledge concerning research methodology. This led to measuring learner motivation by asking about learners' emotional influences (beliefs, goals, interests and habits of thinking), intrinsic motivation (novelty of the task, difficulty and personal interest) and, additionally, by measuring the effect of motivation on learners' efforts.

The research measured learners' attitudes (emotional influence) by using a FaceReader system which measured learners' emotions while acquiring knowledge.

For the cognition part of this research, problem-solving ability was measured based on (1) identifying problems, (2) understanding the game challenges, (3) the ability to create strategy and plans, (4) the ability to use strategy, (5) establishing solutions, and (6) evaluating these solutions. This was measured through interviews, questionnaires and observation. Equally important, critical thinking was measured (Yeh, 2003) using critical-thinking measurements throughout the interviews, questionnaires, and observation.

Lastly, cognitive load was measured via a questionnaire which had questions which utilised a Likert scale (for the responses) that measured difficulty, effort and performance. Observation was also employed to measure learner performance correctly.

The tables below explain the learning factors and themes that were measured.

Table 4.1 Attitude: Autonomous learning

Definition (Autonomous learning)	Measurement Factors	Measurement undertaken by means of:	How the measurement is made
The learning structure which gives learners an opportunity to teach themselves. They are separated from their teacher by time and space; moreover, the learning process is undertaken by using print or electronic resources (M. G. Moore, 1973).	Measure the stages of independent learning: • Willing: explore if the learner has an interest in independent learning (Grow, 1991; Warring, 2013).	• Profiling • Interview	• Answers to the questions in the profile form. • Answers to the interview questions.
	• Confidence: discover if the learner has the confidence and ability to undertake learning and the tasks (Grow, 1991; Warring, 2013).	• Profiling • Interview	• Answers to the questions in the profile form. • Answers to interview questions.
	Measure the independent learning process: • Define the task: this includes two parts: (1) the learner receives clear information and direction from the teacher or instructor on performing the task successfully; (2) the cognitive part is based on the learner retrieving information from long-term memory in order to understand the task. (Schunk, 2012).	(1) Researcher (the author) gives the learner the information that is needed to perform the task. (2) The cognition part measures cognitive load	Excluded
	• Goals and plans: setting goals for learning and planning in order to achieve the goals effectively (Schunk, 2012).	• Interview	• Analyse interview answers
	• Tactics: learners set some tactics to obtain information and improve their knowledge and learning experience (Schunk, 2012).	• Observation	• Analyse observation results
	• Adaptation (optional): learners can evaluate how successful they have been (Schunk, 2012).	• Observation	• Analyse observation results

Table 4.2 Attitude: Curiosity

Definition (Curiosity)	Measurement Factors	Measurement undertaken by means of:	How the measurement is made

Curiosity empowers the learners' needs to discover, interact, and make meaning of their environment (Arnone, 2003)	• Interest: includes learning new skills or knowledge with the assumption of aspiring to enjoyable statuses of interest (Arnone, 2003; Berlyne, 1960).
	
	 • Deprivation: depends on seeking information and knowledge in order to solve problems and fill the gap in the knowledge (Arnone, 2003; Loewenstein, 1994).
		• Using the Melbourne curiosity inventory for measuring curiosity
		    o Trait form for profiling
		    o State form for measuring curiosity
		 • Interview
			• Analyse the two forms
			 • Analyse interview answers

Table 4.3 Attitude: Motivation

Definition (Motivation)	Measurement Factors	Measurement undertaken by means of:	How the measurement is made

• Eagerness and willingness to do something
 • The reason why one wants to do something (Longman dictionary, 2016).
	• Emotional influence
	    o Belief: students' beliefs about themselves as learners, their expectations for success and having positive emotions (American Psychological Association, 1995).
	    o Goal: setting a target to learn (American Psychological Association, 1995).
	    o Interest: willingness to learn (American Psychological Association, 1995).
	    o Habit of thinking: the learner's quality of thinking and information processing (American Psychological Association, 1995).
		• Interview
		 • FaceReader system
			• Analyse interview answers
			 • Analyse FaceReader results

	• Intrinsic motivation
	    o Novelty of the task: discovering if the learner likes novel tasks (American Psychological Association, 1995).
	    o Difficulty: exploring if the learner can engage in complexity and in difficult tasks to gain new knowledge and experience (American Psychological Association, 1995).
	    o Personal interest: exploring if the learner has an interest to learn and achieve new and difficult tasks (American Psychological Association, 1995).
		o Interview	o Analyse interview answers

	• Effect of motivation on effort: discovering if the learner puts in effort and draws up a guideline and strategy for achieving the task(s) (American Psychological Association, 1995).	• Interview	• Analyse interview answers

Table 4.4 Cognitive and higher-order thinking: critical thinking

Definition (Critical thinking)	Measurement factors	Measurement undertaken by means of:	How the measurement is made
• Critical thinking means 'correct thinking in the pursuit of relevant and reliable knowledge about the world. Another way to describe it is reasonable, reflective, responsible, and skilful thinking that is focused on deciding what to believe or do' (Schafersman, 1991, p. 3). • Critical thinking is a cognitive activity, associated with using the mind. Learning to think in critically analytical and evaluative ways means using mental processes such as attention, categorisation, selection, and judgement' (Cottrell, 2005, p. 1).	• Recognition of assumptions: the ability to identify statements or claims implicit in general premises (Yang & Chang, 2013, p. 337; Yeh, 2003).	• Interview (close ended questions and open ended questions)	• Analyse interview answers
	• Induction: the ability to infer the most likely outcome from known facts (Yang & Chang, 2013, p. 337; Yeh, 2003).	• Interview (close ended questions and open ended questions)	• Analyse interview answers
	• Deduction: the ability to use reason to draw a necessary conclusion from two given premises (Yang & Chang, 2013, p. 337; Yeh, 2003).	• Interview (close ended questions and open ended questions)	• Analyse interview answers
	• Interpretation: the ability to determine which phenomena or causal relationships are implied by given statements (Yang & Chang, 2013, p. 337; Yeh, 2003).	• Interview (close ended questions and open ended questions)	• Analyse interview answers
	• Evaluation of arguments: the ability to assess the strength of an argument (Yang & Chang, 2013, p. 337; Yeh, 2003).	• Interview (close ended questions and open ended questions)	• Analyse interview answers

Table 4.5 Cognitive and higher-order thinking: problem solving

Definition (Problem solving)	Measurement point	Measurement undertaken by means of:	How the measurement is made
Problem solving refers to people's efforts to achieve a goal for which they do not have an automatic solution (Schunk, 2012, p. 299).	• Identify problem: define and represent the problem (Schunk, 2012).	• Interview	• Analyse interview responses
	• Understand challenge: finding the information and supporting this by finding related information (Schunk, 2012).	• Interview	• Analyse interview responses
	• Create ideas and strategy from existing experience: create a plan based on connecting between the information the learner has and unknown information (Schunk, 2012).	• Interview	• Analyse interview responses
	• Implement strategy: execute the plan, breaking the problem into sub-problems and finding out how a similar problem has been solved and then using it as a strategy to find a solution (Schunk, 2012).	• Interview	• Analyse interview responses
	• Establish solution: find the solution (Schunk, 2012).	• Interview	• Analyse interview responses
	• Evaluate solution: check that the solution fits with the problem and examine if it is an effective result (Schunk, 2012).	• Interview	• Analyse interview responses

Table 4.6 Cognitive load

Definition (Cognitive load)	• Measurement Factors	Measurement undertaken by means of:	How the measurement is made
Cognitive load focuses on the load in short-term memory during learning (Sweller, Van Merrienboer, & Paas, 1998)	• Effort and difficulty: the learner rates the mental effort and difficulty of a task (Sweller et al., 2011).	• Self-rating effort • Interview	• Analyse self-rating effort and task • Analyse interview answers

	• Performance:
	  ○ the learner undertakes and completes the task and gains knowledge (Sweller et al., 2011).
	  ○ Feel sense of accomplishment (Behn, 2003)
	  ○ Feel comfortable (Lynch & Dembo, 2004)
		• Task performance
		• Interview
		• Observation of task performances by video and audio recording by using Snagit software
			• Analyse interview answers
			• Analyse observed aspects to measure performance

	• Difficulty faced during learning (Sweller et al., 2011).	• Self-rating effort • Interview	• Analyse self-rating of difficulty that is faced in order to do the task • Analyse interview answers

4.3   Design platforms

This section focuses on the design of the experiment platforms which were the gaming technology platform and the e-book platform. Each platform was used to measure the effect of these technologies on learning and to compare gaming technology with the e-book in order to confirm the conceptual framework and explain the impact of these technologies on learning.
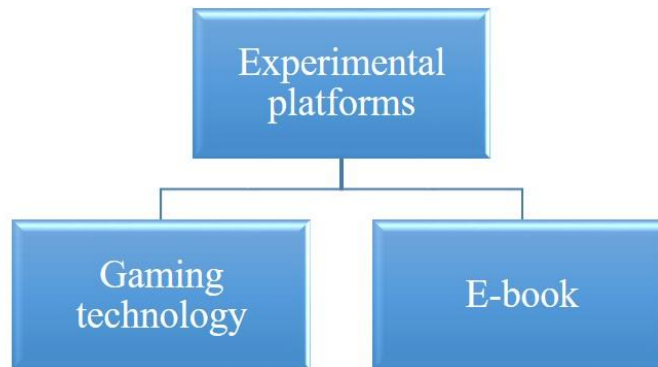
Figure 4.2 The experimental platforms

Both platforms present the same concepts and information about the research methodology used for social science. Each platform has some characteristics that enhance learning outcomes. Table 4.7 provide these characteristics.

Table 4.7 Platforms' characteristics

Gaming technology characteristics	E-book characteristics
3D environment	Text-book
Animation	Images
Visual	
Voice	
Interactive environment	

More discussion is provided in the next sections.

4.3.1   The Research Methodology Game Design

4.3.1.1 Introduction

Gaming technology is used for a variety of different reasons, such as for business, medical, training and learning purposes. Learning and playing a game can provide information and knowledge in an interactive environment alongside having fun and maintaining interest during the learning process. Consequently, gaming can be used to teach difficult concepts. Additionally, it is very important to support students in their understanding of knowledge.

Gaming that is used to teach concepts should meet a learner's needs. J. Chen (2007) suggested that, in order to create an effective game that will be enjoyed, first of all the designer and the technology developer must discover 'what users want'.

In universities, students use research methodology at all levels to undertake research for a course, or to earn an academic degree. Hence, the development of a research methodology game for social science that can support learning in university would be useful because research methodology is a complicated and difficult concept to learn. According to Dawood and Underwood (2010, p. 177), 'Research Methodology is one of the nightmares a researcher has to endure'.

Therefore, the 'Research Methodology Game' for social science was designed and developed to explore how gaming can support learning in order to understand complicated concepts by evaluating its impact on attitude by enhancing autonomous learning, curiosity and motivation. In addition, the intention was to assess the impact on cognition by supporting the critical thinking and problem solving ability and find out if this impact has a positive impact on memory by measuring cognitive load.

The designed research game presented research methodology by providing research methodology concepts in an interactive environment. Moreover, this gaming environment provided learning by using 3D technology and animation to display research methodology concepts.

The Research Methodology Game was developed based on reviewing game design theories and frameworks. These helped in the adoption of certain rules and characteristics in the design of the Research Methodology Game.

Accordingly, in this section of the research, the author explains the main concepts of the gaming characteristics utilised to design the game and focuses on some gaming

characteristics from different theories and from game developers' papers and articles. Additionally, the section on game design explains these characteristics and their adaptation alongside the flow theory in the design of the Research Methodology Game. An exploration of these concepts led to the creation and formation of some of the game design elements utilised for designing the game and, based on these elements, the Research Methodology Game was developed.

This section presents the game's design and the characteristics that were used for the experiment and for collecting data about gaming technology environments. In addition, the gaming technology platform helped to discover the game's influence on students in understanding aspects of research methodology.

In conclusion, the objective of the Research Methodology Game is to help students and researchers understand the basic concepts of research methodology which will help learners in understanding research methodology and setting a successful and efficient research methodology for their research.

The author designed the storyboard and the games' characteristics and utilised game design theories in setting up the Research Methodology Game in order to support learners and enhance their learning.

4.3.1.2 Game design theories

Creating effective game-based learning requires following an efficient game design format. Such a design needs to support the learning factors and elements. In addition, the design needs to make the game interesting and enhance a learner's desire to engage and interact with the game.

According to Gee (2005), the design of good games (which have the aim of enhancing learning) should be developed based on making a learner enjoy learning; this then involves designing an effective and successful game. Thus, a review was undertaken of the different types of gaming design theories and models in order to create a successful educational game that universities can utilise and develop to help learners engage with learning. In addition, this game should help to improve learners' attitudes, cognition and memory, and thus develop learners' academic performance.

Such a game requires having an educational approach, being able to conduct tasks to measure the understanding of knowledge, being able to elaborate and explain the details, to

incorporate fundamental educational support, and to sketch and map learning activities and learning concepts via the game (Pivec & Dziabenko, 2004). Indeed, taking such factors into consideration should lead to designing and developing a game that helps to enhance learning and also helps to measure the learning factors and elements that are required for learners to develop their knowledge, skills and experience.

Pivec and Dziabenko (2004) recognised that such a game should motivate learners and encourage learners' understanding by having some characteristics and elements that help to make the game an effective tool for learning. They also suggested some characteristics for such a game that attempts to enhance learning:

- Interactivity is the main component that makes a game a successful tool for learning.
- Visual learning or thinking makes learning easier in understanding learning concepts and objectives. In brief, interaction between a learner and the game is a vital feature that makes learning more interesting and valuable.
- Rules that describe the game's process are a productive tool in learning. Rules help a learner reach the game's goals and objectives.
- Goals should be set that make the target and the objective of the game clear for learners.
- Challenges and risks support interest and the level of engagement and interaction with the game. Challenges should be provided at each level of the game with different difficulties for each level which should be appropriate to learner ability.
- Fantasy is a part of the game and leads to willingness to participate and efficient learning.
- The learner has control of the game levels and phases.

Furthermore, Gee (2005) suggested several principles that help to create an effective and good game that will enhance learning, such as:

- Empowering the learner by making the learner share in the learning and the doing, in performing some tasks and interacting with the system.
- Problem solving: learners proceed and solve a problem by thinking about it and then use their assumptions and/or reasoning to solve the problem so that they can move forward through the game successfully.

- A rich and effective gaming environment allows learners to lose themselves in the game and to spend a long time in it without being bored. This allows them to study independently without the need for teachers, see table 4.9.

- Challenges in the game need to be balanced in order to fit different player levels and interest levels during the game playing.

- Feedback from the game informs learners if they are on the right road of learning; it also helps learners to build upon their achievements and make progress in understanding the concepts.

- Verbal information can make a game more effective because learners do not need to read in order to focus on a concept that they can acquire via presentations and verbal demonstrations. The Research Methodology Game provides verbal and virtual presentations on research methodology and supports these by making learners practise throughout the game. Practice also helps to advance the learners' experiences of the basics of research methodology. According to Gee (2005), during learning, reading may cause confusion in learners when dealing with complicated notions, but learning supported by visual concepts and practice make ideas clear and coherent and removes confusion. Moreover, visual learning supports the information that learners obtain from a textbook.

- Effective gaming includes the concept of 'learn and practise' that supports understanding and improves skills and experiences (Gee, 2005).

- Gee (2005, p. 14) stated 'people learn skills, strategies and ideas best when they fit into an overall larger system to which they give meaning. In fact, any experience is enhanced when we understand how it fits into a larger meaningful whole'. This leads to making the game efficient by allowing the player or learner to understand elements from the game and to fit these in with the overall concepts which, in turn, enhances skills and experiences.

- People can understand well when they combine words with action. Additionally, experience supports understanding because it makes a relationship between how a learner's mind works and how a game works which, in turn, enhances a learner's cognition via an empowering experience through a game scenario and encourages understanding and skills.

- The main concept for games in general is fun. Utilising 'fun' via a game format can assist a learner in acquiring knowledge and in improving the skills that can enhance

experience. In brief, this leads to using gaming in order to learn complicated concepts, such as research methodology.

As a result, from reviewing game design concepts and theories, the author found that the flow theory is the one that is most relevant to this study's design because it covers most of the design elements required by this study. It is effective for designing learning games (Gee, 2005; K. Kiili, 2005, 2006; K. Kiili, de Freitas, Arnab, & Lainema, 2012; K. Kiili et al., 2014; K. J. Kiili et al., 2014; Pavlas, 2010). In addition, the flow theory has been used in previous research on designing learning games by Kiili (2005, 2006, 2012, 2014); also the flow theory has been used by Gee (2005) and by Pavlas (2012). This leads this author to use the flow theory as the main theory for the design (together with adding some supportive elements) in order to develop a game for enhancing the understanding of research methodology by students.

4.3.1.2.1 The flow theory

The flow theory was created by Csikzentmihaly (1991) to discover and explore the impact of activity and whether it enhances the discovery ability within people. This research used the flow theory to design the game because it is concerned with learners enhancing their ability to learn. According to Kapp (2012, p. 74), flow 'continually adapts to keep the learner at a constant state of interest. The system adapts to the right challenges' level for the learner, not too difficult and not too easy'. Consequently, the Research Methodology Game was created by using aspects of the flow theory.

Moreover, the design of a serious game (with the intention of providing learning) needs to build on an effective game design theory. The flow theory is the one of the efficient and effective theories that can be utilised to design a game and to undertake an analysis of game-based learning (K. Kiili et al., 2012; K. Kiili et al., 2014; Pavlas, 2010).

Previous research has found that the flow state enhances learning attitude, supports investigative behaviour, and supports cognition (K. Kiili, 2005; Skadberg & Kimmel, 2004; Webster, Trevino, & Ryan, 1994).

Moreover, K. Kiili (2005) explored the strong relationship between the flow theory and learning. Flow makes learning effective when using gaming technology.

Accordingly, the gaming technology platform was designed and developed based on the flow theory in order to analyse the impact of gaming technology on learning by testing constructivism and the cognitive load theory.

The flow theory's focal points are happiness, creativity and fun which influence the learner's well-being (J. Chen, 2007; Pavlas, 2010). Flow utilises the feeling of entire and energised focus in an activity, with a high level of pleasure and execution (J. Chen, 2007).

According to J. Chen (2007, p. 31) there are eight components of flow theory in designing games: 'challenging activity requiring skill; a merging of action and awareness; clear goals; direct, immediate feedback; concentration on the task at hand; a sense of control; a loss of self-consciousness, and an altered sense of time'.

4.3.1.2.1.1 Challenges

Challenges influence interest while learning by playing a game. K. Kiili et al. (2014) suggested the main target for learning within a game is to establish a fun environment for learning by providing challenges that balances a learner's skill with avoiding anxiety and being bored during the learning. Difficult challenges cause poor achievement which causes anxiety and easy challenges cause boredom. The challenges need to be related to the learning objectives and tasks and they need to keep the learner in the 'flow area or state' and enhance the learner's skills' level.

Hence, there is a major and important relationship between the challenges set and the learner's skills that influence cognition and understanding. This relationship also has an effect on the learner's attitude and behaviour. As a result, well-balanced challenges can have an impact on learning positively and can provide an effective and efficient learning environment within gaming technology.

4.3.1.2.1.2 Merging of action and awareness

The merging of action and awareness means that a learner is involved in the interactive environment automatically and spontaneously. The learner performs the task by using physical action and mental activity (Csikzentmihaly, 1991). The game can be designed to make the learner engage in activity automatically because gaming technology provides an interactive environment that uses physical action through using the computer keyboard and mouse. Also, the game provides mental activity through understanding the concepts in the learning mode and testing these in the playing mode.

4.3.1.2.1.3 Clear goals

Clear goals indicate that learners should have a clear understanding about what they are going to achieve through playing a game for learning purposes. Clear goals support learners in focusing on learning objectives and tasks. This means that goals need to be related to learning objectives. Furthermore, clear goals offer a benchmark for feedback because they show learners how they performed as measured against the game's goals (Csikzentmihaly, 1991). Therefore, setting clear goals leads to being able to measure learner performance and the ability to complete the game's tasks.

4.3.1.2.1.4 Feedback

Feedback is important because it helps learners to increase their understanding. According to K. Kiili et al. (2014, p. 369), 'the main purpose of the feedback is to inform the player about his performance and progression toward the goal, to monitor the progress of the learner by the tutor, and to create a feedback loop between the game and level achieved'.

Feedback enhances learner concentration and focus during learning. Feedback also informs learners about any weaknesses that need further attention and increases their understanding by allowing them to try other solutions for game problems or questions.

4.3.1.2.1.5 Concentration on the task at hand

Concentration allows learners to focus on the accomplishment of a task and to concentrate totally on the action and/or game. By increasing concentration, learners become more aware of their performance in the game (Csikzentmihaly, 1991; Kapp, 2012). The game leads learners into focusing on the task and on the learning objective. Learners learn independently and concentration is improved which helps to meet their needs and fill in the gaps in their knowledge.

4.3.1.2.1.6 A sense of control

Learners need to feel that they have complete control of the task and to believe that what they do leads to attaining their objective successfully. Because they have this control over a difficult concept or position, they feel empowered (Csikzentmihaly, 1991; Kapp, 2012). A game can make difficult concepts easier to understand and make learners feel they have control over the game by using visual learning (through 3D and animation) and by interacting with the system to accomplish tasks. Additionally, a game designer can set balanced challenges that are concerned with learner ability and this too can make the game feel under the control of the learner.

4.3.1.2.1.7 A loss of self-consciousness

Leaners cannot stop the action or the game until they have finished all the parts of the game. One of the intentions of the game's design is to force learners to lose self-consciousness. The main objective is performing the game in order to gain the best understanding or achievement (Csikzentmihaly, 1991; Kapp, 2012). The gaming technology platform is designed to make learners interested and fill in any gaps in the knowledge that they may have about research methodology. The intention is that playing the game should lead to a loss of self-consciousness, and that the game should be so interesting that learners cannot stop playing the game and learning.

4.3.1.2.1.8 An altered sense of time

An altered sense of time means that learners will ignore time and will engage in the action and/or game and put all their efforts into completing the different parts of the game (Csikzentmihaly, 1991; Kapp, 2012). The Research Methodology Game provides an interactive environment that helps learners become unconcerned about time, instead focusing on their performance by using the majority of their senses. Moreover, research methodology is an important subject for students and this fact also helps students concentrate on completing the game without any consideration of time.

4.3.1.2.1.9 The flow zone

An important and stimulating concept in the flow theory is the flow zone (J. Chen, 2007; Kapp, 2012; K. Kiili et al., 2014; Pavlas, 2010). There is a relationship between the challenges and learner ability that is required in the flow zone. The flow zone is the area or path that makes learning useful and interesting by keeping a balance between learner ability and the challenges in the game in order to keep the learner interested and excited, avoiding boredom or causing anxiety. If the challenges are very easy, this can cause boredom for learners because the challenges are too low for their ability, and if challenges are too taxing, then that causes anxiety for learners because they are too high for their ability (J. Chen, 2007; Kapp, 2012; K. Kiili et al., 2014; Pavlas, 2010).
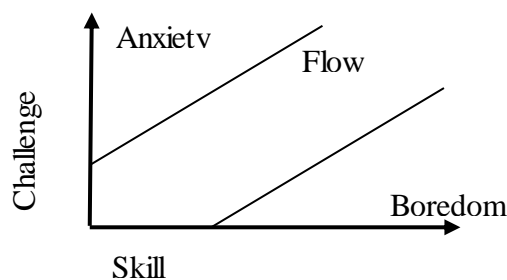
Figure 4.3 The flow theory (showing the flow zone).

In brief, learners need to be in the flow zone to obtain knowledge effectively, enhance their knowledge and improve their skills concerning, and their experience of, research methodology.

4.3.1.3 Challenges faced in developing the Research Methodology Game

During planning for developing the game environment or platform, the researcher faced several challenges and used a great deal of effort to surmount many of these challenges.

The challenges faced during the design of the Research Methodology Game were:

- Creating the game's objective so as to help learners understand the research methodology required for undertaking successful research.
- Portraying this complicated concept in a game environment.
- Creating two modes for the game, a learning mode to obtain knowledge and a playing mode to test knowledge.
- Combining the two modes to enhance a learner's ability to use an effective research methodology for research.
- Developing a suitable 3D environment to test learners' knowledge.
- Avoiding bugs and any unrelated steps in order to make information and the steps in the game clear and coherent.

The author overcame these challenges by going through the research methodology concepts and by undertaking an in-depth investigation to understand the research methodology concepts; then making these concepts simple and easy to understand. Next, the author organised these concepts and established the game's storyboard, characteristics and the game's elements. Finally, the game was established.

4.3.1.4 Game scenarios for learning research methodology

The Research Methodology Game will be explained by looking at the game's design generally in this section. The game was developed and created based on the previous explanations in this thesis of theories and elements. The game's environment is set in a lake that has a shore and there are crocodiles within the lake. This scenario is used to explain and present the steps that are used in research methodology. The user needs to cross the lake by stepping onto the correct stepping stone. Each stone gets the user further across the lake and each stone represents a possible approach [a possible research methodology approach to getting across the lake]

The game has two modes: a learning mode and a playing mode. In the learning mode when learners press any of the steps in the lake, they will hear an explanation about the each of the concepts. The system will show a presentation and thus give a visual explanation about each of the concepts by using 3D, animation and movies. In the playing mode, the system will ask questions of the players and they need to choose the right stepping stones to move safely across the lake. If players choose the wrong steps, they will sink and the crocodiles will eat them. Then they need to go back and start all over again until they can move successfully across the lake.

Figure 4.4 The game scenarios

After learners have completed all the game's steps and levels, they will obtain feedback about their performance including commands and recommendations. The game was set up initially by using certain phases, such as forming the learning objective, explaining the importance of game, and setting the game rules. After that, a storyboard was created to explain the main aspects of the game. Next, the game's characteristics were developed to explain the game's concepts. Later, the game's elements were established based on the flow theory in addition to support from other theories and models. Finally, the game's tasks were created in order to measure the game's impact.

Figure 4.5 The Research Methodology Game

4.3.1.5 The game's objective

The game provides some learning objectives for learners:

1) To understand research methodology
2) To define research methodology approaches
3) To learn how to use research methodology within research
4) To increase a person's ability to justify the research methodology steps chosen
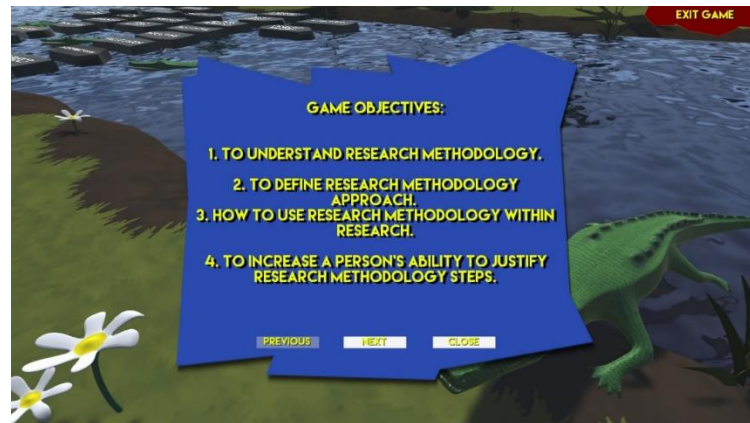
Figure 4.6 The game's objective screen

4.3.1.6 The game's storyboard

A storyboard provides the game's steps. It also describes the game's process flow which helps in designing and developing the game successfully (Cristiano, 2012). Figure 4.7 presents the Research Methodology Game's steps and processes. The storyboard includes the four main processes and two questions. The first process presents the introduction which describes and explains the learning objective of the game. Additionally, it indicates to the learners the importance of the game for their study and academic performance, and gives them the rules of the game. The first question measures the learner's level of knowledge of research methodology before playing the game. The second process is the learning mode which is used to obtain knowledge on research methodology concepts through the use of 3D animation to present information. The third process is the playing mode which tests the learner's knowledge after learning. The system asks a question and then the learner answers the question. If the answer is correct, the learner moves along the game's steps successfully. The learner has the opportunity to go back to the learning mode and restudy, then go to the playing mode once more and complete playing the game. The second question appears after

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the playing mode and measures any improvement in learner knowledge concerning research methodology. Finally, the fourth process provides the researcher and the learner with feedback about the learner's achievements.
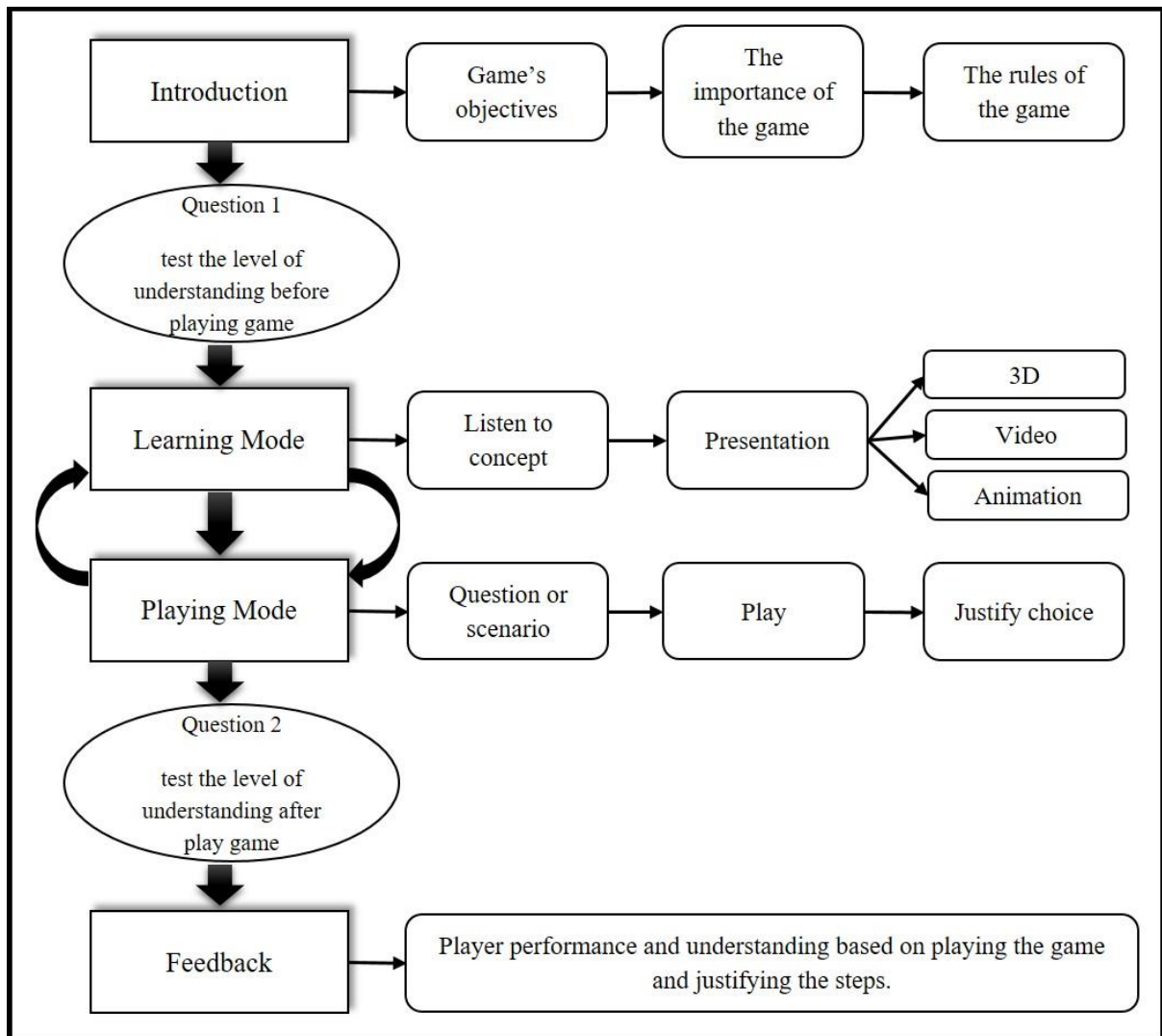
Figure 4.7 The Research Methodology Game storyboard.

4.3.1.7 Game characteristics

According to Elias, Garfield, Gutschera, and Whitley (2012, p. 3), the characteristics of a game are the 'general groups of features that give a high-level description of the sort of game it is'. Table 4.8 presents the main characteristics for the Research Methodology Game.

Table 4.8 Characteristics of the Research Methodology Game

Characteristics		Gaming Technology
Basic	Number of users	One player
	Length of playing time	One hour to learn and complete the task
	Heuristic	The user will receive information through a special explanation (which uses 3D and animation technology) which will improve usability. In addition, the user can play the game to receive more understanding, test his or her ability, and obtain feedback about any lack of understanding.
Infrastructure	Rules	1. The player uses the learning mode to acquire knowledge. 2. The player presses on the concept that he or she does not have knowledge of in order to build up his or her knowledge of research methodology. 3. The player can skip any concepts he or she already knows. 4. The player can go to the playing mode to test his or her knowledge. 5. The player has the opportunity to restudy and go to learning mode again. 6. The player needs to justify his or her choice after each question or scenario.
	Standards	A keyboard and a mouse are the tools that are used for learning and playing the game because the user will be familiar with using a keyboard and a mouse.
	Outcomes	- Feedback is given on what has been completed and what has been understood from the game. - The final grade is achieved in the last screen at the end of the task.
	Ending Conditions	The game ends after the user has finished the learning steps and the task, and has obtained a result on his or her performance.
	Sensory Feedback	When a user chooses the wrong step in an attempt to achieve the task, he or she needs to go back and start again. This indicates to the user that he or she needs to understand that step in order to move forward successfully. Also, feedback on

Characteristics		Gaming Technology
		understanding and performance is given at the end of game.
Player Effort	Cost	There is no cost involved; there is no need to purchase or obtain anything.
	Rewards	Completion of the game and obtaining the grades.
	Downtime	After achieving the game's steps or after an hour.
	Busywork	N/A
	Reward/effort ratio	The user receives an overall grade after achieving all the game's steps.

4.3.1.8 Game design elements

Building upon previous game design elements and theories, the Research Methodology Game is designed based on the flow theory. It also adopts and gains support from game design elements from other aspects of game design because most designer-developed frameworks are based on related ideas for different purposes. The Research Methodology Game was developed based on the elements that are explained in Table 4.9.

Table 4.9 Game design elements based on the flow theory

Element	Description
Challenge	The game provides three scenarios that need to be solved based on the information that was obtained from the learning mode in the game and from the learner's experiences. The challenges in the game needed to be balanced to fit different player levels and ability by providing three tasks. Each task has different difficulties that meet most participant abilities.
Feedback	The learner receives different types of feedback, such as immediate feedback when he or she chooses the wrong step. Then, the learner needs to go back and start the scenario once again until he or she gains the right steps to move through the game. Additionally, the learner receives the final feedback that describes his or her performance.
Clear goals	The game has a clear objective and goals provided by the system at the beginning of the game.
Performance and awareness	After performing all the game modes and tasks, the learner will understand research methodology concepts and aspects.

Element	Description
Task	The game has three tasks (see 4.3.1.9). The learner needs to achieve these tasks in order to measure his or her own performance.
Control	The learner has control of the game and he or she can switch between learning mode and playing mode and choose the questions. The learner undertakes all the game's tasks in an interactive environment.
Loss of self-consciousness	The game is designed in a three-dimensional environment with high quality visual and sounds that makes it an entertaining environment for the learner. There are also some animations that aid the learner in engaging in the game with a loss of self-consciousness.
Altered sense of time	The environment and the game were designed as an interactive environment for the users to explore various options while having fun.

Additionally, there are some other elements that can support the Research Methodology Game and these are presented in Table 4.10.

Table 4.10 Supportive game design elements

Element	Description
Interactivity	The game is based on an interactive system to obtain information.
Visual learning	The game provides a 3D environment and animation to explain the research methodology perspective.
Verbal information	The game provides sound and audio when presenting research methodology concepts.
Fantasy	The game engages in fantasy by building the game environment as a lake with dangers everywhere. Within the fantasy world within the game a user might end up being eaten by a crocodile.
Fun	Fantasy incorporates fun and interest because it presents complicated and difficult information in an unusual format.
Learn and practice	The game has two modes: learning mode and playing mode. Learners can obtain information from the learning mode and practise that information until they are ready to test their understanding in the playing mode.

Based on these elements, the game establishes three scenarios to solve problems and to assist in establishing the appropriate research methodology to undertake a particular study and to fill the gap in the knowledge by solving the problems.

4.3.1.8.1 Game Tasks

The game describes what learners need to do in the game by written instructions and through the 'About' part of the game. Players need to work through the learning mode in order to acquire knowledge about research methodology and thus improve their awareness and enhance their learning experience and skills. Subsequently, learners need to go through the playing mode to accomplish three tasks and test their understanding. Each task provides a special scenario which utilises research methodology. Learners have to correctly answer each question and then move forward until they have accomplished all the tasks. These tasks and scenarios are as follows:

Question 1:

A medical organisation wants to test new pills/tablets to assist people in dieting and losing weight in order to control diabetes, blood pressure and cholesterol level. These tablets have been created based on some medical theory. Clinicians are testing the impact of the tablets on people with different problems. Choose the suitable research philosophy and research methodology to undertake this research and measure the tablets' effect on patients.
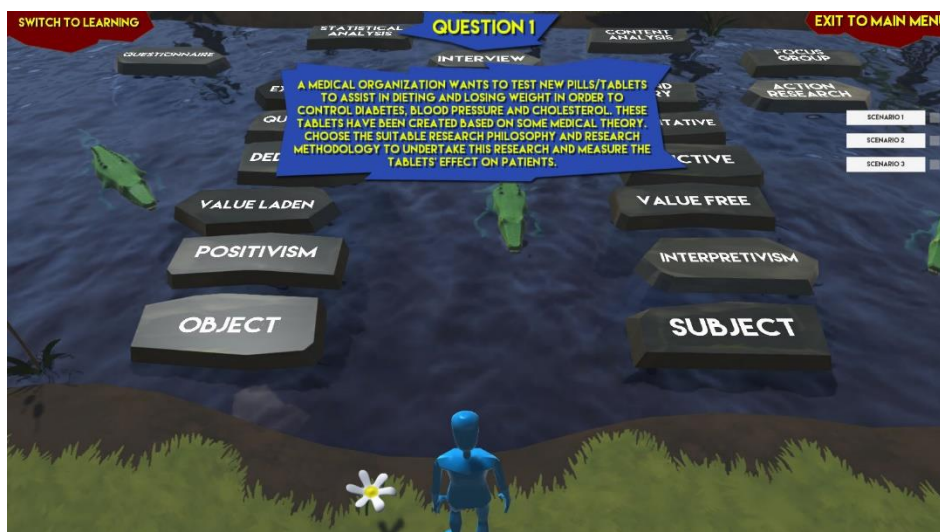
Figure 4.8. Task 1 Screen

Question 2:

A medical organisation plans to change patients' behaviour to help them control their weight, diabetes, blood pressure and cholesterol level. Their research is concerned with what the patients want to change and how they can change. The research looks at how patients can be encouraged to undertake some exercise and take up some activities in addition to eating healthy food. Choose the suitable research philosophy and research methodology to undertake this research.

Question 3:

Your organisation has a problem with its webpage interface. It is very complicated to use. Your organisation is looking for an efficient interface design to improve usability and make it more helpful for users.

Each scenario or question has a particular research methodology that is required in order to achieve an appropriate outcome. These scenarios and questions will test the learner's knowledge and teach the learner how to choose the best research methodology for each scenario. The next section looks at the creation of the game design framework for the Research Methodology Game.

4.3.1.8.2 The game's design framework

The game's design framework was based on all the game elements in the flow theory and on other supportive elements from previous research and gaming design. The framework in Figure 4.9 shows, in the first layer, the flow theory elements which are: challenges, clear goals, task, performance and awareness, feedback, an altered sense of time, loss of self-consciousness, and control. In the second layer, the supportive elements are: fantasy, interactivity, visual learning, verbal learning rules, learning and practice that enables students to have fun, and being interested and happy during learning and studying. On the whole, these elements help to create an effective learning environment through playing the game and using gaming technology to acquire appropriate knowledge efficiently. Therefore, the game's design was created to develop a gaming technology platform in order to test learning factors and the researcher's research questions and to explore some learning factors that support game-based learning. All the game elements supported learning factors and caused the learner to be interested and happy to learn (which, in turn, affects learner attitude, cognition, and memory). This gaming technology platform was created to discover if gaming

technology leads learners to learn independently and whether it enhances learners' curiosity and motivates them to go through a learning process. It was also created to influence learners' cognition and to increase learners' higher-order thinking through using problem solving and critical thinking to find a solution. The game was also created to measure cognitive load.
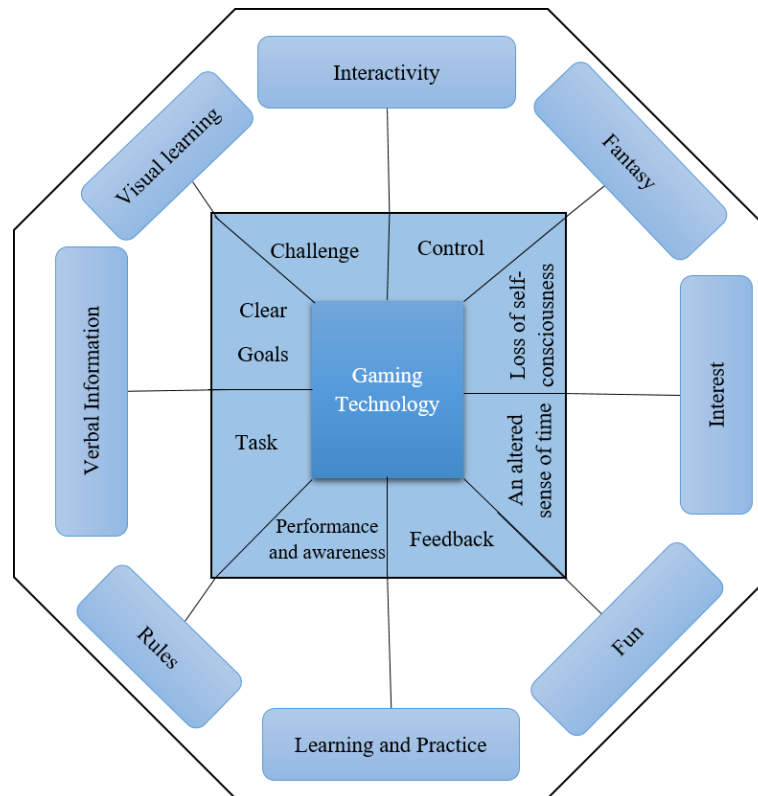
Figure 4.9 The Research Methodology Game design framework.

4.3.2   E-book design

The e-book design did not have a particular theory for its creation. The e-book was designed as a digital textbook which included the same information that was provided in the gaming technology environment with nice fonts' styles, size and colour. Moreover, the e-book included pictures and figures to explain concepts. Pictures and figures provided in the e-book were taken from the Research Methodology Game to provide the same concepts and content which were used in the gaming environment. Also, the e-book group had the same tasks as the gaming technology group with a justification form to provide reasons for their steps and choices. As a result, both technologies had the same concepts' content, but the learning environment was different in order to make a comparison between gaming technology and the e-book.

Figure 4.10 A sample of the e-book's content and pages.

4.4   Summary

This chapter provided an outline of the conceptual framework and this led to the creation of the experimental platforms to test and explore the impact of gaming technology on themes (attitude, cognition and memory) and their factors (autonomous learning, curiosity and

motivation within the attitude theme). In addition, higher-order thinking (which included critical thinking and problem solving) was tested and explored under the cognition theme. Finally, the memory theme used the cognitive load theory as a measure. The creation of the conceptual framework led to the development of the experiment platforms.

Two experiment platforms were developed: a gaming technology platform and an e-book platform. The gaming technology platform was supported by the flow theory which has helped to build gaming environments, whereas the e-book platform was designed as a digital textbook. In the Research Methodology Game learners improve their knowledge in the learning mode phase. Then, in the playing mode, they utilise the knowledge gained to develop research experience by performing tasks that build upon previous knowledge. The e-book was developed for the same purpose and utilised reading and problem-solving tasks. As a result, both technologies affect the participants' research skills. Furthermore, both technologies could affect higher-order thinking through problem-solving and critical thinking. Additionally, gaming technology could have an effect on the memory effort required to acquire knowledge in a gaming environment. These platforms were used to measure the impact of both gaming technology and e-book technology on learning and to compare their impact in order to provide the best environment for learning. The findings and results of this research are discussed in the next chapters.

Chapter 5. The impact of gaming technology on learners' attitudes

5.1   Introduction

The purpose of this chapter is to report on the exploration, testing and evaluation of the impact of gaming technology on learning attitudes (autonomous learning, curiosity and motivation) and to compare this impact with that of the e-book. This research looks at the impact of the gaming technology on learning attitudes by supporting the learning factors that exist and come together in the conceptual framework. This section includes a discussion of the quantitative analysis of some of the factors and elements, and uses qualitative analysis to support the quantitative analysis in order to discover the impact of gaming technology on learning. Descriptive statistics were utilised to measure the satisfaction of participants. Satisfaction levels were rated by the participants on a scale from one to five. Based on this scale, if the average result was greater than four, then the satisfaction rating was excellent. If the average result was between four and three, then the satisfaction rating was good. However, if the average result was between three and two, this corresponded to a low level of satisfaction and, finally, if the average result was below two, this corresponded to a very low level of satisfaction. In addition, some parts of the questionnaire were used either to conduct paired-sample t-tests or to compare factor means before and after using gaming technology (such as the trait of curiosity and the state of curiosity). In addition, an independent-samples t-test was used to compare the influence of gaming technology on participants with that of the e-book. The researcher established the factors and the sub-factors that were needed to be measured in order to understand the impact of gaming technology and the e-book on learning. In addition, in order to discover even more sub-factors and elements for each factor, the research explored and tested learning attitudes by looking at factors such as autonomous learning, curiosity and motivation. The results illustrate and compare the impact of gaming technology with that of the e-book on learning behaviour.

5.2   Attitude

Attitude relates to the behaviours and emotions that participants need to use in order to learn through the use of gaming technology. It is important when studying learning through the use of gaming technology to measure attitude, and to explore autonomous learning which will, undoubtedly, form a large factor within future learning. Additionally, in this study,

curiosity was measured by testing the impact of the e-book on participants and exploring how the e-book influenced the participants' curiosity to learn. Motivation was measured to find out which elements best motivate participants to learn. In this section, the study tests and explores three factors which are autonomous learning, curiosity and motivation, and compares the results of the impact of the gaming technology with the impact of the e-book on learners' attitudes.
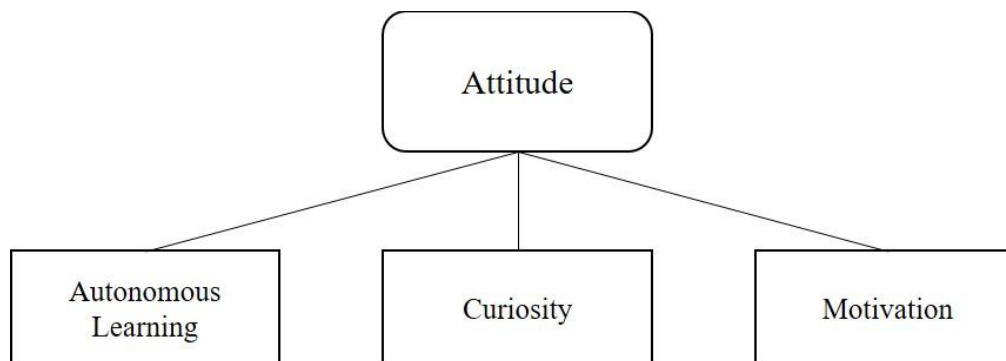
Figure 5.1 Attitude factors.

5.2.1 Autonomous Learning

The following section evaluates whether gaming technology enhances learning and describes the factors that make up game-enhanced autonomous learning, so as to compare that with the impact of the e-book.

Based on Grow's model for independent learning, autonomous learning has four stages: the first stage is the 'dependent' stage which is where that a learner is not able to gain knowledge without the support of a teacher or instructor. The second stage is the 'interest' stage which is where a learner is ready and confident to learn and will make an effort to learn; however he or she still needs direction and support from an instructor. The third stage is the 'involved' stage which is where a learner has the ability to perform tasks but needs motivation and confidence. The fourth stage is the 'self-directed' stage which is where a learner can learn independently without a need for an instructor (Warring, 2013).

The independent learning stage was measured before and after playing the game to demonstrate the impact of gaming technology on autonomous learning. Participants answered a questionnaire that asked them to choose the statement that described their ability

to perform a task in the game. Participants were provided with four statements from which to choose; each answer described one stage of independent learning (Appendix 4).

Based on the responses to this question (as seen in Table 5.1), the results demonstrated that gaming technology enhances the ability to study independently. Most of the participants were in the second stage ('interest') before playing the game (12 out of 15, or 80% of the sample), two participants were in stage three ('involved') (13.3%) and one participant was in stage four ('self-directed') (6.7%). However, these results changed after using the gaming technology because the number of participants in stage two was reduced to three (20%) and the number of participants in the third stage was increased to 11 (73.3%). There was no difference in the number of participants who were at stage four. The results point out that participants who were at stages one and two can enhance their learning stage to a higher stage by using gaming technology. These results show that gaming technology enhances autonomous learning. Figure 5.2 shows and explains the differences between the stages before and after using the gaming technology.

Table 5.1 Autonomous learning stages before and after using the gaming technology

	Before Playing the Game		After Playing the Game	
	Frequency	Percentage	Frequency	Percentage
Dependent	0	0	0	0
Interest	12	80.0	3	20.0
Involved	2	13.3	11	73.3
Self-directed	1	6.7	1	6.7
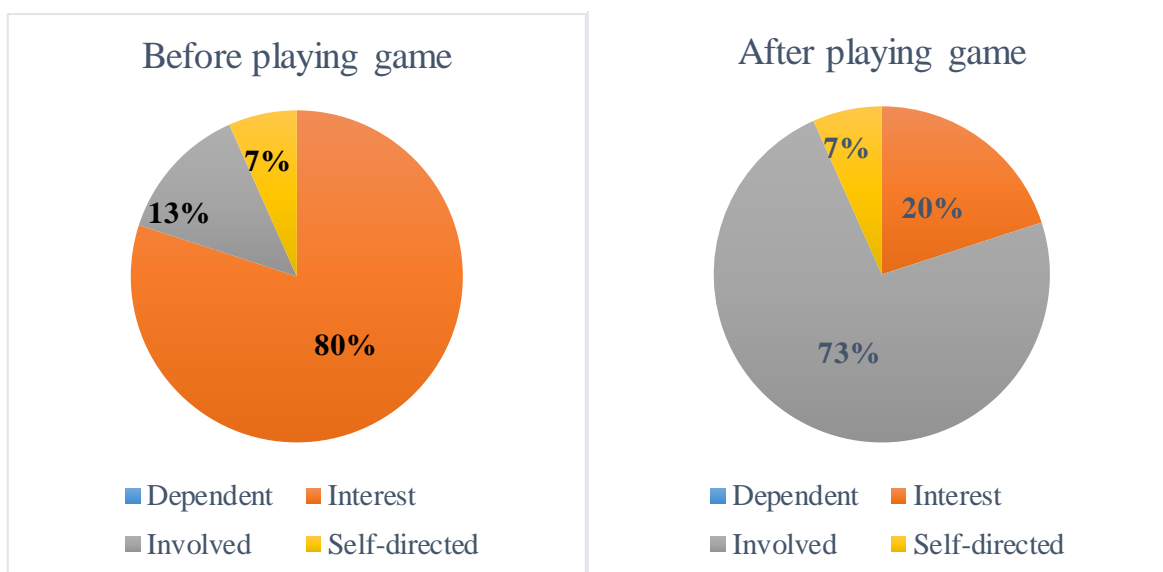
Figure 5.2 Differences between the autonomous learning stages before and after using gaming technology.

The same question was posed to the e-book group. However, the e-book did not have a significant impact on the autonomous learning level (see Table 5.2).

Table 5.2 Autonomous learning stages before and after reading the e-book.

	Before Reading the E-book		After Reading the E-book	
	Frequency	Percentage	Frequency	Percentage
Dependent	0	0	1	6.7
Interest	9	60.0	7	46.7
Involved	3	20.0	3	20.0
Self-directed	3	20.0	4	26.7

Table 5.2 shows that e-books do not have an impact on independent learning ability. Before reading the e-book, participants did not categorize themselves at the dependent stage. After reading the e-book, however, one of participants choose to reduce his ability and placed himself in stage one because he thought that he needed an instructor to explain the research methodology to him as it was difficult and complicated. However, another one of the participants moved from stage two to stage four because he felt that the e-book made learning easy and simple for him (based on several reasons which will be provided in the content analysis section which looks at the impact of the e-book on learning). The other participants remained in their original stages. These results show that the e-book had no clear impact on

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autonomous learning and did not enhance participants' independent learning (see Figure 5.3).
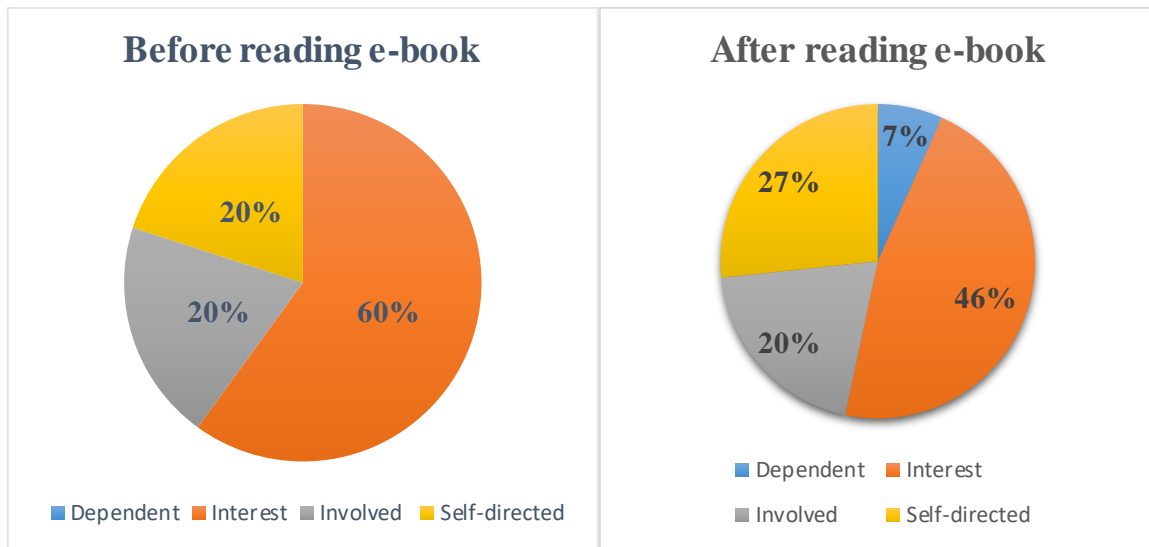
Figure 5.3 Differences between the autonomous learning stages before and after reading the e-book.

In order to evaluate the impact of gaming technology and the impact of the e-book on autonomous learning, the following closed question was asked:

Q: Does learning through (gaming technology/e-book) enhance autonomous learning?

The descriptive results show that participants rated this fact at a minimum of three, which was 'neutral', and a maximum of five, which was 'strongly agree', with a mean of (M = 4.40, SD = .632). Thus, in the participants' opinions, gaming technology enhanced their ability to be an independent learner and to gain knowledge, experience and skills. Figure 5.4 shows the results.
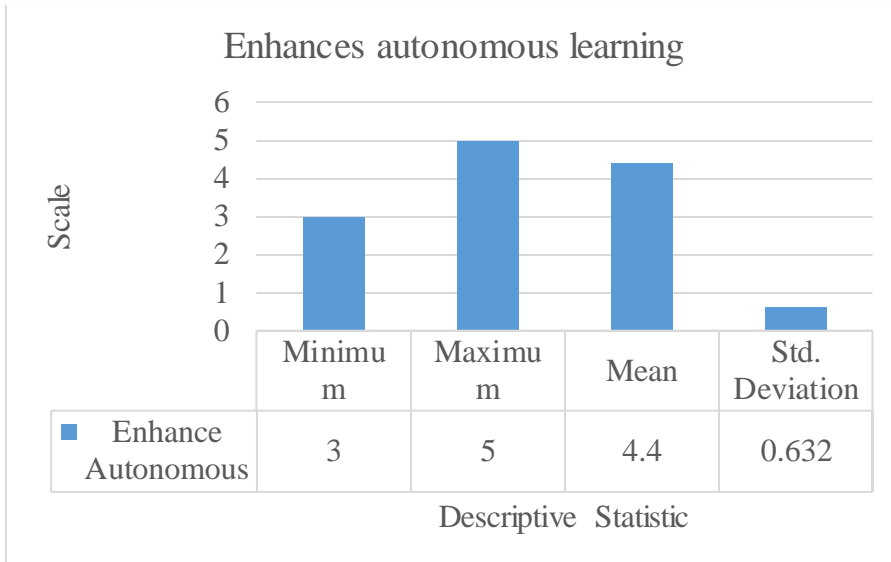
Figure 5.4 Results for the descriptive statistics for the factor 'Gaming technology enhances autonomous learning'.

When the same question was asked of the e-book group, (i.e., whether the e-book enhanced autonomous learning), responses from the participants ranged from the minimum of two, which was 'disagree', to the maximum of five, which was 'strongly agree'. Moreover, the mean was (M = 4.07, SD = .884). This shows an excellent satisfaction rating, according to the participants' opinions. The participants decided that the e-book enhanced autonomous learning (the results are shown in Figure 5.5).
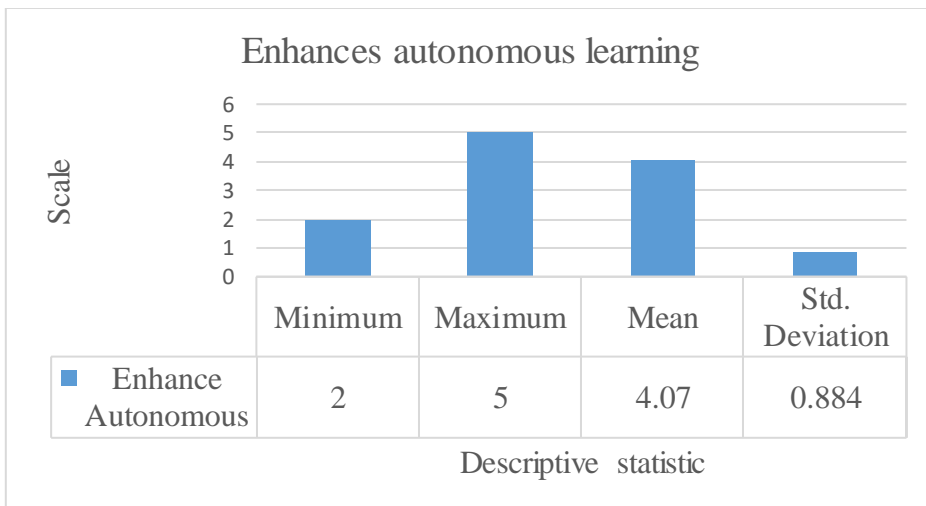
Figure 5.5 Results for the descriptive statistics for the factor 'E-books enhance autonomous learning'.

In this particular stage of the analysis of gaming technology, the researcher looked at whether the gaming technology enhanced autonomous learning. It made a difference to participants' stages after playing the game in that 60% of the participants in stage two ('interest') moved to stage three ('involved'). However, for the e-book group, the e-book did not have a similar impact. 6.7% of the participants moved from stage two to stage one and another one moved from stage two to stage four. There was no other movement between stages for the other participants in the e-book group, and the majority of participants stayed at their original stage of independent learning.

Based on the question as to whether the gaming technology and the e-book enhance autonomous learning, an independent-samples t-test was conducted to compare the impact of the gaming technology on autonomous learning with the impact of the e-book on autonomous learning. There was no significant difference between the result for gaming technology (M = 4.40, SD = .632) and the e-book (M = 4.07, SD = .228): t (28) = 1.188, p =.245. This result suggests that the gaming technology had the same effect as the e-book on autonomous learning and that they can work together to enhance independent learning. Table 5.3 shows the t-test results. Figure 5.6 compares the mean result between gaming technology and the e-book.

Table 5.3 Independent-samples t-test results when comparing gaming technology with the e-book in terms of whether they enhance autonomous learning.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Enhance Autonomous Learning	Gaming Technology	15	4.40	.632	.163
	E-book	15	4.07	.884	.228

	Levene's Test for Equality of Variances		T-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.135	.716	1.188	28	.245	.333	.281	-.241	.908
Equal variances not assumed			1.188	25.361	.246	.333	.281	-.244	.911
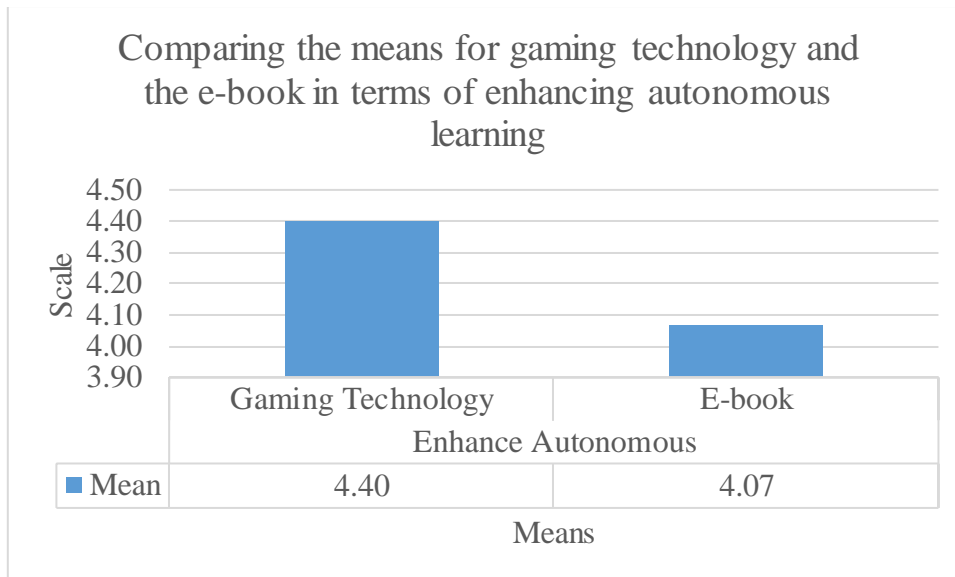
Figure 5.6 Comparing the means of gaming technology with the e-book in terms of enhancing autonomous learning.

All in all, gaming technology enhanced autonomous learning better than the e-book.

There were factors, sub-factors and elements that helped to enhance independent learning (as explored through the interviews and content analysis). Figure 5.7 shows the factor and sub-factors that form the framework in order to explore the influence of gaming technology and e-books on participants' opinions with regard to the sub-factors.
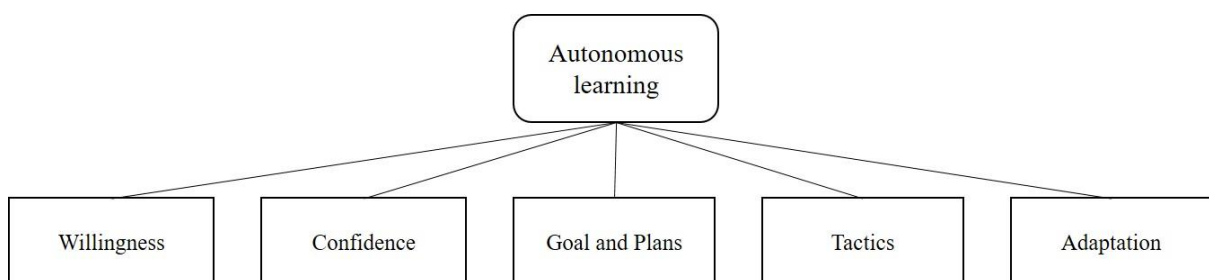
Figure 5.7 The factor of Autonomous Learning and its sub-factors

There is some differentiation, however, which can be seen in the content analysis, which provides information on the factors, sub-factors and elements. The main factors in the content analysis are the same for both gaming technology and the e-book, but there are some

differences in the elements within each factor and sub-factor which indicate that gaming technology has more possibilities for supporting autonomous learning.

Based on Grow's model, willingness and confidence are the most important sub-factors in encouraging autonomous learning in addition to certain other sub-factors such as goals and a plan that helps in the performing of tasks. In addition, while achieving tasks, users employed tactics and adapted solutions. The following sections explain these elements and show the differences between gaming technology and the e-book in terms of how both technologies enhance autonomous learning.

5.2.1.1 Willingness

In order to explore those elements that support willingness for learning independently when using gaming technology and the e-book, the following question was asked:

Q: Did (gaming technology/the e-book) enhance your willingness to learn independently? Why? How?

The results show some similar elements that support willingness and some different elements for gaming technology and the e-book. The following table (Table 5.4) shows the differences between gaming technology and the e-book.

Table 5.4 Comparison of the elements that support willingness between gaming technology and the e-book.

Sub-factor	Elements	Gaming Technology	E-book
Willingness	Availability	✓	✓
	Usability	✓	✓
	Flexibility	✓	✓
	Diversity	✓	✓
	Human senses (e.g. vision)	✓	✓
	Enjoyability	✓	✗
	Attention	✓	✗
	Concentration	✓	✗
	Trustworthiness	✗	✓

The subjects responded to the interview questions and explained how gaming technology and the e-book enhanced their willingness to learn independently. Table 5.5 illustrates some of these responses and ideas.

Table 5.5 Responses from participants in response to the question: Did (gaming technology/the e-book) enhance your willingness to learn independently? Why? How?

Elements	Gaming Technology	E-book
Availability • Use it anywhere and at any time • Use it in any situation	GT 4 said 'I can use a game at any time and in any place. For example, I can use a game to study by playing games during travels on an aeroplane or train and I can study when staying at home or before sleeping in bed'.	EB11 stated 'E-books are available to use at any time and in any place and by using several types of device via using the Internet.' EB13 stated 'I can save documents on my own devices and read them when I need them'.
Usability • Easy to use • Suitable with most types of information literacy ability • Easy to install/ download and use	GT13 stated 'This game is easy to use and it is easy to interact with to learn, and does not need a high level of ICT skills'. GT2 stated, 'I can learn from the game by clicking on the keyboard or using a mouse, which make learning easy'.	EB1 said 'Users can highlight the important concepts and definitions, users can write notes on any part of the e-book, and users can filter information or documents and go to specific information/knowledge and narrow down the research to find accurate information'. EB3 stated 'E-books can be easily adjusted because a user has the ability to zoom in and to make the font bigger and, thus, comfortable to read'.

Elements	Gaming Technology	E-book
Flexibility • Use it with several types of technology, such as PC, laptop, tablet and smart mobile. • Use several types of strategy to learn and to perform the task	GT 15 said 'I have several choices in order to play the game. First, I can enhance my understanding about research methodology by using the learning mode then undertaking the game's tasks on this occasion. The second choice is where I can start with the tasks. I can take a risk and try my chance and this may cause me to fail and sink. The third choice is where I can start and go back to the learning mode to find the answer(s) and pursue my steps further. This flexibility helps me to use an effective strategy for learning that is suitable for my ability'. Also, observation showed that participants used different strategies to perform tasks. GT9 stated 'I can use different devices (laptop, tablet, smartphone) to play the game'.	EB12 said 'I can read an e-book by using several types of device, such a laptop and a mobile. I prefer big devices because small devices affect my vision and eyes.'

Elements	Gaming Technology	E-book
Diversity • Use to enhance the different aspects of knowledge and skills.	GT1 pointed out 'Gaming technology can be used for different aspects, for different types of knowledge and science. Also it can be used for training to enhance skills'.	EB2 said 'E-books can include a variety of knowledge and I can choose what I want to learn'.
Human senses (e.g. vision) • Vision • Listen • Touching	GT5 pointed out 'The game includes audio and verbal learning, which means that participants use their senses to learn (such as listening, seeing, touching and interacting with the game in this way). Learning in this manner increases learning ability and makes learning effective and efficient'.	EB1 stated 'E-books include pictures to explain concepts and make reading comfortable. Users can use their visual sense to support their understanding of concepts and definitions because pictures make definitions easier to understand and make learning much easier also'.
Enjoyability • Interactive environment • Suitable for a new generation	GT2 stated 'Gaming technology can make learning enjoyable and can entertain a user. It helps to avoid boredom during learning because the user is interacting with system'. GT4 said, 'A new generation is growing up alongside specialised gaming technology.	

Elements	Gaming Technology	E-book
	Moreover, new generations of students can gain a lot of indirect knowledge through gaming technology because it is enjoyable for them'.	
Attention	GT8 stated 'The game captures my attention because gaming technology includes visual learning such as pictures, animations and videos'.	
Concentration	GT6 pointed out 'Gaming technology enhances my concentration and allows me to focus on concepts and on important points because I have to deal with hazards and secure myself within the game; I have to pass through the hazards safely'.	
Trustworthiness		EB6 said 'Most e-books are created by academic staff or academic authors and e-books created for academic purposes will help participants perform well in universities'.

There is some differentiation, however, within the content analysis that explains the factors, sub-factors and elements. The main factors in the content analysis are the same for both

gaming technology and the e-book. However, there are some differences in the elements within each factor and sub-factor which indicate that gaming technology has more possibilities for supporting autonomous learning. The similar elements within the willingness factor are availability, usability, flexibility, diversity and the use of human senses (such as vision, etc.). However, gaming technology has more elements than the e-book, and this makes it more interesting for the participants as the e-book did not capture participants' attention and concentration. Overall, the e-book did not provide an enjoyable experience for the participants. However, the e-book was more trusted than gaming technology by the participants because e-books are utilised much of the time in universities and in academic environments for review and evaluation. Figure 5.8 shows the willingness elements and the differences between the gaming technology and the e-book in terms of these elements.
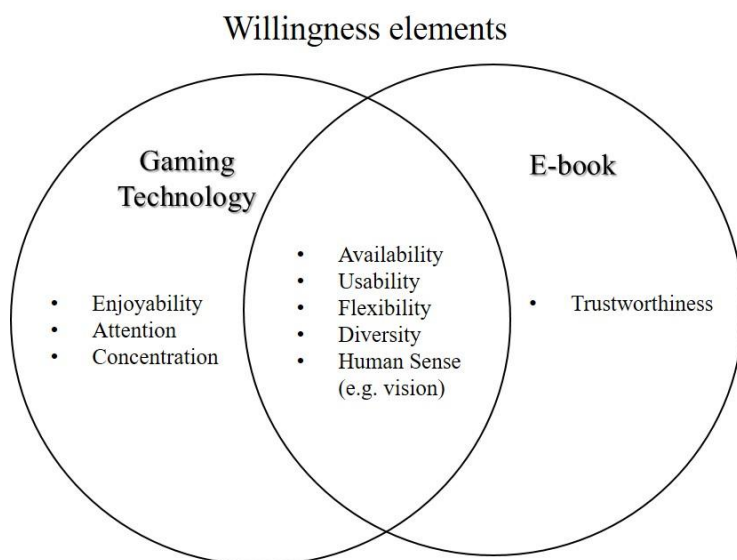
Figure 5.8 Willingness elements for gaming technology and the e-book.

5.2.1.2 Confidence

In order to find out the impact of gaming technology and the e-book on the confidence of the participants in terms of learning independently, the following question was asked:

Q: Did (gaming technology/e-book) enhance your confidence to learn independently? Why? How?

Table 5.6 shows the confidence elements (for gaming technology and the e-book) that were found based on the participants' responses.

Table 5.6 Comparison between gaming technology and the e-book in terms of the elements that support confidence.

Sub-factor	Elements	Gaming Technology	E-book
Confidence	Feedback	✓	✗
	Restudy	✓	✓
	Private environment	✓	✓
	Performance	✓	✓
	Rich knowledge	✗	✓

Participants responded to the question about confidence and explained how gaming technology or the e-book had an impact on their confidence. Table 5.7 provides some examples of these responses.

Table 5.7 Responses from participants with regard to the question: Did (gaming technology/e-book) enhance your confidence to learn independently? Why? How?

Elements	Gaming Technology	E-book
Feedback • Evaluated and assessed participant performance directly	GT1 said 'Feedback from the game evaluated and assessed my performance directly and helped me to focus on my weaknesses and develop my knowledge'.	
Restudy • Clears up any confusion that a participant might have • Encourages a participant to obtain more understanding • Helps to fill in a gap in a participant's knowledge	GT13 stated 'Switching between the learning mode and playing the game gave me an opportunity to test my knowledge and to go back to ensure my understanding is correct and this also helped to confirm my understanding'.	EB3 stated 'I can go back to re-read if I have any misunderstanding or confusion'.

Elements	Gaming Technology	E-book
Private environment • Avoids feelings of shame and embarrassment.	GT3 said 'Gaming technology enhances my confidence because when I study alone I feel confident because no one observes my work. I can study and I can make a mistake without any shyness or shame and I can fix my mistakes. This increases my confidence because I achieve my target by myself'.	Most of the participants indicated that they tended to avoid asking people questions and that they preferred to find answers to their queries by using technology, such as the Internet, asking questions online, and using e-books.
Performance • Achieves task successfully	GT 13 explained the experience thus: 'All in all, even with zero knowledge, I did well and created the right research methodology. It is not as scary as I thought. I understand some of the concepts, such as the inductive approach, the deductive approach and positivism, and that increased my confidence'.	
Rich Knowledge • Abundance of knowledge		EB10 said 'Reading through e-books can ensure that users can obtain a lot of knowledge on research methodology and that can increase user confidence.

Elements	Gaming Technology	E-book
		When a user has a lot of information, this can improve performance and make the user very confident in their ability to implement an effective research methodology'.

The participants' responses to the interview questions show there was a balance of elements. Gaming technology has the advantage of giving feedback about the participants' performance, while the e-book provides rich knowledge which improves confidence. However, from responses in the interviews, the researcher found that the gaming technology group participants were more confident than the e-book group participants. All the participants in the gaming technology group accepted that the game encouraged their confidence whereas, in the e-book group, nine of the participants did not have complete confidence in what they had learned and occasionally needed help with difficult concepts. In conclusion, gaming technology was shown to enhance confidence more than the e-book.

Figure 5.9 shows the confidence elements and the differences in terms of these elements between gaming technology and the e-book.
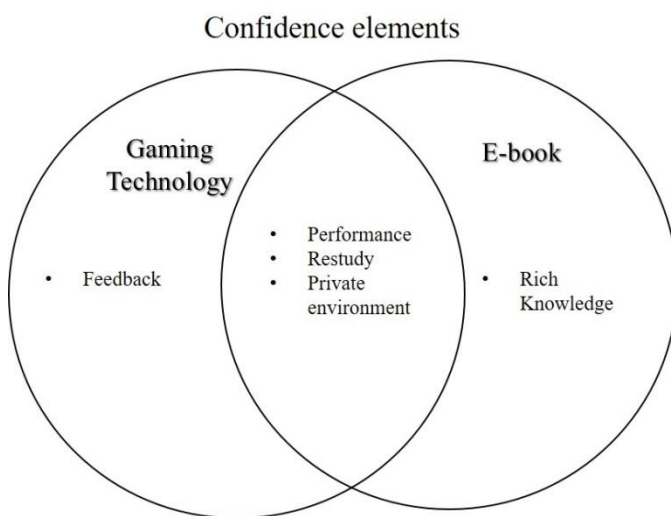
Figure 5.9 Confidence elements for gaming technology and the e-book.

5.2.1.3 Goals and plans

To measure participants' ability to have a goal and a plan in learning through using gaming technology and the e-book, the following question was asked:

Q: What goals and plan did you set out when learning about research methodology in order to prepare yourself for conducting the task?

The results show that both groups of participants had planned goals to perform the task. The following table shows both groups' goals and the plans they used based on their responses to the interview question.

Table 5.8 Goals and plans that participants used to perform tasks.

Gaming Technology Group	E-book Group
Goals: • To complete the game's steps safely and successfully • To achieve the game's tasks	Goals: • To discover more about and understand research methodology (which will help to improve learners' ability to undertake research) • To perform the task
Plan: • To go to play mode and read the scenario. • To define the aim and objectives for each scenario by recognizing the focus of each scenario. • To choose the right moves to move along the steps. • If the participant had any confusion or misunderstanding, they understood that they needed to go back to the learning mode to ensure they understood the step's	Plan: Most of the participants followed these steps: (1) Reading the scenario (2) Defining the research question, aim and objective based on their background knowledge of research methodology (3) Reading the e-book to clarify some unknown concepts (4) Commencing undertaking the tasks and setting up the research methodology for the scenario

Gaming Technology Group	E-book Group
definition in order to be able to choose the right steps. • To move along to the end of the game by choosing the suitable steps in each layer, which leads to applying and evaluating the solution and using tactics to improve understanding. Different participants followed the same steps in a different order. For example, some participants started by reading the scenarios and defining the problem in the scenario, the aim and objectives, then went to the learning mode to increase their understanding about new definitions and concepts in the game steps (by moving between the learning mode and game mode to improve their ability, knowledge, skill and experience of research methodology).	(5) Returning to the e-book and studying if there was any confusion (6) Achieving the tasks and meeting the challenge of picking the right research methodology for each scenario (because each scenario had requirements) Other participants wanted to discover facts via the e-book in order to learn how to organise the concepts and build links between them, and how to simplify difficult concepts.

As a result, it can be seen that learning requires goals and plans regardless of whether a learner uses an e-book or gaming technology in order to make learning efficient and fruitful.

In conclusion, learning requires goal-setting and planning in order to learn effectively with each type of technology. Moreover, participants used tactics to reach their targets and these were observed during experiments.

5.2.1.4 Tactics

Observation was utilised to see if the participants utilised any tactics to achieve their tasks while using gaming technology and the e-book. The observation showed that both groups used tactics to perform their tasks during the experiments.

Participants used different types of tactics to enhance their understanding and to assist themselves in choosing the most appropriate research methodology for each scenario.

Table 5.9 Tactics that were used to perform the tasks by the gaming technology group and the e-book group.

Tactics	Gaming Technology Group	E-book Group
Taking notes	Taking notes while in the learning mode to use in the playing mode.	Some users took notes to remember the concepts during the achievement of the tasks. Remembering the concepts led the participants to utiliseing them during the tasks and, thus, to find the appropriate research methodology for each scenario.
Trying	Trying some steps and then learning effectively from their mistakes; this improved their understanding of the research methodology steps and layers. Subsequently, participants then applied the right research methodology for each scenario. (In so doing, they used step-by-step learning and testing their understanding by playing the game.)	
Guidelines (mind mapping)	Some participants used mind mapping to increase their understanding. Some	

Tactics	Gaming Technology Group	E-book Group
	students tried to take a picture of the learning mode screen and the playing mode screen, and some of them asked the researcher to print off a copy of the screens for them. When asked, they stated that they intended to use the copy as a guideline or as a mind map to set their research methodology. Their mind map was the game screen, the organization of the concepts and the definition in the learning mode of the game and also in the game steps in the playing mode. This helped them to memorise the concepts and remember them easily (see Figures 5.10 and 5.11).	
Step-by-step approach	Participants used a step-by-step approach to move safety in the playing mode and to go back to the learning mode in order to be sure about the next step.	Participants undertook the tasks step-by-step in order to approach the task. They undertook one layer of research and then went on to the next layer until they had finished all the research methodology steps by moving between the

Tactics	Gaming Technology Group	E-book Group
		scenario, the e-books and Google.
Highlighting		Some participants used the highlighter function during reading in order to assist in their comprehension and to undertake the tasks.

Figure 5.10 Learning mode screen.
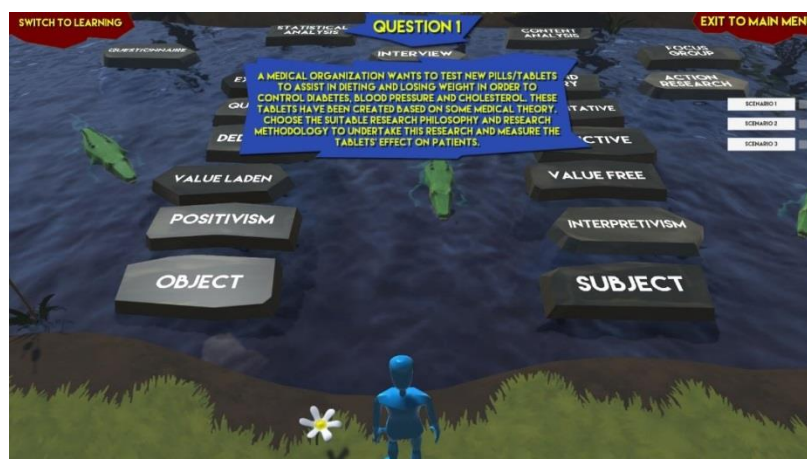
Figure 5.11 Playing mode screen.

Thus, participants need to use tactics to learn and acquire knowledge effectively and, subsequently, to use this knowledge to perform learning tasks.

5.2.1.5 Adaptation

Adaptation is an optional choice that can be observed in the measurement of autonomous learning. Based on observation, the researcher found that participants in the gaming technology group had an opportunity to adapt their choices. However, participants in the e-book group did not have that opportunity.

Playing the game involved an adaptation of knowledge and the use of steps, because learners used the knowledge gained in the learning mode and tested it in the playing mode until finishing the game and winning. The game provided an opportunity for indirect adaptation. This means that participants applied and used steps to evaluate if they were of help in moving through the game successfully and obtaining high grades. As soon as the participants had finished the learning phase, they could imagine how to solve the scenario problem. Subsequently, the participants used their knowledge (that they had learned and acquired independently) from the learning mode and tested their solutions to evaluate the game and then to move through the game successfully by using appropriate solutions.

Within the adaptation sub-factor, gaming technology provided feedback and measured the outcome for each scenario, thus making this kind of learning more efficient and effective because it confirmed solutions or enhanced understanding which helped to find appropriate solutions.

Thus, both gaming technology and the e-book enhance autonomous learning, with a slight advantage on the side of gaming technology. The next part of the thesis compares the impact of both gaming technology and the e-book on curiosity.

5.2.2 Curiosity

This section explores and tests the impact of gaming technology on learners' curiosity. This section will provide some statistical analyses and results that will help to measure the effect of gaming technology on curiosity (such as the state and trait inventory). Some closed questions that related to curiosity were asked of the participants. Subsequently, the answers were used in content analysis in order to discover some new sub-factors and elements that relate to the factor of curiosity. Then, the impact of gaming technology was compared to the impact of the e-book.

In order to measure the impact of gaming technology and the e-book on participants' curiosity, the Melbourne A State Curiosity Inventory questionnaire and aTrait Curiosity

Inventory questionnaire was used to find out the level of curiosity before the experiment (trait inventory) and compare that with the impact that gaming technology and the e-book had on participants' curiosity levels (state inventory) after achieving the tasks in the experiment (see Appendix 2). Each questionnaire had twenty questions that aimed to show, via the responses to the questions, if gaming technology and the e-book enhanced curiosity or not.

When the data were collected (by using the trait and state inventory questionnaires) and analysed for the gaming technology group, it was discovered that all the participants had a high level of curiosity for learning about research methodology. In the ratings given by the participants to the questionnaire, the minimum was 3.40, the maximum was 4.55 and the mean was (M = 3.90, SD = .36736). Figure 5.12 shows the descriptive results.
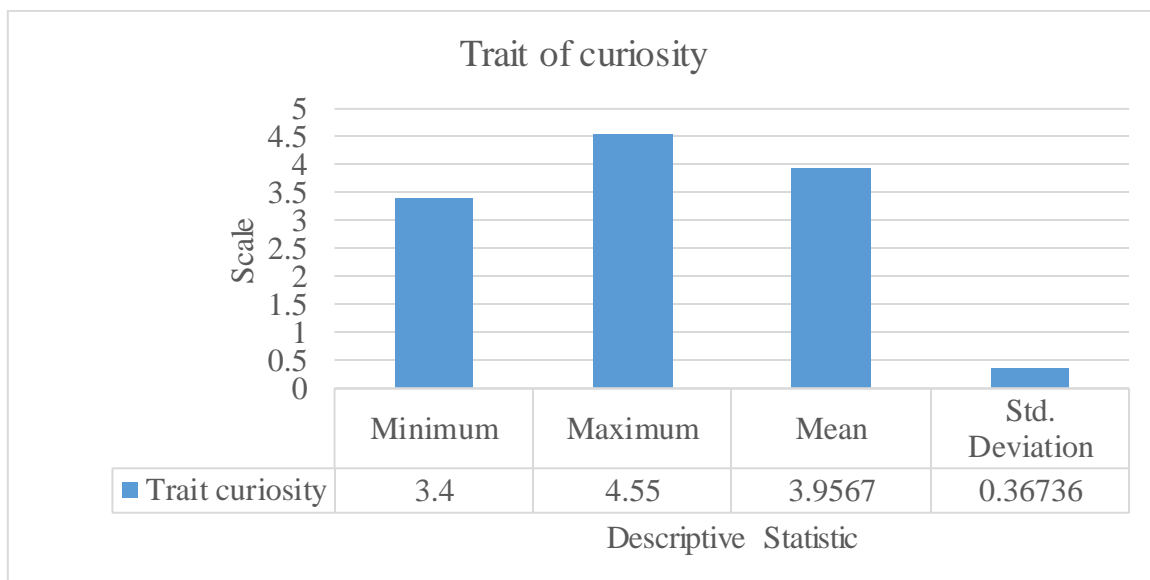
Figure 5.12 The descriptive statistics for the trait of curiosity (gaming technology group).

The state of curiosity was also high because, as rated by participants, the minimum was 3.60 and the maximum was 4.90 and mean was (M = 4.1967, SD = .38101). Figure 5.13 shows the results.
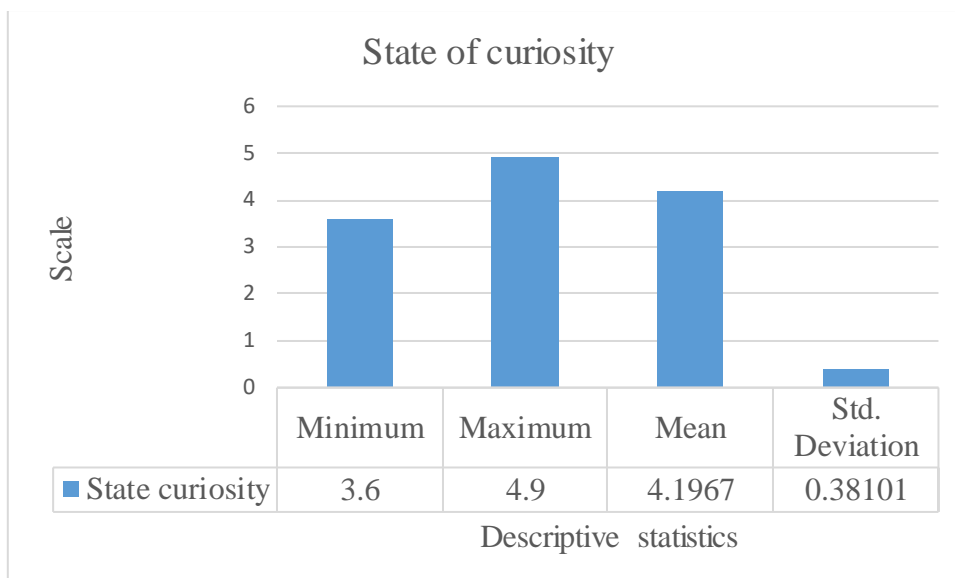
Figure 5.13 The descriptive statistics for the state of curiosity (gaming technology group).

Subsequently, a paired-sample t-test was conducted to compare the trait of curiosity (before using the gaming technology) to the state of curiosity (after using the gaming technology). There was a significant difference in the score for the trait of curiosity (M = 3.9567, SD = .36736) and the state of curiosity (M = 4.1967, SD = .38101); t (14) = -2.405, p = .031. These results point out that using the gaming technology in learning enhances learners' curiosity to find knowledge and to improve their skills and experience. Table 5.10 presents the t-test results and Figure 5.14 presents the paired-sample t-test.

Table 5.10 The paired-sample t-test result that measured the trait and state of curiosity for the gaming technology group.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	CURT-CURS	3.9567	15	.36736	.09485
		4.1967	15	.38101	.09838

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Trait curiosity State curiosity	-.24000	.38647	.09979	-.45402	-.02598	-2.405	14	.031

144
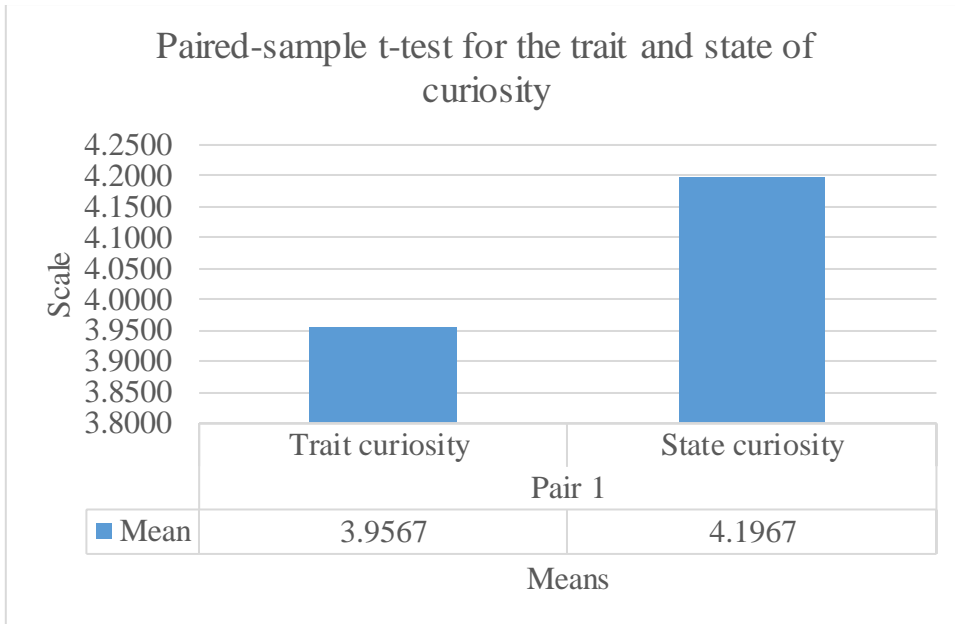
Figure 5.14 The paired-sample t-test for the trait of curiosity and the state of curiosity for the gaming technology group.

However, when the researcher measured the factor curiosity for the e-book group, the results from the trait inventory showed that the minimum was 2.90 and the maximum was 4.75 and the mean was (M = 3.91, SD = .499). This shows that the participants had a high level of curiosity with regard to studying research methodology (see Figure 5.15).
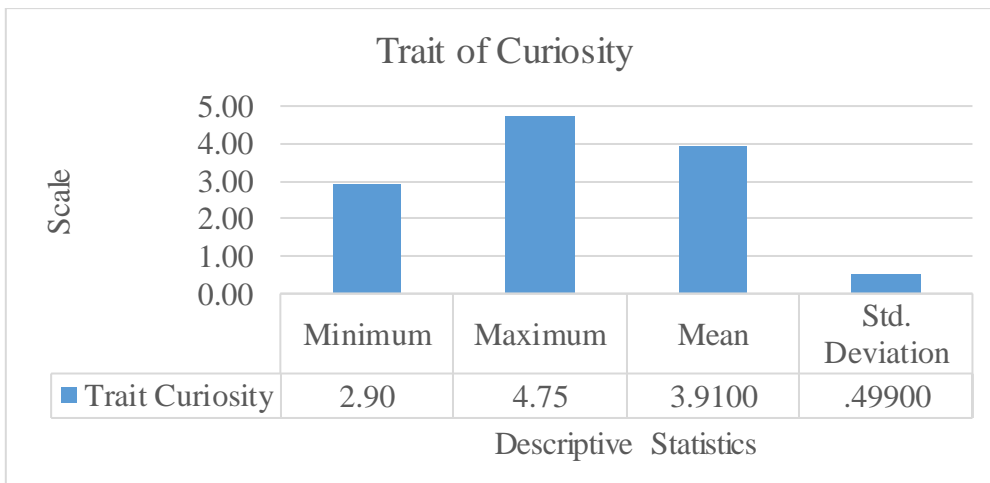
Figure 5.15 The descriptive statistics for the trait of curiosity (e-book group).

Additionally, the state inventory showed that the minimum was 3.13 and the maximum was 4.80 and the mean was (M =3.96, SD = .47667). This shows that the e-book enhanced participants' curiosity regarding using e-books in learning research methodology (see Figure 5.16).
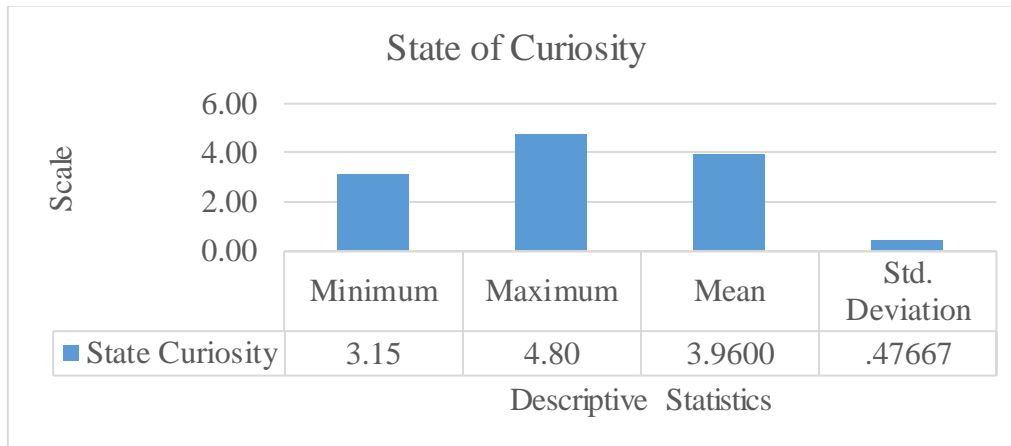
Figure 5.16 The descriptive statistics for the state of curiosity (e-book group).

However, when a paired-sample t-test was conducted to compare the trait of curiosity (before using the e-book) with the state of curiosity (after using the e-book), there was no significant difference in the score. The score for trait curiosity was (M = 3.91, SD = .499) and state curiosity scored (M = 3.96, SD = .47667); t (14) = -.388, p = .704. These results showed that using e-books in learning does not have a significant impact on enhancing learner curiosity to find knowledge and to improve skills and experience. Table 5.11 and Figure 5.17 show the paired-sample t-test that compares the trait and state of curiosity.

Table 5.11 Paired-sample t-test result that measured the trait and state curiosity for the e-book group.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Trait curiosity	3.9100	15	.49900	.12884
	State curiosity	3.9600	15	.47667	.12308

	Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 Trait curiosity - State curiosity	-.05000	.49929	.12891	-.32649	.22649	-.388	14	.704
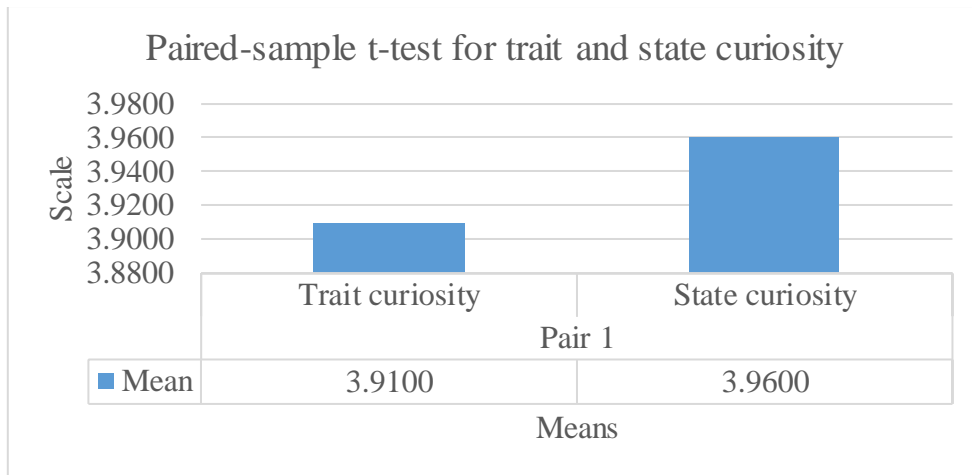
Figure 5.17 Paired-sample t-test for trait and state curiosity for the e-book group.

Thus, the gaming technology group showed a significant difference between the trait of curiosity and the state of curiosity in the results (based on a paired-sample t-test), but the e-book group did not show a significant difference between the trait of curiosity and the state of curiosity in the results. Thus, gaming technology has an influence on enhancing learners' curiosity.

Moreover, as could be seen via the content analysis, the participants stated that gaming technology enhances learners' curiosity. For example, GT6 said 'Gaming technology aroused my curiosity to learn more about research methodology because I found that I needed to have more information in order to have a good understanding of research methodology'. Figure 5.18 shows the factor and sub-factors of curiosity that form the framework in order to explore the influence of gaming technology and e-books on participants' opinions with regard to the sub-factors.
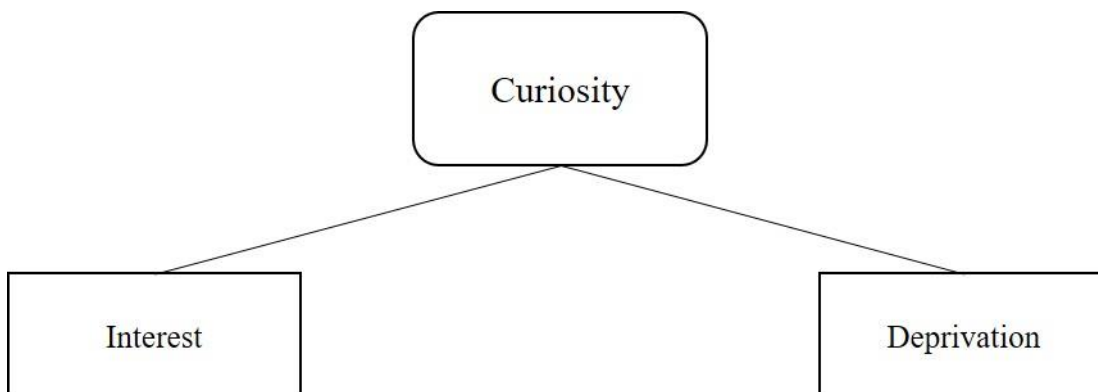
Figure 5.18 The factor of curiosity and its sub-factors.

5.2.2.1 Interest

In order to measure learners' interest, the following closed question was asked:

Q: Were you interested in learning more about research methodology through using (gaming technology/e-book)?

The outcome for the gaming technology group was considered positive because participants awarded a minimum of three, which is 'neutral', and a maximum of five, which means 'strongly agree', and the mean was (M = 4.40, SD = .828). Figure 5.19 provides the descriptive statistics for interest for the gaming technology group.
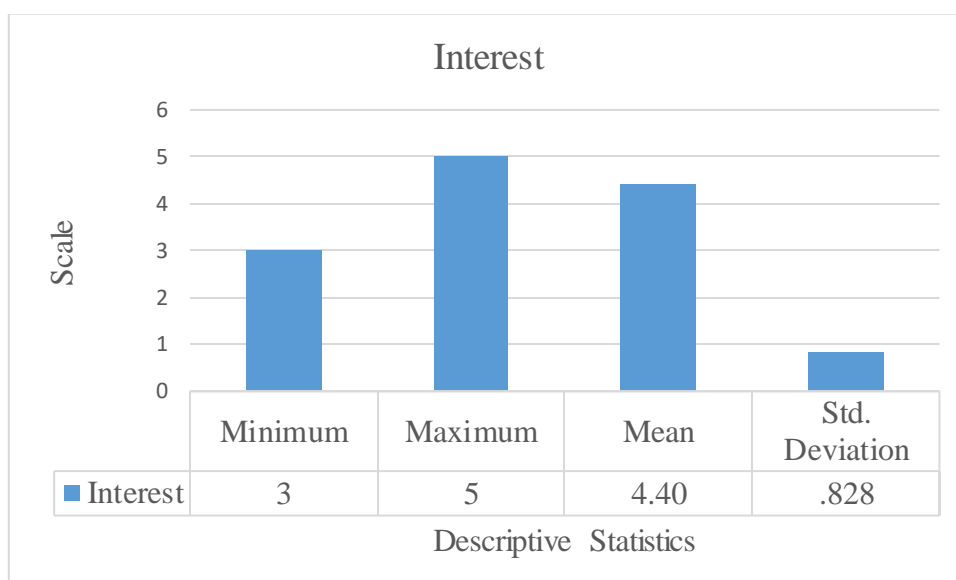
Figure 5.19 The descriptive statistics for interest (gaming technology group).

Thus gaming technology received a satisfaction rating of excellent with regard to capturing learners' interest.

Furthermore, the researcher tested the interest for the e-book group by asking the same question with regard to e-books in learning. The results showed that the minimum was three, which is 'neutral', and the maximum was five, which is 'strongly agree', and the mean was (M = 4.27, SD = .594) Figure 5.20 provides the descriptive statistics for interest for the e-book group.
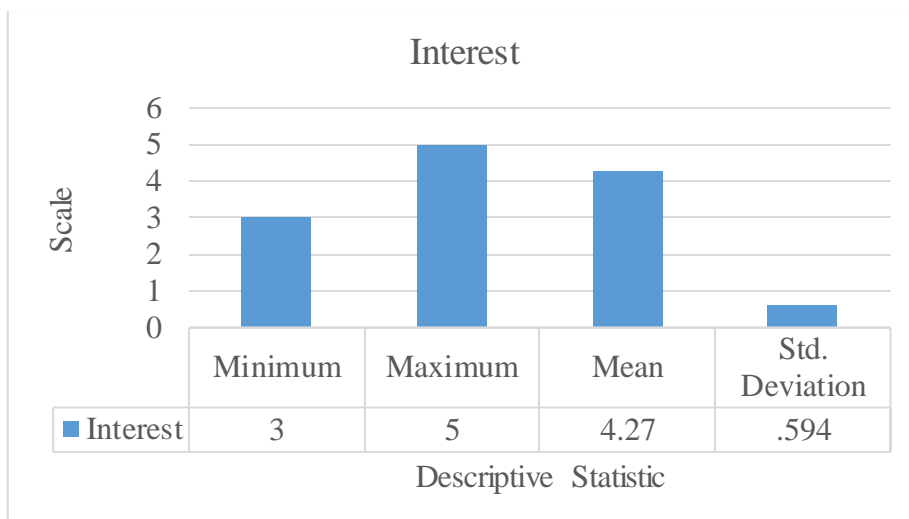
Figure 5.20 The descriptive statistics for interest (e-book group).

In brief, the e-book received a satisfaction rating of excellent with regard to participants' interest when they were learning about research methodology, and the e-book had a positive effect on their interest.

In terms of participants' interest, the impact of gaming technology was compared to the impact of the e-book. Interest was measured by conducting an independent-samples t-test. The result for the gaming technology was (M = 4.40, SD = .828) and the result for the e-book was (M = 4.27, SD =.594): t (28) = .507, p= .616. Table 5.12 and Figure 5.21 show the results.

Table 5.12 An independent-samples t-test result for the factor 'interest' with regard to gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Interest	Gaming Technology	15	4.40	.828	.214
	E-book	15	4.27	.594	.153

		Levene's Test for Equality of Variances		T-test for Equality of Means							
										95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference		Lower	Upper
Interest	Equal variances assumed	3.536	.070	.507	28	.616	.133	.263		-.406	.672
	Equal variances not assumed			.507	25.383	.617	.133	.263		-.408	.675
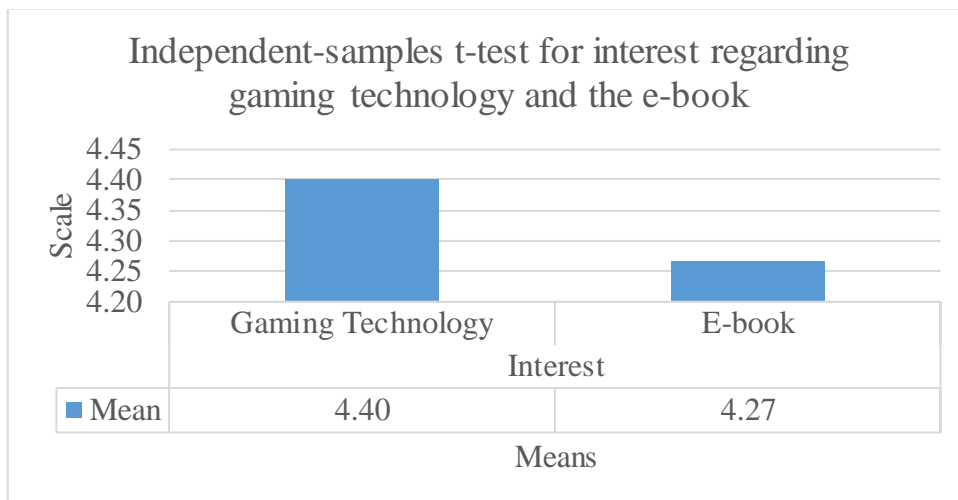
Figure 5.21 An independent-samples t-test result for the factor 'interest' with regard to gaming technology and the e-book.

Hence, there is no significant difference between gaming technology and the e-book in terms of interest. Both technologies provide information and knowledge, which increase participants' interest.

Moreover, an open question was asked to obtain further explanations regarding the impact of gaming technology and the e-book on participants' interest. The following question was asked:

Q: Were you prepared to spend a considerable amount of time exploring the research methodology concepts?

Participants responded to this question and provided some elements that enhance their interest with regard to both technologies. Table 5.13 shows elements and responses from the participants.

Table 5.13 Elements and participants' responses regarding interest.

Elements	Gaming Technology	E-book
Needs • to understand research methodology for their degree and research	GT4 participant said 'I want to explore more about research methodology because research methodology is the road map and guide for doing everything in our life. It helps to connect all the concepts together and to set the research layers and steps to perform research successfully'. GT10 said 'After I played the game, I discovered that I need to use mixed methods for my research – the game has lead me to understand mixed method details'.	EB1 commented 'I do not like research methodology, but I need to understand it to do my research because research methodology is fundamental for a PhD to succeed'.
Simplify • to make difficult and complicated aspects and concepts easy to understand	GT6 said 'Gaming technology makes my mind work correctly and organizes my knowledge, which increases my interest'.	
Involvement • allows participants to be involved in the game and to lose self-consciousness	GT15 said 'The game enhances my engagement with the learning environment and makes me feel that I am part of the game and lose myself.	

It could be seen via the content analysis that gaming technology has more elements listed under 'interest'. Both technologies support interest because they meet the participants' needs. Gaming technologies make knowledge simple and easy to understand (which means that the game provides challenges and difficulties that are generally balanced against

participants' abilities). Additionally, gaming technology also causes participants to become involved in the game and this, in turn, improves their interest.

As a result, gaming technology has more ability than the e-book to enhance interest in learning, which leads to boosting the curiosity to learn.

5.2.2.2 Deprivation

In order to measure deprivation, the third question concerned deprivation and the search for information and knowledge in order to fill in a learner's gaps within his or her knowledge. The following question was asked:

Q: Did learning about research methodology through gaming technology/e-book help you to understand how you can create a correct research methodology and fill in any gaps you have in your knowledge about research methodology?

The results for the gaming technology group showed that the participants rated this factor at a minimum of three, which is 'neutral', and a maximum of five, which is 'strongly agree'. Moreover, the mean was (M = 4.47, SD = .640). Figure 5.22 shows the results.
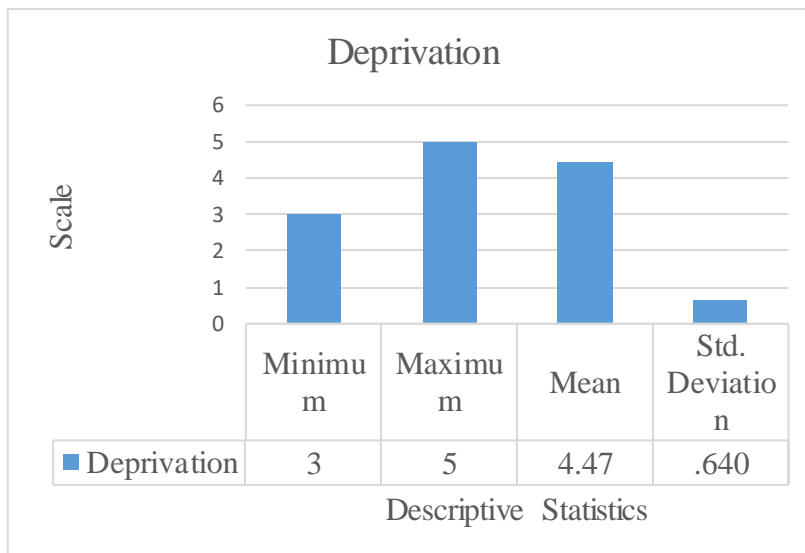
Figure 5.22 The descriptive statistics for deprivation (gaming technology group).

In conclusion, gaming technology received a satisfaction rating of excellent with regard to filling in any gaps in knowledge with regard to the sub-factor of deprivation and in terms of encouraging curiosity.

In addition, the same question was asked of the e-book group. The results showed that the minimum given was two, which is 'disagree', and the maximum given was five, which is 'strongly agree', with an average of (M =3.87, SD = .834), see Figure 5.23. Hence, the e-book used in this research obtained a satisfaction rating of good with regard to filling in gaps in the knowledge about research methodology.
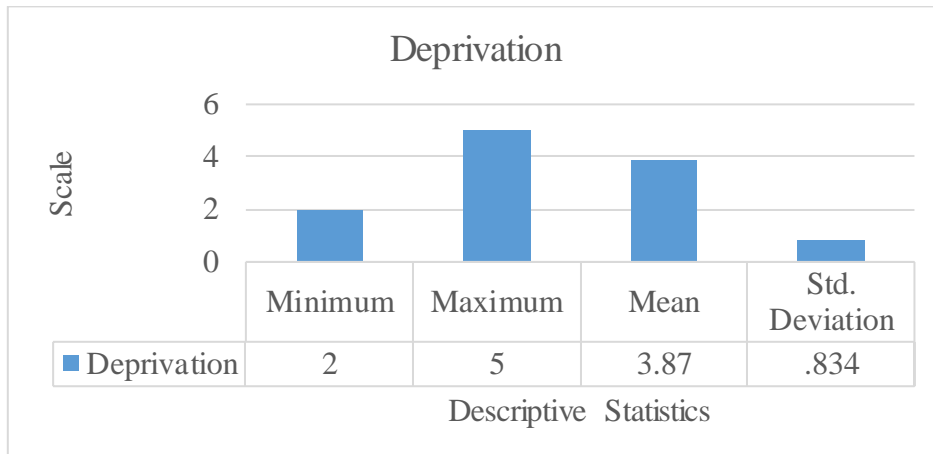
Figure 5.23 The descriptive statistics for deprivation (e-book group).

In conclusion, the e-book helped participants to find the information and knowledge that they needed to fill any gaps in their knowledge; such gaps support the learners' curiosity.

Deprivation was compared between the gaming technology group and the e-book group. An independent-samples t-test was conducted to measure the deprivation for both groups. There was a significant difference in the results: for the gaming technology, results were (M = 4.47, SD = .64) and for the e-book, results were (3.87, SD = .834): t (28) = 2.211, p = .035. Table 5.14 and Figure 5.24 show the results.

Table 5.14 An independent-samples t-test result pertaining to the factor 'deprivation' with regard to gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Deprivation	Gaming Technology	15	4.47	.640	.165
	E-book	15	3.87	.834	.215

		Levene's Test for Equality of Variances		T-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Deprivation	Equal variances assumed	.028	.868	2.211	28	.035	.600	.271	.044	1.156
	Equal variances not assumed			2.211	26.245	.036	.600	.271	.042	1.158
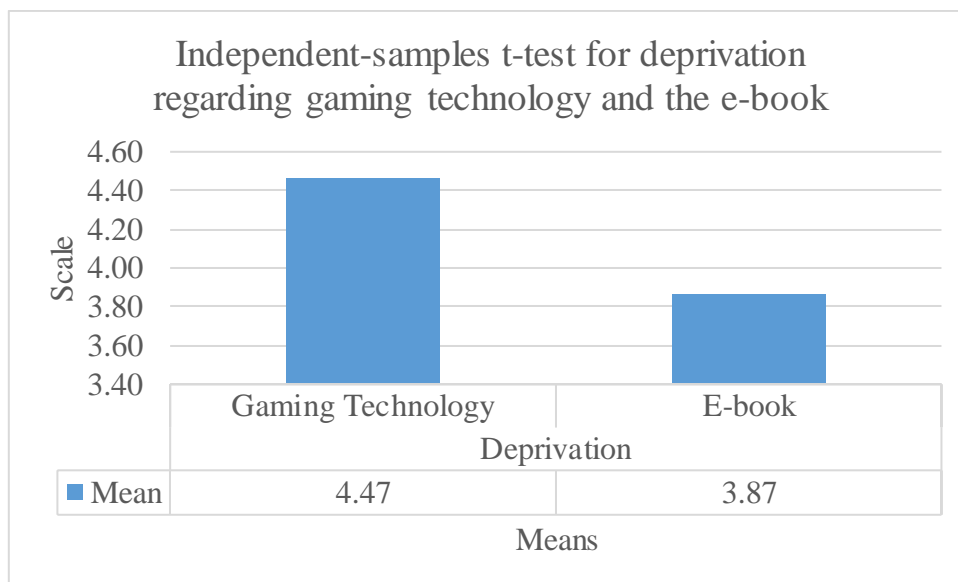
Figure 5.24 An independent-samples t-test result for the factor 'deprivation' with regard to gaming technology and the e-book.

An open question was asked in order to explain the impact of the gaming technology/e-book on participants' deprivation. The following question was asked:

Q: Did you feel you needed to learn more in order to ensure you understand research methodology concepts? Why?

Table 5.15 shows the deprivation elements that were found based on the participants' responses.

Table 5.15 The elements of deprivation that were found based on participants' responses.

Elements	Gaming Technology	E-book
Mistakes • learn from mistakes	GT1 stated 'If I make a mistake, then fall in the water, that encourages me to focus on my misunderstanding or on any weakness or gap in my knowledge. This leads me to be curious in order to enhance my understanding.'	
Justification • assisted the participants in improving their understanding to justify each layer in research methodology	GT13 said 'After playing and using the justification screen in the game I am going to learn more about research methodology to ensure that my work is on the right path by justifying each step'.	EB4 stated 'The justification form in the task improved my curiosity to find the reason for undertaking each step in the research methodology because when I justified my work and provides reasons for each step this increased my understanding and made information accurate and coherent'.

From the content analysis, it could be seen that gaming technology and the e-book have elements that help participants to fill in any gaps in the knowledge that they have. For example, gaming technology gave learners opportunities to make mistakes and learn from their mistakes. However, the e-book did not provide such opportunities. On the other hand, participants in both groups liked the justification form which gave them an opportunity to improve their understanding about research methodology. This means that the e-book

requires a workbook, or other additional technology, to allow readers to practise their understanding.

Thus, gaming technology helps participants to fill in any gaps in the knowledge that they have better than the e-book and it helped the participants to fill in gaps in their knowledge; it also supported their feelings of curiosity.

Table 5.16 shows the differences between gaming technology and the e-book in terms of the factor of curiosity, its sub-factors and elements.

Table 5.16 The differences between gaming technology and the e-book with regard to the factor 'curiosity', its sub-factors and elements.

Sub-factor	Elements	Gaming Technology	E-book
Interest	Needs	✓	✓
	Simplify	✓	✗
	Involvement	✓	✗
Deprivation	Mistakes	✓	✗
	Justification	✓	✓

Furthermore, from observation, the researcher found that the gaming technology group participants' curiosity was enhanced if the concepts were related to the participants' needs. For instance, one experiment participant was a Ph.D. student who required a knowledge of research methodology to assist him in acquiring his degree. After undertaking the experiment, this participant came to the researcher's office to further satisfy his curiosity about research methodology and to fill in the gaps in the knowledge that he had. More than an hour was spent discussing research methodology. Moreover, one of the participants came and had a discussion with the researcher and developed his knowledge of research methodology prior to his interim assessment. He passed the assessment and came back to thank the researcher. When participants are interested, this leads them to be curious and to improve their abilities to discover more which increases innovation and creation.

Thus, gaming technology supported participant curiosity more than the e-book and gaming technology was more effective than the e-book in terms of inciting participants' curiosity to learn and to increase their knowledge, skills and experience.

Thus, curiosity encourages participants' motivation and inspires participants to learn.

5.2.3 Motivation

In this section, the research explores and discovers the impact of gaming technology on participant motivation by means of some closed questions, the FaceReader system and open questions in the interviews. The analysis combined statistical analysis and content analysis to provide accurate and coherent results that help to explain gaming technology's impact on participant motivation. This impact was then compared to the impact made by the e-book.

In order to measure the impact of gaming technology and the e-book on motivation, the following question was asked:

Q: Did learning through (gaming technology/e-book) motivate you to gain new knowledge, experience and skills in the area of research methodology?

The results received from the gaming technology group indicated a good response because the minimum result given by the participants was three, which is 'neutral', and the maximum was five, which is 'strongly agree'. The mean was (M =4.47, SD =.640). Figure 5.25 shows the results and demonstrates that gaming technology was rated by the participants as having excellent satisfaction in motivating participants to learn. In other words, gaming technology received a satisfaction rating of excellent in terms of motivating learners (because the participants felt that gaming technology motivated them to use gaming technology to learn about research methodology).
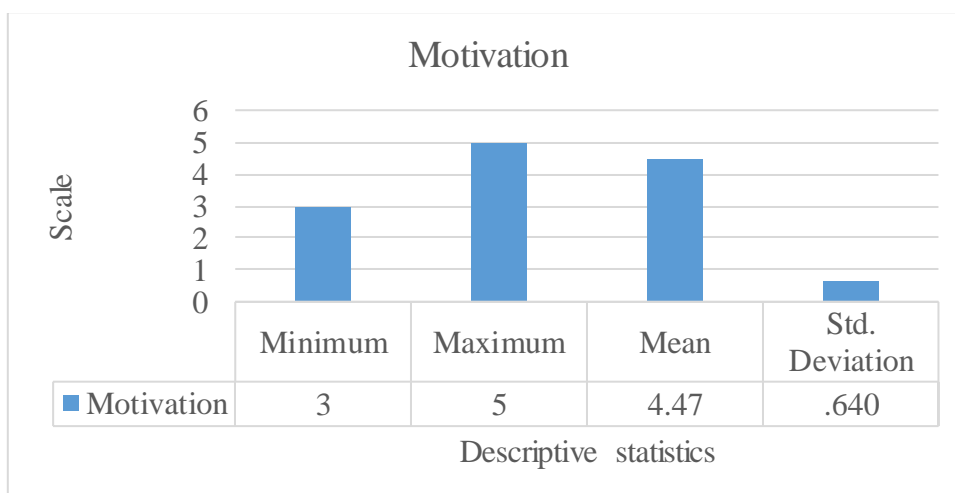
Figure 5.25 The descriptive statistics for motivation (gaming technology group).

The same question was asked of the e-book group participants. The results showed the minimum given by the participants was two, which was 'disagree', and maximum given by

the participants was five, which was 'strongly agree' and the mean was (M = 4.07, SD = .799). Figure 5.26 shows the impact of the e-book on learners' motivation. The results show that the participants gave the e-book a 'good' satisfaction rating for its ability to motivate participants to acquire knowledge and develop experience and skills.
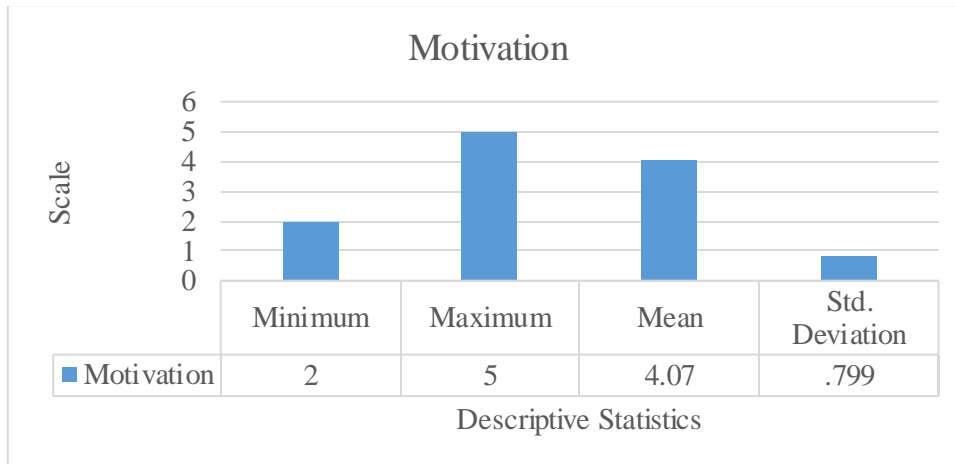
Figure 5.26 The descriptive statistics for motivation (e-book group).

Initially, an independent-samples t-test was conducted to compare the gaming technology's impact with the e-book's impact in terms of motivating participants to gain knowledge, experience and skills. There was no significant difference in the result for gaming technology (M = 4.47, SD =.640) and the e-book (M = 4.07, SD = .799): t (28) = 1.514, p =.141. Table 5.17 and Figure 5.27 show the t-test results, which indicate that gaming technology and the e-book can support learners' motivation with a slight advantage on the side of gaming technology.

Table 5.17 The independent-samples t-test result concerning motivation when using gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Motivation	Gaming Technology	15	4.47	.640	.165
	E-book	15	4.07	.799	.206

		Levene's Test for Equality of Variances		T-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Motivation	Equal variances assumed	.174	.680	1.514	28	.141	.400	.264	-.141	.941
	Equal variances not assumed			1.514	26.728	.142	.400	.264	-.143	.943
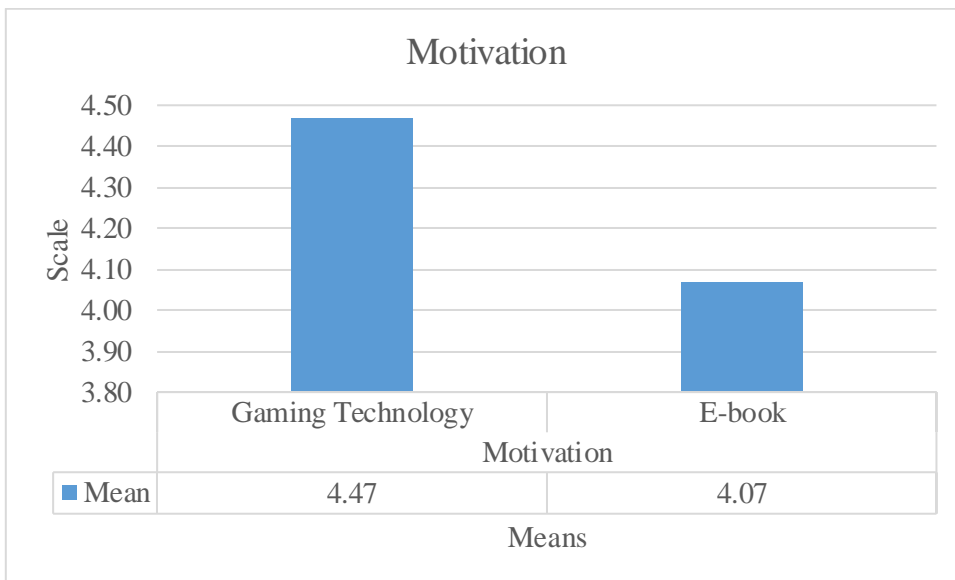
Figure 5.27 Comparison of the means for gaming technology and the e-book in terms of their motivation of learners to gain knowledge, experience and skills.

Content analysis compared the elements that have an impact on the motivation sub-factors. Figure 5.28 shows the factor of motivation and its sub-factors. Further explanations regarding the impact of gaming technology and the e-book on motivation are obtained by the FaceReader results (which show the impact on learners' emotions). This figure shows motivation's factors and sub-factors that form the framework in order to explore the influence of gaming technology and e-book on participants' opinions with regard to sub-factors.
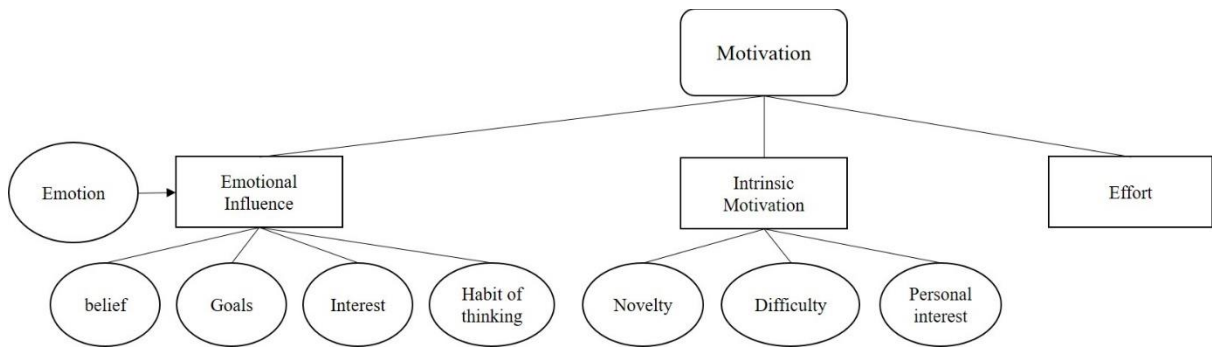
Figure 5.28 The factor of motivation and its sub-factors.

5.2.3.1 Emotional

In order to discover the emotional influence of gaming technology and the e-book on participants, the FaceReader system was used which observed and measured participants' emotions during learning.

The FaceReader system showed several types of emotion that the gaming technology group participants felt during the experiment. Within this group, the participants felt neutral, happy, sad, angry, surprised, scared and disgusted in addition to other emotions. The most expressed emotion was neutral (M =.39620, SD= .149134), then, in order, angry (M = .16427, SD = .184590); disgusted (M = .09793, SD= .126296); surprised (M = .922, SD = .91779); happy (M = .08593, SD = .087431); sad (M = .04313, SD = .107545); scared (M = .04293, SD = .057430) and, finally, there were some other emotions (M = .04753, SD = .040164). Figure 5.29 shows the means for these emotions and Figure 5.30 shows how gaming technology influenced the participants' emotions.
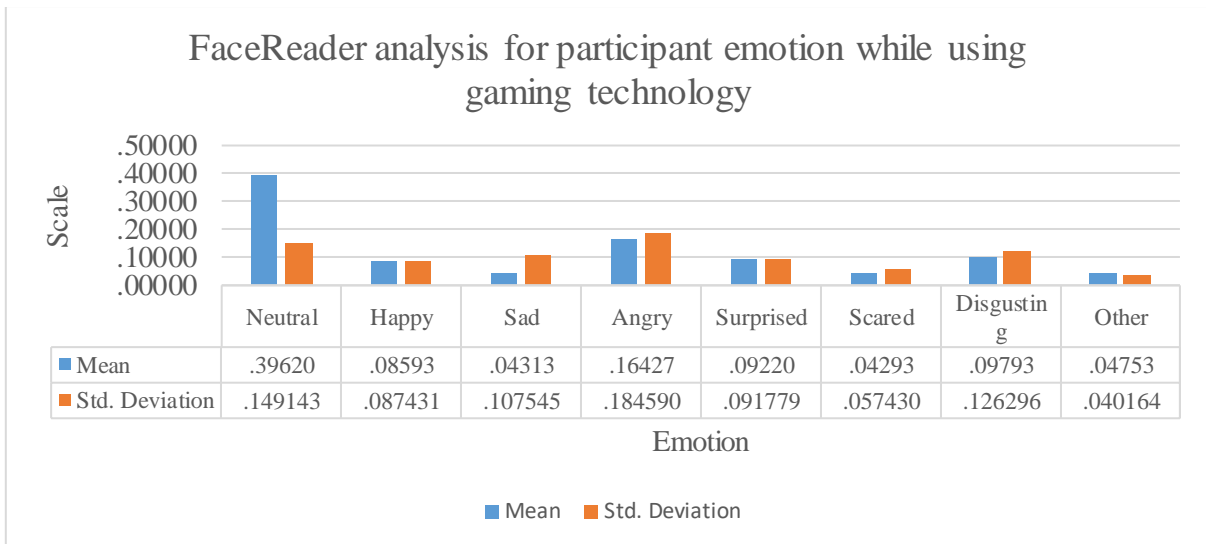
Figure 5.29 Means for emotions (gaming technology group).
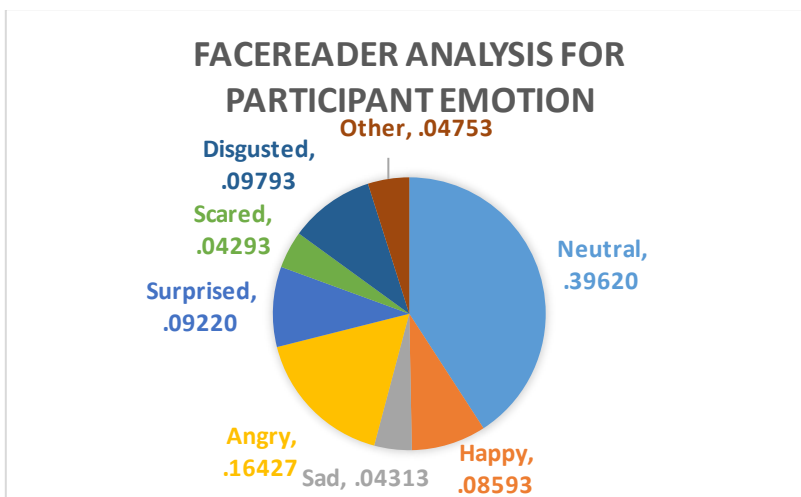
Figure 5.30 FaceReader analysis of participants' emotion whilst using the gaming technology.

The FaceReader system suggested that, when the participants played the game, at first they felt negative emotions such as anger, disgust, sadness and surprise. However, when the participants were going through the game's process, the negative emotions were reduced and participants start being neutral then continued on to being happy or stayed with a neutral emotion. Participants were then nervous while reading the scenarios and trying to focus on understanding the problems. The participants went through the steps of game and became neutral or happy. Participants felt happy after completing a scenario successfully and became happier and excited after completing all the scenarios. Additionally, the happiness level became high when participants completed scenarios without any mistakes and when they

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experienced receiving full marks and felt 'the euphoria of victory'. Thus, participants felt several types of emotions while learning through using the gaming technology.

All in all, both negative and positive emotions occurred for different reasons while participants learned by playing the game. Negative feelings were felt initially when playing the game and during the learning phase or learning mode. Also, negative feelings were felt when reading the scenarios, because they required focusing upon in order to be understood. Negative feelings were also felt when participants chose the wrong steps in the playing mode. However, positive feelings increased after a period of time when participants had started playing the game. Moreover, positive feeling increased. In the learning mode, when a participant understood the concepts and when they found the information relating to their needs, this supported their understanding. In addition, positive emotions increased when the participants played and chose the right steps in the game and when the participants completed each scenario successfully and when participants obtained full marks. GT3 stated 'When I pass the game with full marks, I feel I am a hero'. At the end of the game, the participants became relaxed. The positive feelings felt at the end of doing the tasks and completing the game motivated participants to use gaming for learning.

Stress also plays a role and affects participant. Stress, in this study, occurred for different reasons. The first reason was because most of participants were not familiar with gaming technology. Six of the participants had never used gaming technology and eight of them had only used it sometimes. Just one of the participants had used gaming technology fairly frequently. The second reason for stress was the camera recording of the participants undertaking the tests. This increased the stress on the participants. Additionally, the experiment and the observation added some stress and had an impact on participants' emotions during the learning process.

The FaceReader system showed the several types of emotions that the participants felt while learning through using gaming technology. Additionally, in order to support the FaceReader system results, the following open question was asked:

Q: Can you describe your emotion when you started learning about research methodology?

Content analysis explains the participants' emotions while learning by using gaming technology. Content analysis also explains the emotional influence factors, the sub-factors and the elements.

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Gaming technology affected participants' emotions and made the participants feel several types of reactions during learning. These emotions made participants more motivated because when participants feel all kind of emotions they can assess when they feel happy and they know how gaming technology can move them from the negative emotions to positive emotions (when the participants perform the game's tasks and receive a high score in order to win and avoid all the hazards in the game). The emotional process they undergo is presented here: at the beginning, participants feel fear because they do not know what is going to happen in the game and people usually fear a new experience. Subsequently, participants feel nervous and some stress with regard to the game's concepts. This is because the game's concepts are about research methodology which, to most people, involves boring, difficult and complicated concepts. Participants also feel some anxiety as to whether they can complete the game or not and whether they can win in the game. For instance, some participants did not realize that they could actually finish the game. Further on, when a participant understood the meaning of the game and had also explored the game's objectives and the game's importance, then the participant felt comfortable. The next step was the learning mode and building up information via an interactive and fun environment that involved participants in the game and made participants feel relaxed, because at this stage they had a full understanding of the game and the rules that would help them to perform the tasks. When a participant played the game and successfully completed a scenario, the participant felt happy. Eventually, the participant finished all the scenarios and won the game. The impact of this caused the participant to feel interested in gaming technology tool (as it made learning easy). Additionally, this made a participant excited to learn more about research methodology and, thus, increased the participant's motivation. For instance, GT8 explained her emotions as follows when she played the Research Methodology Game: 'When I was in the game's environment, I created an environment around myself to engage in gaming and learning. When I undertook some wrong steps, the consequence was death! If I went wrong, that meant I had to go back and that would, naturally, affect my emotions. When I read books, I do not feel like this. In the game, I got nervous because I did not know what would happen if I skipped this part or that part? The game kept me in an interactive environment with some pressure on me to pass the game. I think I needed that pressure to keep my attention going and it made the interactive system more pleasurable by using most of my emotions in order to learn. That helped to keep me understanding the concept that I was learning and not to forget that information and knowledge. It can improve my skills and

experience because I used all of my feelings and emotions to pass the game, which is very relatable to the real environment'.

The FaceReader system results present all kinds of emotions because participants feel they are at risk within the game and that the crocodile is going to eat them, which, as a consequence, applies some pressure. Figure 5.31 shows the emotional stages and processes during the playing of the game.
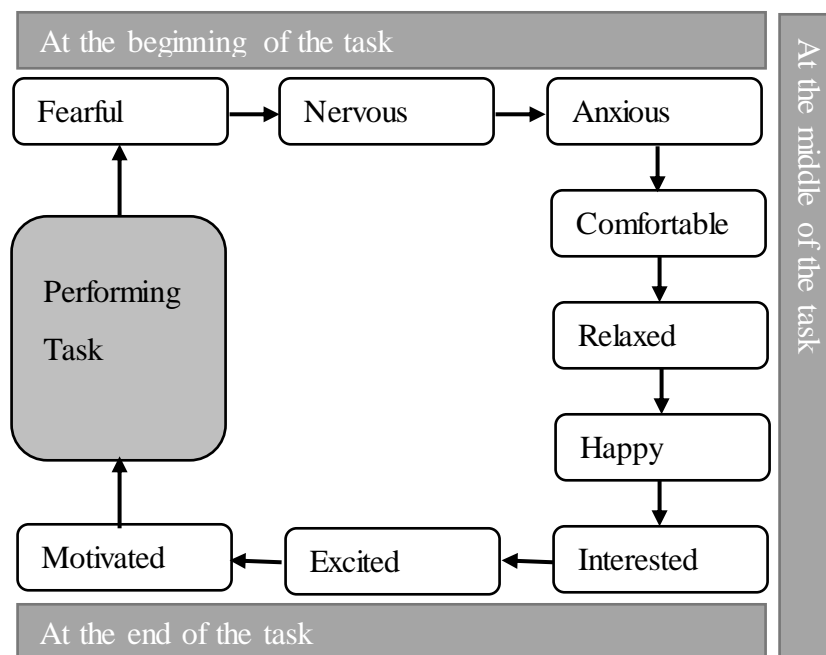
Figure 5.31 Participants' emotional stages and processes during learning via gaming technology.

Subsequently, the FaceReader system was used to measure emotions that the participants felt while learning through the e-book. The FaceReader results showed that, mostly, the participants were neutral (M = .84273, SD = .1.718131) and then, in order, the emotions expressed were: anger (M = .30193, SD = .214743); disgust (M = .16193, SD = .165577; surprise (M = .09440, SD = .094023), happy (M =.04393, SD =.062041; being scared (M = .01827, SD = .055732) and, finally, there were some other emotions (M = .04480, SD = .029248). No sadness was shown during the reading of the research methodology e-book and during undertaking the tasks because Ph.D. students are familiar with e-books as they are a main resource for their research. Figure 5.32 and Figure 5.33 show how the e-book used in this study influenced participants' emotions.
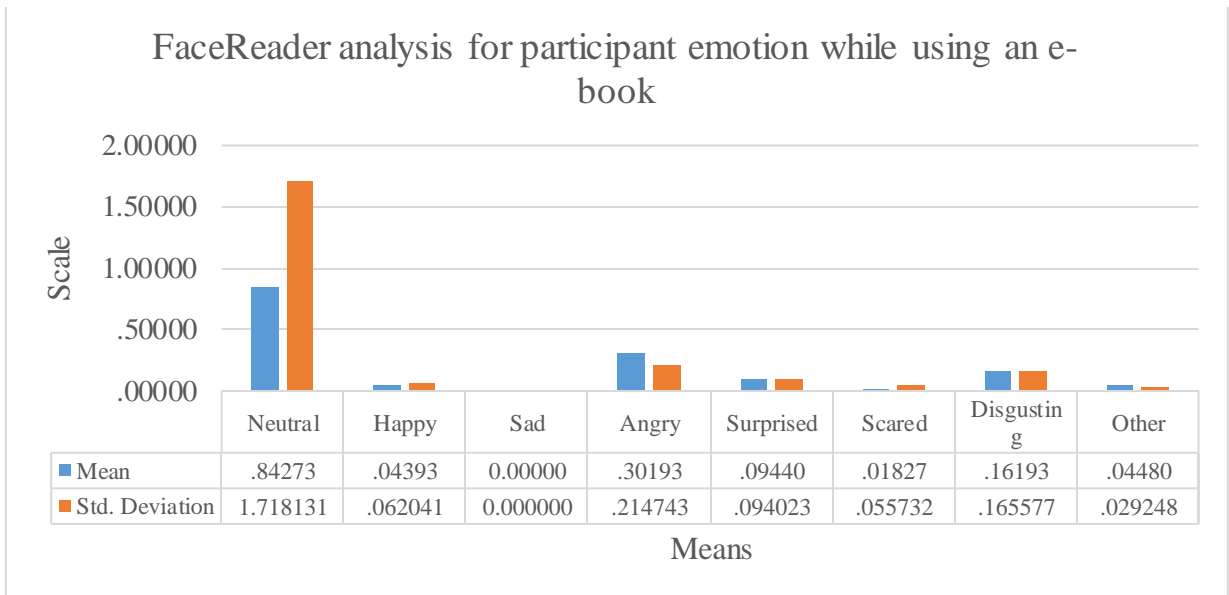
Figure 5.32 Means for emotions (e-book group).
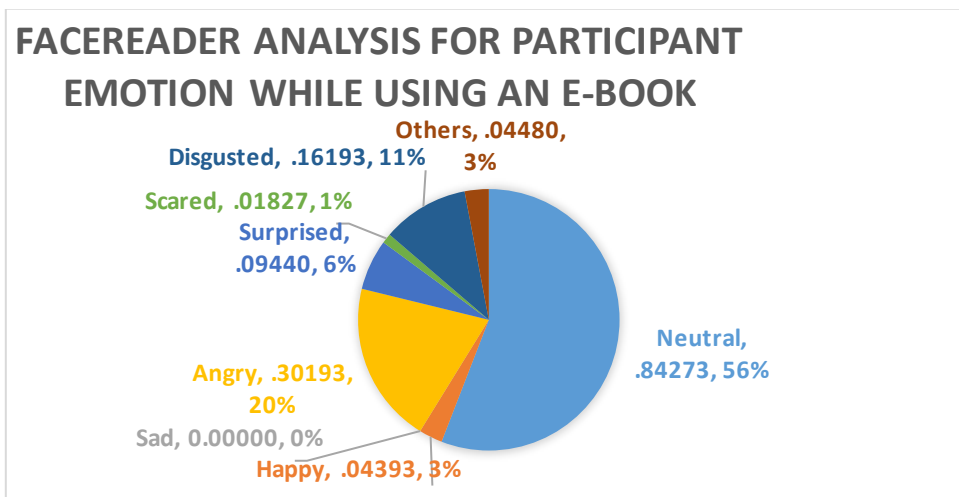
Figure 5.33 FaceReader analysis of participants' emotions while reading the e-book.

The FaceReader system showed several types of emotions that participants felt during their learning by reading the e-book. Content analysis explains the participants' emotions felt during learning via using the e-book.

The following open question was asked to explain these emotions:

Q: Can you describe your emotions when you started learning about research methodology?

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Based on the responses from participants, content analysis showed that, when commencing to read the e-book, most of the participants were anxious and worried because they did not know the task ahead and they feared an unknown task. And at first, when reading, most of the learners felt bored, then became neutral. The participants' emotions shown while using an e-book were as follows. When they began reading the first scenario, they found it was easy to understand and, as they worked through the task, they became familiar with the scenarios and their worries reduced; they felt comfortable and enjoyed learning.

Furthermore, emotional influence was measured by comparing the FaceReader system results from both the gaming technology participants and the e-book participants and also by comparing the content analysis results.

An independent-samples t-test was conducted to compare the emotions that participants felt while learning about research methodology through gaming technology and through the e-book. There was no significant difference in the results for:

(1) Neutral emotion: gaming technology (M = .39620, SD =.149143) and the e-book (M =.84273, SD = 1.718131); t (28) = -1.003, p =.325.

(2) Emotion of happiness: gaming technology (M = .08593, SD =.84273) and the e-book (M =.04393, SD = .062041); t (28) = 1.517, p = .140.

(3) Emotion of sadness: gaming technology (M = .04313, SD = .107545) and the e-book (M = 0, SD = 0); t (28) = 1.553, p = .132.

(4) Emotion of anger: gaming technology (M =. 16427, SD =.184590) and the e-book (M = .30193, SD = .214734); t (28) = -.137667, p = .070.

(5) Emotion of surprise: gaming technology (M = .09220, SD = .091779) and the e-book (M = .09440, SD = .094023); t (28) = -.065, p = .949.

(6) Emotion of being scared: gaming technology (M = .04293, SD = .057430) and the e-book (M = .01827, SD = .055732); t (28) = 1.194, p = .243.

(7) Emotion of disgust: gaming technology (M = .09793, SD = .126296) and the e-book (M = .16193, SD = .165577); t (28) = -1.190, p = .244.

(8) Others emotions: gaming technology (M = .04753, SD = .040164) and the e-book (M = .04480, SD = .029248); t (28) = .213, p = .833.

Table 5.18 and Figure 5.34 show the t-test results. These results show that gaming technology and the e-book have the same influence on participants' emotions and elicit the same emotions that any learner would feel when studying by using any type of technology. However, some technologies help to reduce negative emotions and encourage positive emotions.

Table 5.18 The results for the independent-samples t-test from the FaceReader system.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Neutral	Gaming Technology	15	.39620	.149143	.038509
	E-book	15	.84273	1.718131	.443620
Happy	Gaming Technology	15	.08593	.087431	.022575
	E-book	15	.04393	.062041	.016019
Sad	Gaming Technology	15	.04313	.107545	.027768
	E-book	15	.00000	.000000	.000000
Angry	Gaming Technology	15	.16427	.184590	.047661
	E-book	15	.30193	.214743	.055446
Surprised	Gaming Technology	15	.09220	.091779	.023697
	E-book	15	.09440	.094023	.024277
Scared	Gaming Technology	15	.04293	.057430	.014828
	E-book	15	.01827	.055732	.014390
Disgusted	Gaming Technology	15	.09793	.126296	.032610
	E-book	15	.16193	.165577	.042752
Other	Gaming Technology	15	.04753	.040164	.010370
	E-book	15	.04480	.029248	.007552

		Levene's Test for Equality of Variances		T-test for Equality of Means				Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference		Lower	Upper
Neutral	Equal variances assumed	3.532	.071	-1.003	28	.325	-.446533	.445288	-1.358664	.465598
	Equal variances not assumed			-1.003	14.211	.333	-.446533	.445288	-1.400252	.507186
Happy	Equal variances assumed	.280	.601	1.517	28	.140	.042000	.027681	-.014701	.098701
	Equal variances not assumed			1.517	25.247	.142	.042000	.027681	-.014981	.098981
Sad	Equal variances assumed	11.054	.002	1.553	28	.132	.043133	.027768	-.013747	.100013
	Equal variances not assumed			1.553	14.000	.143	.043133	.027768	-.016423	.102690

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Angry	Equal variances assumed	.704	.409	-1.883	28	.070	-.137667	.073116	-.287437	.012104
	Equal variances not assumed			-1.883	27.383	.070	-.137667	.073116	-.287589	.012256
Surprised	Equal variances assumed	.152	.699	-.065	28	.949	-.002200	.033925	-.071692	.067292
	Equal variances not assumed			-.065	27.984	.949	-.002200	.033925	-.071694	.067294
Scared	Equal variances assumed	2.379	.134	1.194	28	.243	.024667	.020663	-.017659	.066993
	Equal variances not assumed			1.194	27.975	.243	.024667	.020663	-.017661	.066994
Disgusted	Equal variances assumed	1.003	.325	-1.190	28	.244	-.064000	.053769	-.174141	.046141
	Equal variances not assumed			-1.190	26.171	.245	-.064000	.053769	-.174489	.046489
Other	Equal variances assumed	1.069	.310	.213	28	.833	.002733	.012829	-.023545	.029011
	Equal variances not assumed			.213	25.589	.833	.002733	.012829	-.023657	.029123
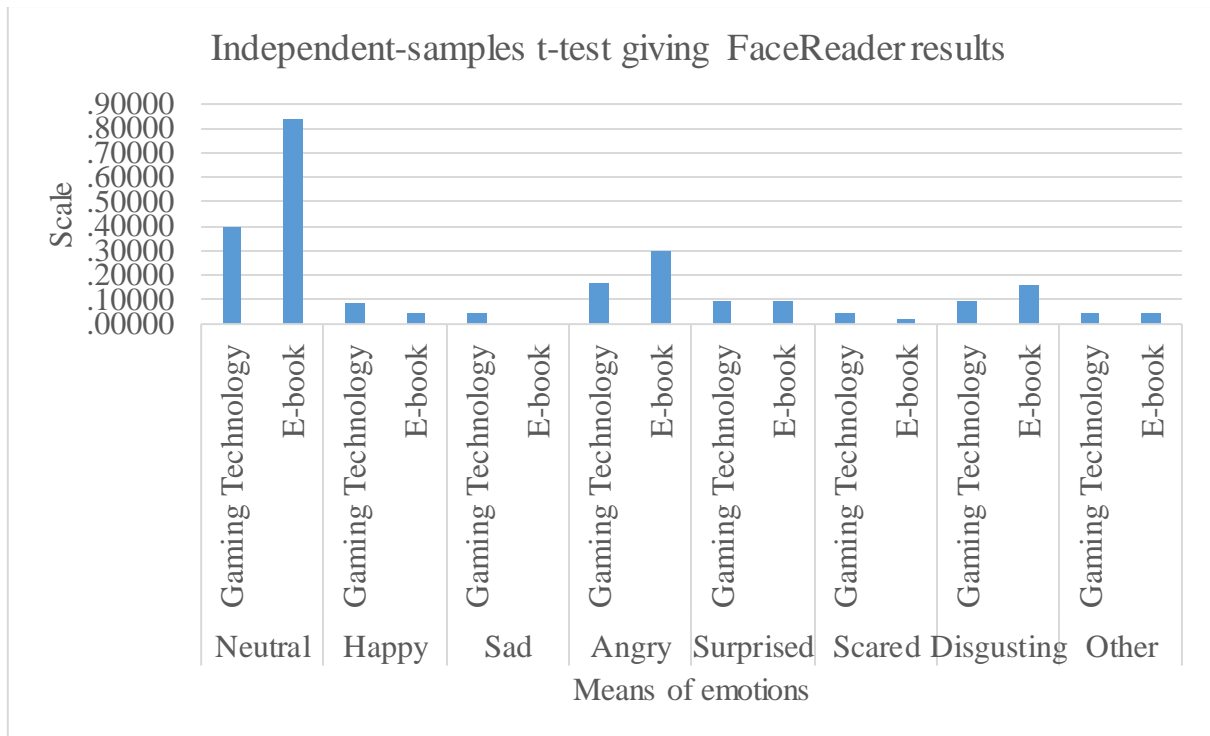
Figure 5.34 The independent-samples t-test showing the FaceReader results.

Content analysis brought to the fore the emotions that the participants felt during the learning process for both technologies, such as fear, nervousness, stress and anxiety at the beginning of the experiment, and then feeling comfortable and happy when performing and finishing the tasks.

Gaming technology and the e-book both affect other significant emotions that are required in order to motivate participants, such as beliefs, goals, interests and habits of thinking.

5.2.3.1.1 Emotional influence

5.2.3.1.1.1 Belief

In order to measure the influence of gaming technology and the influence of the e-book on learner beliefs, the following question was asked:

Q: Did you believe that could successfully accomplish learning about research methodology? Why?

The responses of the participants showed that most of them felt that the game had increased their belief in being able to learn successfully by playing the game. This is because gaming technology gave them a better understanding than a book or a lecture as the gaming

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technology provided an exciting environment. Not only was it easy to use, but also the interactive environment made difficult concepts easy to learn, which encouraged the participant's belief in being able to successfully learn and complete the tasks in the game. This built a positive relationship between belief and usability and the interactive environment. Moreover, feedback about performance as well as obtaining high scores and winning the game also encouraged participants' belief because it showed participants that they had the ability to be successful playing the game. GT5 believed that he could learn from gaming technology because he had had experience of gaming and had learned more about Roman civilization by playing a strategy game. He indicated that the Research Methodology Game improved his understanding of research methodology concepts.

However, when the e-book group was asked about their belief, five of the participants did not have a complete belief in the e-book and the knowledge it could impart. They thought that they needed additional support from instructors, teachers, lecturers and discussion groups to be confident in their knowledge of research methodology, as research methodology concepts are difficult and complicated and they felt they needed more explanation from experts, academic staff and supervisors.

On the other hand, most of participants believed that they could achieve the task and learn from the e-book because it provided links between scenarios and learning concepts. Their belief was enhanced after performing the task and answering the questions with support from the e-book. Their belief increased with their growing confidence.

In conclusion, e-books can help to develop belief and confidence if they contain some features that can provide feedback on participants' performance, which, in turn, encourages their belief and confidence.

The content analysis made a comparison between gaming technology and the e-book and found that both technologies help and support participants' beliefs with more advantage on the side of gaming technology.

5.2.3.1.1.2 Goals

In order to discover if participants had a goal with regard to learning, the following question was asked:

Q: What were your targets when you started to learn about research methodology?

The responses of the participants show that both groups had set some targets in order to achieve tasks.

Table 5.19 Goals set by the gaming technology group and the e-book group.

Gaming Technology Group	E-book Group
GT13 said 'I can do anything if I put mind to it. Nothing is hard for me if it is my goal and target'. Goals: - To define their weaknesses concerning research methodology and to work hard to understand and improve on all their weaknesses and improve their knowledge - To understand the research methodology concepts and terminology because they had some confusion pertaining to them - To explore the game and how it presented these difficult concepts - To decide what type of approach was needed to be used for undertaking their Ph.D. research - To complete the game without any mistakes and obtain a high score in order to win - To test their knowledge about research methodology	Goals: - To learn and discover new knowledge and information - To answer the scenarios' questions successfully by identifying the research methodology steps for each scenario and justifying all the steps - To increase their knowledge of research methodology - To understand and explore research methodology steps and processes

In conclusion, participants in both groups had goals to achieve and both groups learned research methodology concepts.

5.2.3.1.1.3 Interest

In order to explore the participants' interest, the following question was asked:

Q: Were you willing and interested in learning about research methodology by using (gaming technology/the e-book)? Why?

Responses from the participants show that the game increased personal interest because of the fun aspect of the game (by utilizing an interactive environment to learn serious concepts by completing interactive steps in the game and learning from the system). For example, GT15 stated, 'Research methodology is very boring and the game makes it very exciting. And the game creates more interest and fun in interactive learning and makes learning informal learning.' Moreover, playing the game was fun and exciting because games are almost always fun, and linking fun to education enriches the educational process and advances the participants in the deepening of their knowledge. Fun in a game helps participants to easily and quickly acquire the information they want and, by so doing, saves time and effort. Also, fun enhances the participants' desire to play the game and enhance their knowledge.

In the e-book group, some participants were interested because they already knew some information on research methodology and they discovered more new information and concepts concerning research methodology. For instance, EB10 said 'I have found some new knowledge that I need which encourages me to define my need and the gaps in my knowledge and to develop my knowledge and fill in the gaps in the knowledge that I have'.

As a result, for the gaming technology group, interest was generated from the fun that the game created. For the e-book group, however, the interest came from the new knowledge that was acquired from the e-book.

5.2.3.1.1.4 Habits of thinking

In order to measure if participants used any thinking habits during the experiments, the following question was asked:

Q: Did you use any special thinking habits or strategies to learn about research methodology? What are these habits or strategies?

The responses to this question illustrate these thinking habits which are shown in Table 5.20.

Table 5.20 Thinking habits used by the gaming technology group and the e-book group.

Gaming Technology Group	E-book Group
• Linking: participants linked the information that they had discovered in the game scenarios to their background and experience in order to perform tasks. • Learning from mistakes: participants utilised the strategy of learning from their mistakes by trying again and fixing their mistakes. • Thinking out loud: participants used the habit of thinking aloud because thinking aloud improves their attention and focus, and assists them in avoiding mistakes. • Guessing: some participants guessed the assumption for each scenario (in order to solve the problem) by guessing the aim and objectives.	• Linking: participants linked their background knowledge of research methodology with the information obtained via the e-book in order to enhance their knowledge and perform the task. • Memorising: some participants tried memorising some of the concepts of research methodology because the memorising habit helped them to perform tasks. In addition, they felt memorising helped them to understand research methodology and to use this information for their Ph.D. research. • Thinking out loud: some participants used thinking aloud to discuss ideas while performing the task.

Both groups of participants used several thinking habits. Both groups used thinking aloud and linking between participant experience and new experiences and knowledge. The gaming technology group also used a 'learning from mistakes' strategy and guessing. The e-book group participants used memorising.

5.2.3.1.1.5 Stimulation

From the interview responses and observation, the researcher found and explored a new emotional influence sub-factor (stimulation) on the participants who learned through using gaming technology. Gaming technology stimulates participants to complete the game's levels, stages and steps successfully and to avoid any mistakes. This arouses a participant's

stimulation to be happy while playing the game and obtaining an effective performance. In addition, participants are stimulated to explore within the game, to find out how it works and to meet the learning objectives that they hope to achieve.

However, based on the results, the e-book did not have this ability to stimulate. Both technologies had an influence on participants' emotions and supported motivation either positively or negatively) but most of the motivation (which was measured) encouraged participants to learn.

5.2.3.2 Intrinsic motivation

Intrinsic motivation concerns a participant's desire to engage in learning. It is measured based on the novelty of the task and the difficulty of the task and it is based on personal interest. Intrinsic motivation was measured in both groups, with the gaming technology group and with the e-book group.

5.2.3.2.1 Novelty

In order to measure the novelty factor within gaming technology and the e-book, the following question was asked:

Q: Is learning about research methodology through (gaming technology/e-book) new and is it a novel way to improve knowledge and learn a new skill?

When asked about gaming technology, whether it was a novel and new technology within learning, participants' responses ranged from three, which was 'neutral', through to a maximum of five, which was 'strongly agree', and the mean was (M = 4.67, SD = .724). Figure 5.35 presents the results of the ratings given to the statement that gaming technology is a novel and new technology within learning. On the whole, gaming technology received an excellent satisfaction rating in terms of being novel and new in learning. Because gaming technology is novel and new in the teaching of research methodology, this supported the participants' motivation and encouraged them to use gaming technology for learning.
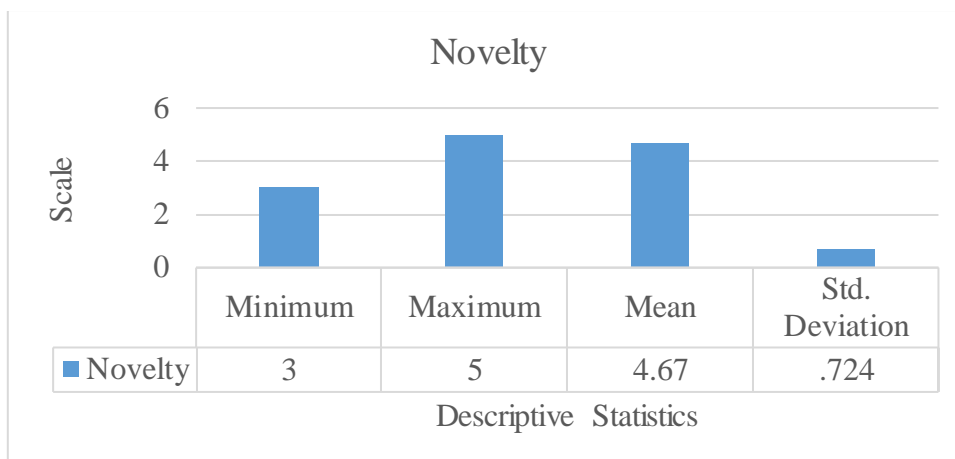
Figure 5.35 The results as rated by the participants as to whether gaming technology is a new technology within learning.

As a result, the game can provide new knowledge by using novel ways of presentation which increases the influence it has on motivating participants to discover new knowledge. GT8 said 'The Research Methodology Game provides a new way of thinking and of organizing the concepts and definitions about research methodology that I have not used before and it helps me increase my understanding of research methodology'. Moreover, the Research Methodology Game explains philosophical concepts and thus provides a new tool for Ph.D. students.

When asked about e-books and whether they are a novel and new technology within learning, the responses from the participants ranged from a minimum of two, which was 'disagree', to the maximum of five, which was 'strongly agree', and the mean was (M = 3.67, SD = 1.175). Figure 5.36 presents these results. The e-book received a satisfaction rating of good for novelty. Thus participants generally rated e-books as being satisfactory in terms of being a novel/new technology in learning. The resources and the new technology that are associated with e-books create a new style that encourages learners to use them.

Generally, e-books provide new elements in learning by adding on technology, such as YouTube or gaming technology to teach a subject (e.g., research methodology). Thus, e-books that are aligned with such technology and resources can provide a novel experience and can support participants' motivation and encourage them to use e-books for learning.

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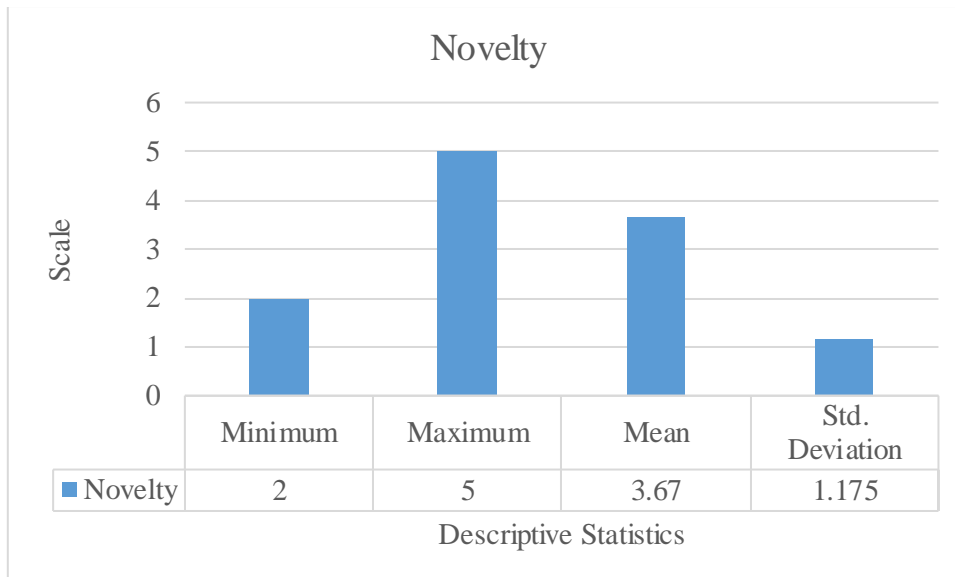
Figure 5.36 The results as rated by the participants as to whether e-books are a new technology within learning.

An independent-samples t-test was conducted to compare gaming technology with the e-book.

There was a significant difference in the results for gaming technology (M = 4.67, SD = .724) and the e-book (M = 3.67, SD = 1.175) in terms of novelty: t (28) = 2.806, p = .009. Table 5.21 and Figure 5.37 show the t-test results. These results show that gaming technology provides a new and better resource and tool for learning, more so than the e-book. Thus gaming technology is more motivational for the participants.

Table 5.21 The independent-samples t-test result regarding the factor 'novelty' in terms of gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Novelty	Gaming Technology	15	4.67	.724	.187
	E-book	15	3.67	1.175	.303

		Levene's Test for Equality of Variances		T-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Novelty	Equal variances assumed	7.463	.011	2.806	28	.009	1.000	.356	.270	1.730
	Equal variances not assumed			2.806	23.285	.010	1.000	.356	.263	1.737
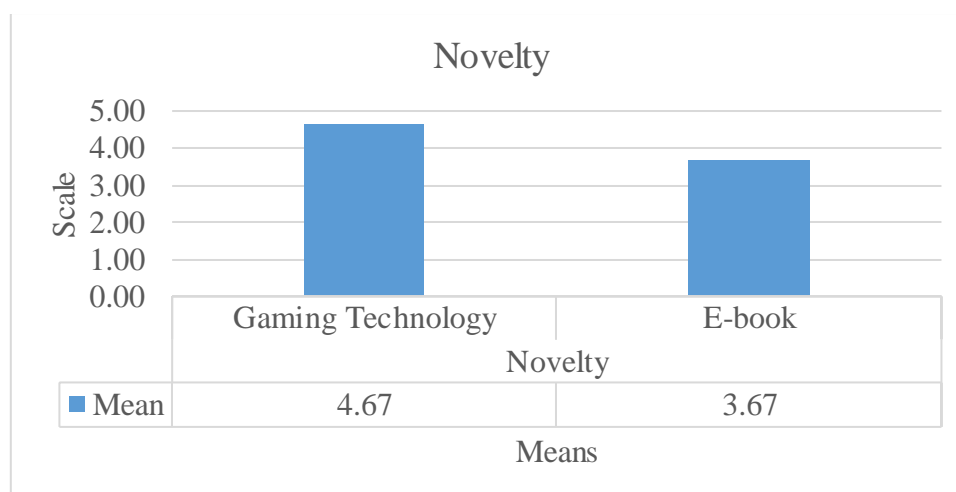
Figure 5.37 Comparison of the means for 'novelty' with regard to gaming technology and the e-book in the area of learning.

5.2.3.2.2 Difficulty

In order to discover the difficulties that participants faced during learning from gaming technology and the e-book, the following question was asked:

Q: How would you rate the difficulty of learning about research methodology?

With regard to this question the participants' responses ranged from a minimum of two, which was 'high', to a maximum of five, which means 'very low', and the mean was (M =

3.60, SD = .910). Figure 5.38 shows the results of the participants' ratings on the difficulty of using the gaming technology. As a result, it can be seen that gaming technology received a satisfaction rating of good in terms of difficulty (because gaming technology makes difficult and complicated concepts and tasks easy to understand/undertake and this, in turn, motivates the participates to engage in undertaking difficult tasks and learning).

Figure 5.38 Results showing the participants' ratings of difficulty for using the gaming technology.

In the e-book group, when the participants were asked to rate difficulty, the participant's answers ranged from the minimum of one which was 'very high' through to the maximum of five which meant 'very low' and the mean was (M= 3.13, SD= .990). Figure 5.39 shows these results. Thus, the e-book received a satisfaction rating of good in terms of making difficult and complicated concepts easy to understand and tasks easy to undertake. They also rated the e-book as satisfactory in terms of motivating participants to engage in undertaking difficult tasks and learning. From the content analysis, it could be seen that the participants accepted the use of e-books in the studying of difficult concepts because they assist in making difficult concepts easy to understand, as explained in the willingness section.
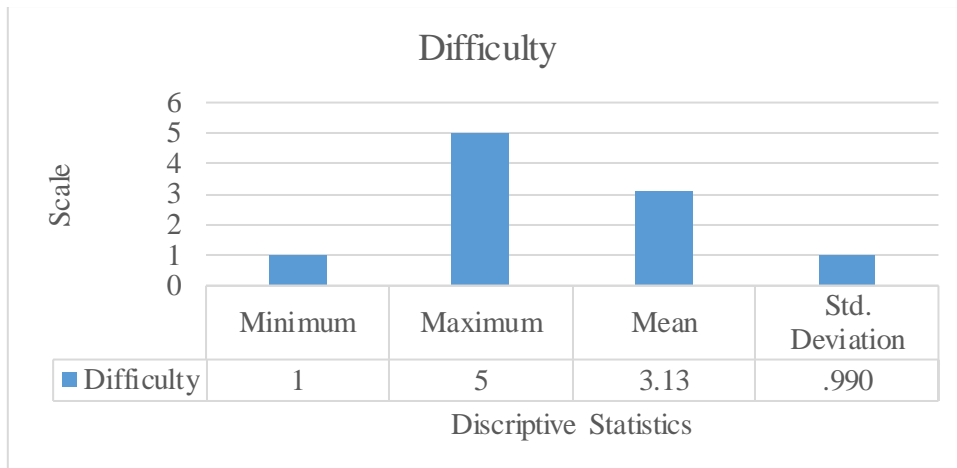
Figure 5.39 Results showing the participants' ratings of difficulty with regards to using the e-book.

An independent-samples t-test was conducted to compare the amount of difficulty of learning about research methodology through using gaming technology and through reading the e-book. There was no significant difference in the result for gaming technology (M = 3.60, SD = .910) and the e-book (M = 3.13, SD = .990): t (28) = 1.344, p =.190. Table 5.22 and Figure 5.40 show the t-test results which demonstrate that gaming technology and the e-book have the same amount of influence on difficulty/making knowledge easy to acquire, with a very slight advantage on the part of the gaming technology.

Table 5.22 The independent-samples t-test results in the amount of difficulty of learning about research methodology through gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Difficulty	Gaming Technology	15	3.60	.910	.235
	E-book	15	3.13	.990	.256

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Difficulty	Equal variances assumed	.093	.763	1.344	28	.190	.467	.347	-.245	1.178
	Equal variances not assumed			1.344	27.803	.190	.467	.347	-.245	1.178

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	Difficulty	
	Gaming Technology	E-book
■ Mean	3.60	3.13
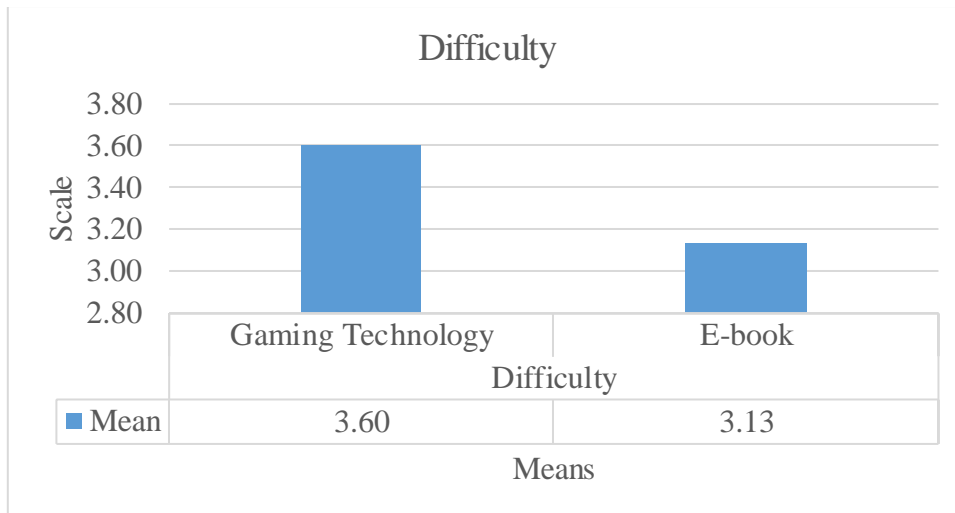
Figure 5.40 Comparison of the amount of difficulty in learning about research methodology through gaming technology and the e-book.

5.2.3.2.3 Personal interest

In order to measure personal interest while playing the game or reading the e-book, the following question was asked:

Q: How would you rate your personal interest in learning about research methodology?

The researcher asked the gaming technology group to rate their personal interest in learning through gaming technology. The results from the participants showed a minimum of three, which was 'neutral', and a maximum of five, which was 'strongly agree', and a mean of (M = 4.13, SD = .640). Figure 5.41 shows the results for participants' personal interest. Gaming technology overall received a satisfaction rating of excellent in terms of the participants' personal interest (because most of the participants were interested in using the gaming technology in order to learn about research methodology and perform the tasks).
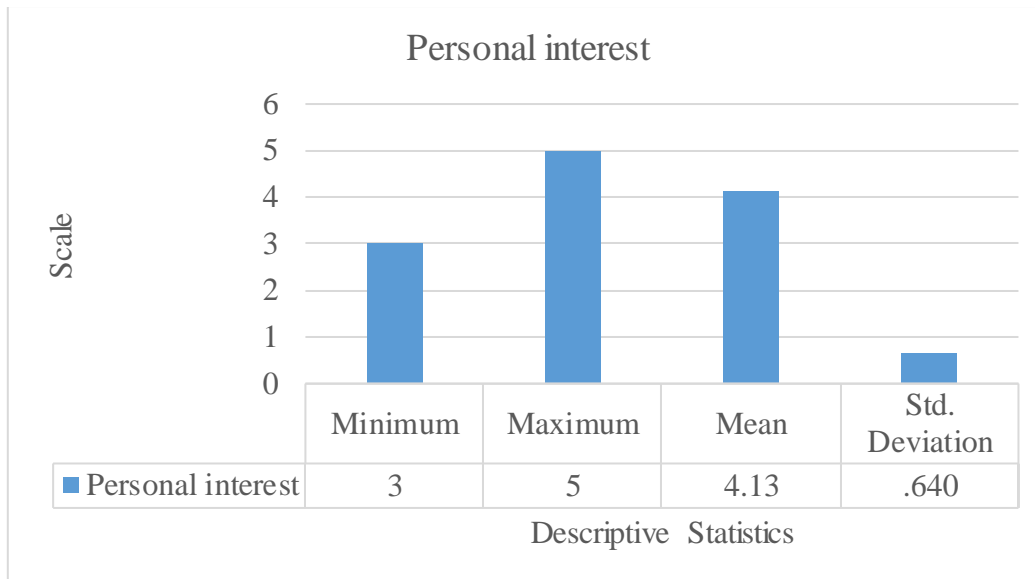
Figure 5.41 Results for the ratings of participants' personal interest in learning (gaming technology group).

The researcher asked the participants in the e-book group to rate their personal interest by learning about research methodology through reading the e-book. The results showed that the participants awarded a minimum of three, which was 'neutral', and a maximum of five, which was 'strongly agree', with an average of (M = 4.00, SD = .655). Figure 5.42 shows the results for participants' personal interest. The results show the e-book received a satisfaction rating of good with regard to the participants' personal interest in the e-book. This means that most of the participants were interested in using the e-book when learning about research methodology and performing tasks.
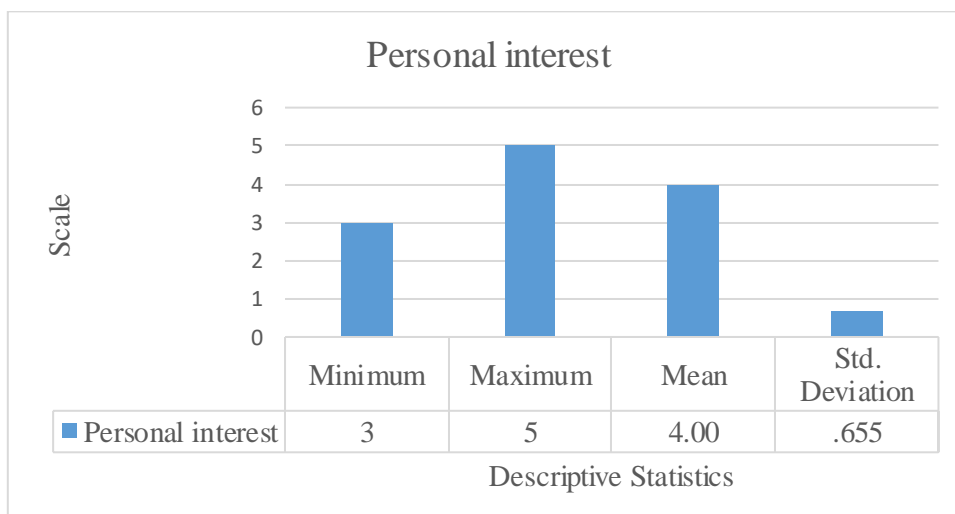
Figure 5.42 Results for the ratings of participants' personal interest in learning (e-book group).

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Next, an independent-samples t-test was conducted to compare gaming technology with the e-book in terms of encouraging personal interest. There was no significant difference in the result for gaming technology (M = 4.13, SD = .640) and the e-book (M = 4.00, SD = .655): t (28) = .564, p =.577. Table 5.23 and Figure 5.43 show the t-test results which indicate that gaming technology and the e-book support/provide personal interest for the participants. Personal interest is related to the design of the gaming technology and the e-book.

Table 5.23 The independent-samples t-test results concerning participants' personal interest with regard to gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Personal Interest	Gaming Technology	15	4.13	.640	.165
	E-book	15	4.00	.655	.169

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Personal Interest	Equal variances assumed	.133	.718	.564	28	.577	.133	.236	-.351	.618
	Equal variances not assumed			.564	27.986	.577	.133	.236	-.351	.618
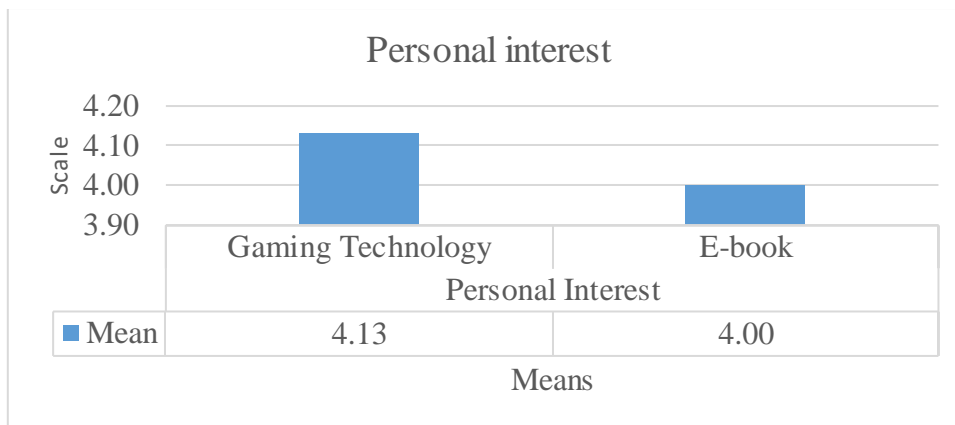
Figure 5.43 Comparison of the personal interest factor between the gaming technology and the e-book groups.

In conclusion, gaming technology supports learning by combining all the intrinsic elements (novelty, difficulty and personal interest). The results for these elements (making up intrinsic motivation) as per the ratings given by the participants showed a minimum of 3.67 and a maximum was 4.67 and a mean of (M = 4.1333, SD = .37374). Figure 5.44 show the results (as rated by the participants) of the influence of gaming technology on intrinsic motivation.
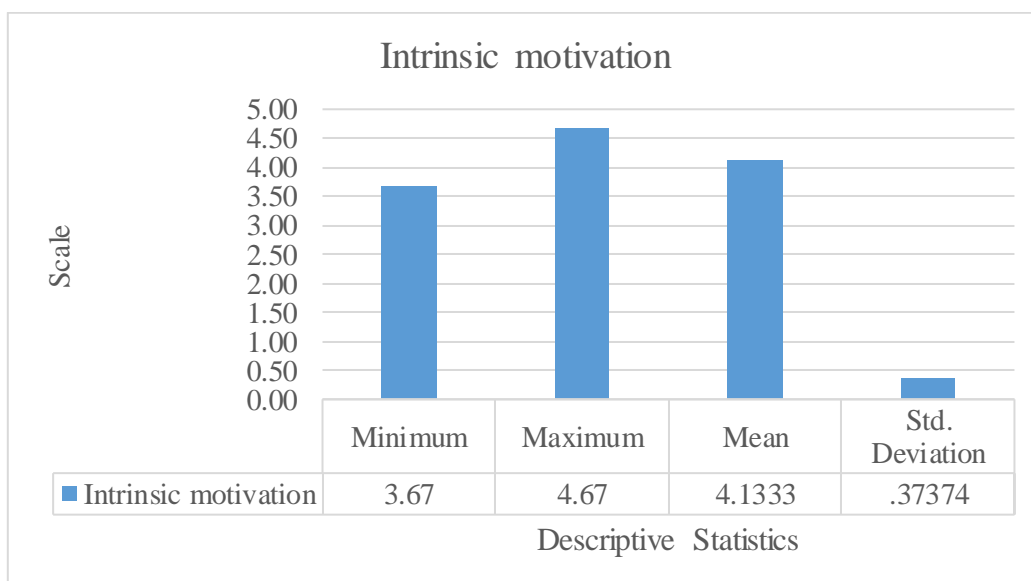
Figure 5.44 The results (as rated by the participants) of the influence of gaming technology on intrinsic motivation.

It can be seen from the results that gaming technology received a satisfaction rating of excellent in terms of its influence on intrinsic motivation. Thus gaming technology supports intrinsic motivation and also supports motivational factors for learning.

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Also, e-books support motivation and this can be measured by combining the ratings from the participants for all the intrinsic elements (novelty, difficulty and personal interest) The results showed that the minimum was (2.67) and the maximum was (4.67) with a mean of (M = 3.60, SD = .55205). Figure 5.45 shows the result regarding the influence of e-books on intrinsic motivation.
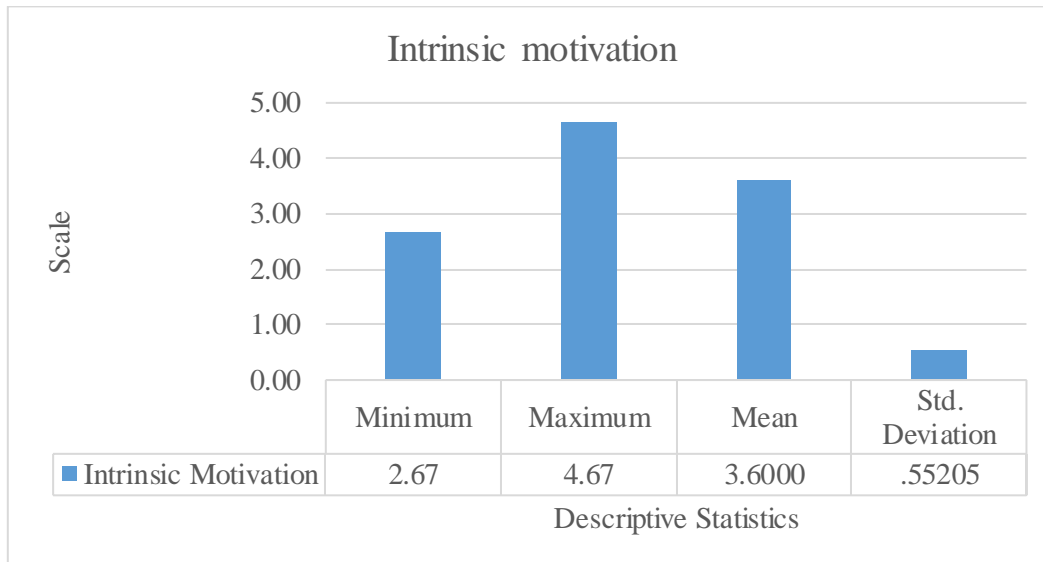
Figure 5.45 The results (as rated by the participants) of the influence of the e-book on intrinsic motivation.

The intrinsic motivation descriptive statistics showed good satisfaction ratings and this means that e-books support intrinsic motivation and this, in turn, supports learning.

To compare intrinsic motivation as a whole, an independent-samples t-test was conducted to compare gaming technology and the e-book in terms of intrinsic motivation for the participants. There was a significant difference in the results for gaming technology's (M = 4.1333, SD = .37374) and the e-book's (M = 3.60, SD = .55205) influence: t (28) = 3.098, p =.004. Table 5.24 and Figure 5.46 show the t-test results which demonstrate that gaming technology influences intrinsic motivation more than the e-book.

Table 5.24 The independent-samples t-test results for intrinsic motivation when using gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
IntriM	Gaming Technology	15	4.1333	.37374	.09650
	E-book	15	3.6000	.55205	.14254

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
IntriM	Equal variances assumed	1.222	.278	3.098	28	.004	.53333	.17213	.18074	.88593
	Equal variances not assumed			3.098	24.605	.005	.53333	.17213	.17853	.88814
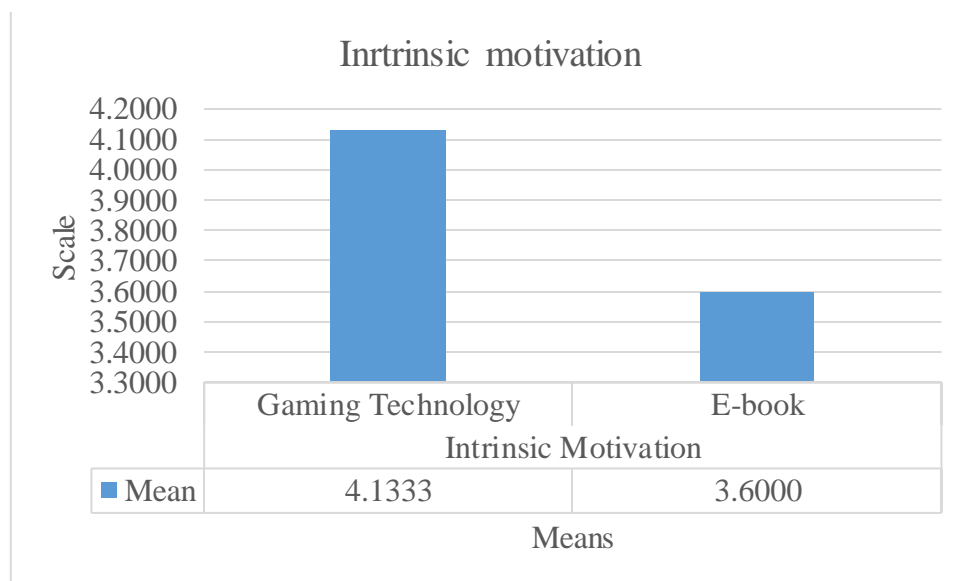
Figure 5.46 Comparison of intrinsic motivation when using gaming technology and the e-book.

5.2.3.3 Effort

Participants were asked to rate the effort that they used to achieve the tasks when using gaming technology. The results of their ratings showed a minimum of two, which was 'high', and a maximum of five, which was 'very low', and the mean was (M = 3.47, SD =.834). Figure 5.47 shows the participants' effort while using gaming technology. This means that gaming technology received a satisfaction rating of good in terms of participants using low

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effort in terms of utilizing the technology. However, some effort was expended by participants in performing the tasks. After the game, participants indicated that they would like to put in more effort to learn more by using the gaming technology environment.
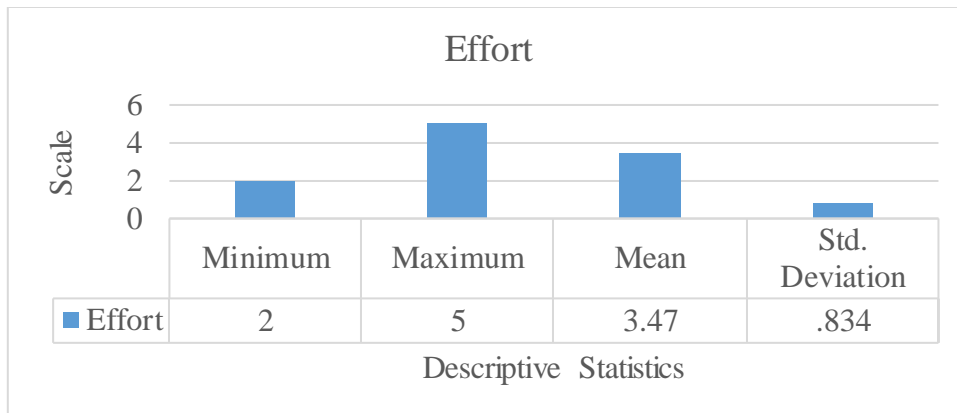
Figure 5.47 Participants' ratings for effort required by gaming technology.

The researcher asked the participants to rate the effort they used to achieve the tasks by using the e-book. The results given by the participants showed a minimum of two, which was 'high', and a maximum of four, which was 'very low', with a mean of (M = 3.07, SD = .594). Figure 5.48 presents the participants' effort while using the e-book.
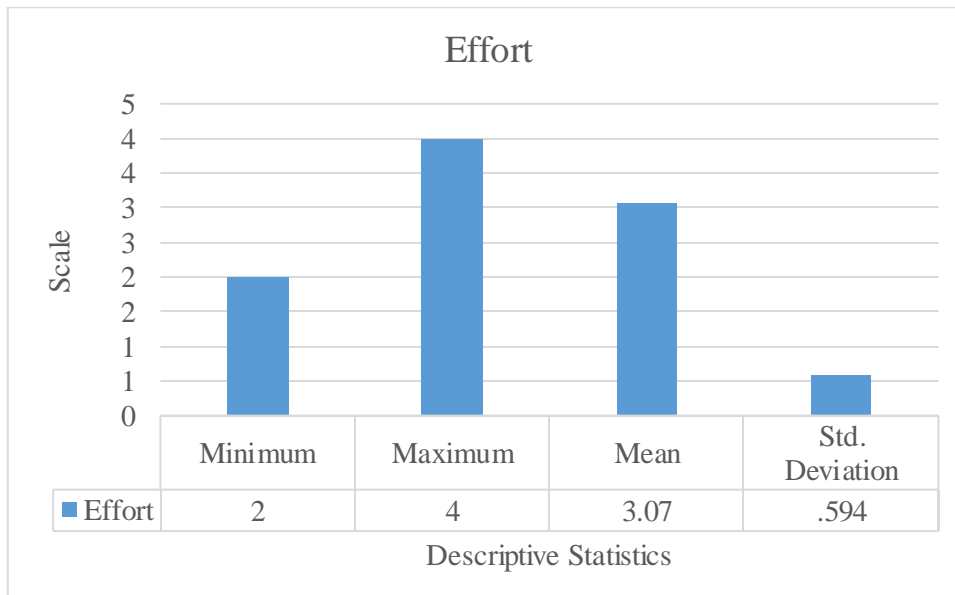
Figure 5.48 Participants' ratings for effort required by the e-book.

This results show that e-books make learning easy and that only low effort is required. This is shown by the fact that the mean showed a satisfaction rating of good (although some effort

was expended by the participants to perform the tasks). A learner can expend more effort if they are learning through an e-book.

An independent-samples t-test was conducted to compare the amount of effort that participants used in playing the game and in reading the e-book in order to learn about research methodology by using gaming technology and by reading the e-book. There was no significant difference in the results for gaming technology (M = 3.47, SD = .834) and the e-book (M = 3.07, SD = .594): t (28) = 1.514, p = .141. Table 5.25 and Figure 5.49 show the t-test results which illustrate that gaming technology and the e-book have the same amount of influence on the effort that is required.

Table 5.25 The independent-samples t-test results on rating the effort it take to learn through gaming technology and the e-book.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Effort	Gaming Technology	15	3.47	.834	.215
	E-book	15	3.07	.594	.153

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Effort	Equal variances assumed	4.386	.045	1.514	28	.141	.400	.264	-.141	.941
	Equal variances not assumed			1.514	25.291	.143	.400	.264	-.144	.944
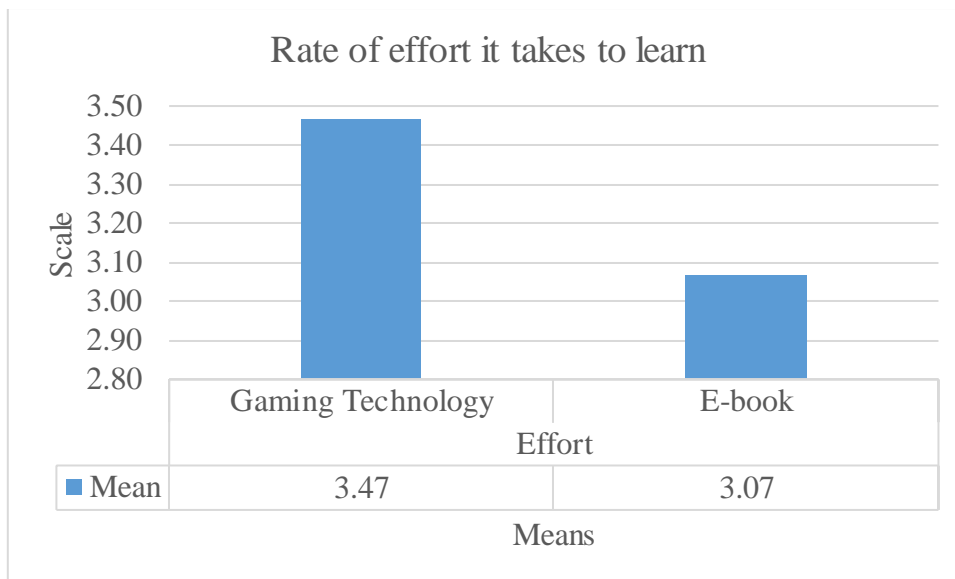
Figure 5.49 Comparison of the amount of effort it takes to learn in terms of using gaming technology and the e-book.

To explore if participants had to put in more effort to learn about research methodology, the following question was asked:

Q: Did you feel you need more effort to learn about research methodology?

The responses of the participants show that those in the gaming technology group were motivated to put in more effort because of their level of understanding of research methodology and their need to expand their understanding by using tools, such as the e-book. Also, gaming technology focused on the specific information that participants needed to complete the tasks. GT11 stated 'Learning needs effort and the game helps to lower the effort because it is easy'.

Moreover, the e-book group also felt the need to put in more effort to learn. Learning through the e-book in this study made the participants feel that they needed to study hard in order to get a clear understanding of research methodology.

Content analysis shows that both groups had both the ability and the desire to put more effort into learning about research methodology by using gaming technology and the e-book.

5.2.3.4 Extrinsic motivation

A new sub-factor was explored within the motivation factor. The participants' responses to the interview questions and the content analysis reveal that an extrinsic motivation for gaming technology helps and supports motivation when playing the game for learning purposes.

Gaming technology influences extrinsic motivation and helps to motivate participants to engage with the learning environment in order to gain knowledge, develop their skills and enrich their experience. Gaming technology has an impact on learning thanks to three elements: challenges, a high score and winning.

No one within the e-book group, however, made any mention of extrinsic motivation.

5.2.3.4.1 Challenges

The game provided balanced challenges that avoided both causing anxiety and being boring. The game required participants to find the appropriate steps for each scenario which led them to challenge themselves to obtain a high grade and to avoid mistakes. This motivated them to focus on their understanding. Participants tested themselves to complete the challenges and to win the game.

5.2.3.4.2 High score

Most of participants challenged themselves to obtain a high score and this, in turn, improved their motivation. GT5 stated 'I challenged myself to pass with a high score'.

5.2.3.4.3 Winning

Gaming technology can make players feel that they are in a dangerous situation and they need to be sure of their steps in order to overcome the game's hazards and win. This makes the participants focus on their learning and, in turn, improves participants' understanding and helps participants to think deeply about the steps in the game to avoid making any mistake or incurring a loss. Furthermore, the gaming technology users look forward and always have the motivation to win. When participants win in a game, this makes them feel like champions, which enhances their motivation to gain more knowledge. In addition, winning shows that the participants have gained good experience and good knowledge.

In conclusion, based on the above results, gaming technology has more advantages and more capacity to support participants' motivation. Thus to summarise, gaming technology motivated learning more than the e-book did.

5.3 Discussion:

Via the statistical and content analysis, this research shows more support for autonomous learning when using gaming technology. Gaming technology had more impact on the participants' attitude because the autonomous learning was enhanced by increased technology; the participants moved from the lower stage of independent learning to the higher stage. However, e-book participants stayed on their initial level and sometimes moved to a lower stage. Gaming technology also enhanced learner curiosity; the use of the e-book did not.

In addition, content analysis shows the gaming environment increased curiosity because it provided interactivity. The game also provided an opportunity to test the learner's knowledge. There was greater motivation within the gaming technology group versus the e-book group because gaming technology provided an emotional impetus, as shown in the content analysis. Gaming technology had extrinsic motivation which was lacking in the e-book technology. Table 5.26 presents a summary of the influence of gaming technology and of the e-book in learning.

Table 5.26 Comparison of all the results from the experiments, questionnaire, observation and interviews.

Independent Variable Cause		Analysis Type	Experiment Group Gaming Technology	Control Group E-book	Comparing Gaming Technology to the E-book
Dependent Variable Effect					
Attitude	Autonomous Learning	Statistical analysis	Gaming technology supported participants to move from a low stage to a higher stage.	No significant improvement in the stage of independent learning Excellent satisfaction. Content analysis shows there is influence on	In the stage of independent learning, gaming technology supported participants to move from a low stage to a higher one.

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Independent Variable Cause / Dependent Variable Effect		Analysis Type	Experiment Group Gaming Technology	Control Group E-book	Comparing Gaming Technology to the E-book
			Excellent satisfaction	autonomous learning.	There is no significant difference in the results from the closed questions. Gaming technology is of more significance than the e-book.
		Content analysis	Sub-factors: Willingness – Confidence – Goals and a Plan – Tactics – Adaptation	Sub-factors: Willingness – Goals and a Plan – Tactics – Adaptation Confidence not overly strong because some students felt they needed help with difficult concepts. Overall, the e-book supports autonomous learning.	Gaming technology has a more clear influence on autonomous learning than the e-book.
	Curiosity	Statistical analysis	Significant difference between the trait of curiosity and state of curiosity	There is no significant difference between the trait and state of curiosity	Gaming technology is better than the e-book because it has a significant difference between the trait of curiosity and the state of curiosity. The e-book does not have a significant difference

Independent Variable Cause / Dependent Variable Effect		Analysis Type	Experiment Group Gaming Technology	Control Group E-book	Comparing Gaming Technology to the E-book
					between the trait of curiosity and the state of curiosity.
		Content analysis	Sub-factors: Interest – Deprivation – Environment	Sub-factors: Interest – Deprivation	Gaming technology has an influence from the gaming environment that is not provided in the e-book.
	Motivation	Statistical analysis	Excellent satisfaction	Excellent satisfaction	There is no significant difference between gaming technology and the e-book.
		Content analysis	Sub-factors: Emotional influence- intrinsic motivation- extrinsic motivation- effort	Sub-factors: Emotional influence- intrinsic motivation- effort	Gaming technology has extrinsic motivation that is not provided by the e-book.

5.4　Summary

In conclusion, gaming technology had a positive effect on learning attitudes because it created satisfaction which had an impact on participants' attitudes. Gaming technology can enhance autonomous learning by supporting willingness and confidence. Moreover, statistical results show that gaming technology participants moved to a higher level of independency and that gaming technology was more supportive than the e-book in enhancing autonomous learning. Gaming technology supports curiosity more than the e-book because the result from the question about the trait of curiosity and the state of curiosity showed a significant difference in the curiosity level before and after playing the game. However, the e-book did not have any significant difference in the curiosity level before and after reading the e-book and the content analysis explained that impact clearly.

Motivation was influenced more by gaming technology than the e-book because there were more elements in gaming technology than in the e-book that supported motivation. This means that gaming technology was more supportive for enhancing motivation.

Thus, gaming technology has been proved to be an effective tool and resource in learning. It can enhance learners' attitudes and can give learners 21st-century learning skills.

Chapter 6. Considering the influence of gaming technology on learners' higher-order thinking

6.1 Introduction

This chapter examines the impact of gaming technology and e-books on participants' cognition and, especially, on their higher-order thinking, including their critical thinking and problem solving abilities. An experiment, a questionnaire and an interview were utilised to measure these impacts. Moreover, a descriptive analysis was used to measure the participants' satisfaction, and a t-test was used to compare the impacts of the studied gaming technology and the e-book. Explanations were drawn from the content analysis.

6.2 Cognition

Initially, the research measured the participants' understanding of the concepts of the research methodology before and after the use of the gaming technology. In order to evaluate the participants' understanding, the following question was asked before and after the participants used gaming technology and the e-book:

Q: What is your level of understanding concerning research methodology?

A paired-sample t-test was conducted to compare the participants' understandings of the research methodology before (M = 2.73, SD = .594) and after (M = 4.27, SD = .799) the use of the gaming technology (t(14) = -9.28, p = 0). Table 6.1 and Figure 6.1 show the results.

Table 6.1 Results of the paired-sample t-test for the level of understanding of research methodology before and after the use of gaming technology

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Understanding level 1	2.73	15	.594	.153
	Understanding level 2	4.27	15	.799	.206

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Understanding level 1 - Understanding level 2	-1.533	.640	.165	-1.888	-1.179	-9.280	14	.000
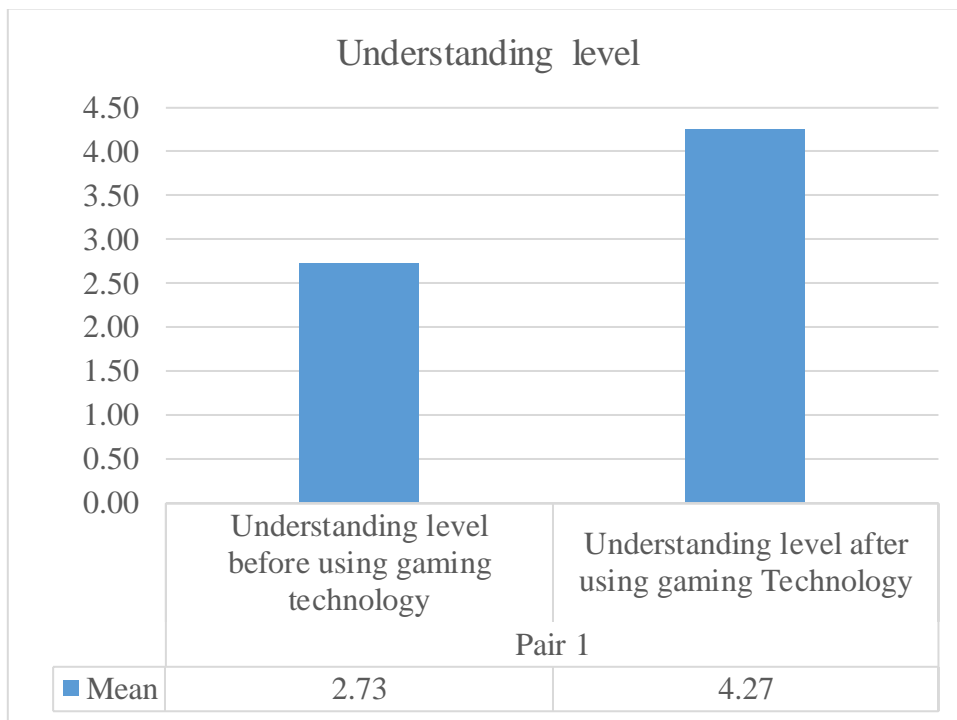
Figure 6.1 Results of the paired-sample t-test for the level of understanding of research methodology before and after the use of gaming technology

These results show that there was a significant difference in the participants' levels of understanding of research methodology before and after their use of gaming technology. In brief, gaming technology enhanced the participants' understanding of difficult and complicated knowledge (i.e., of research methodology) and helped them acquire that knowledge.

Next, the research measured the participants' understandings of the concepts of research methodology before and after reading the e-book.

A paired sample t-test was conducted to compare the participants' understandings of research methodology before (M = 3.60, SD = .507) and after (M = 4.00, SD = .535) reading the e-book (t (14) = -2.449, p = .028). Table 6.2 and Figure 6.2 show the results of the t-test.

Table 6.2 Results of the paired sample t-test showing the participants' levels of understanding of research methodology before and after reading the e-book

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Understanding level 1	3.60	15	.507	.131
	Understanding level 2	4.00	15	.535	.138

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Understanding level 1 - Understanding level 2	-.400	.632	.163	-.750	-.050	-2.449	14	.028
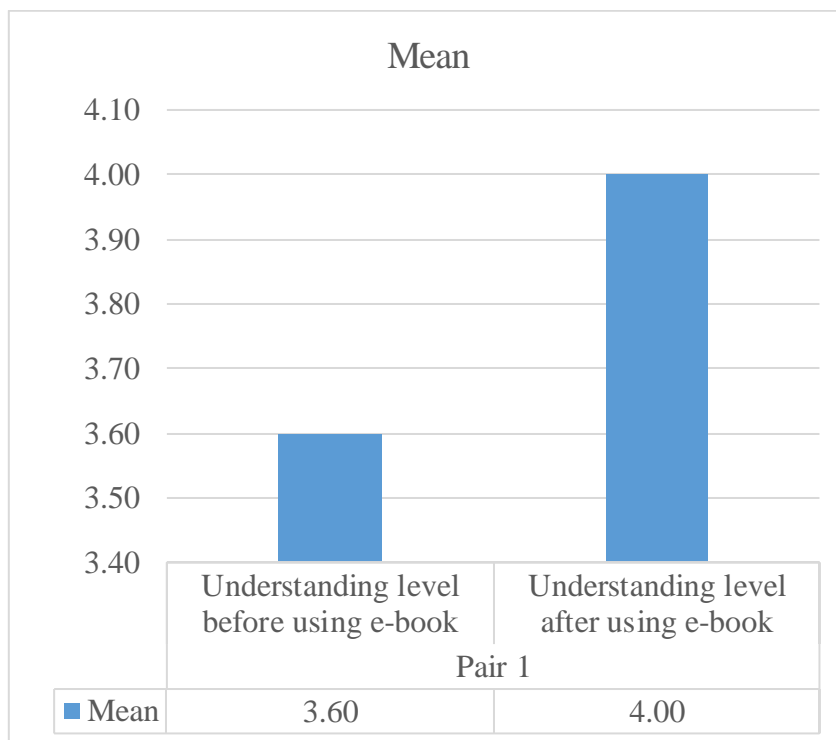
Figure 6.2 Results of the paired sample t-test showing the participants' levels of understanding of research methodology before and after reading the e-book

These results show that there was a significant difference in the participants' levels of understanding of research methodology before and after they read the e-book. In brief, the

e-book enhanced the participants' understanding of difficult and complicated knowledge (i.e., of research methodology) and helped them acquire that knowledge. Therefore, e-books can be said to support participant cognition because if any participant is confused about any aspect of a given topic (in this case, research methodology), an e-book can make the concept clearer.

In terms of cognition, the research found that gaming technology and the e-book resulted in significant differences between the participants' pre-experiment and post-experiment understandings. Specifically, the results show that both gaming technology and the e-book enhanced participant understanding.

The second question in this section concerned the participants' analysis ability, as supported by the use of gaming technology. Analysis ability is the first level of higher-order thinking. The following question was asked to evaluate the participants' analysis ability:

Q: Were you able to analyse the information learned from gaming technology/the e-book and to develop the research methodology, as specified in the task?

The results show that gaming technology supported the participants' analysis ability because the participants' ratings ranged from a minimum response of two (i.e., 'disagree') to a maximum response of five (i.e., 'strongly agree'), with an average response of 4.13 (SD = .834). Figure 6.3 shows the results regarding the impact of gaming technology on analysis ability, as rated by the participants.
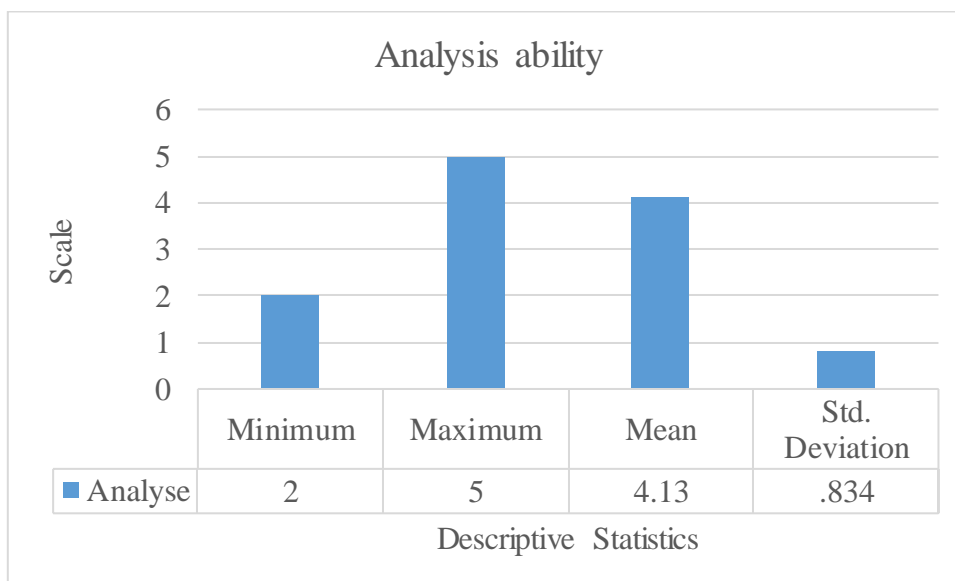
Figure 6.3 Impact of gaming technology on analysis ability

These results indicate that gaming technology had an excellent impact on the participants' analysis ability. Thus, the participants were able to use gaming technology to support their analysis ability and sustain higher-order thinking.

The same question was asked to measure and test the impact of the e-book on the participants' analysis ability.
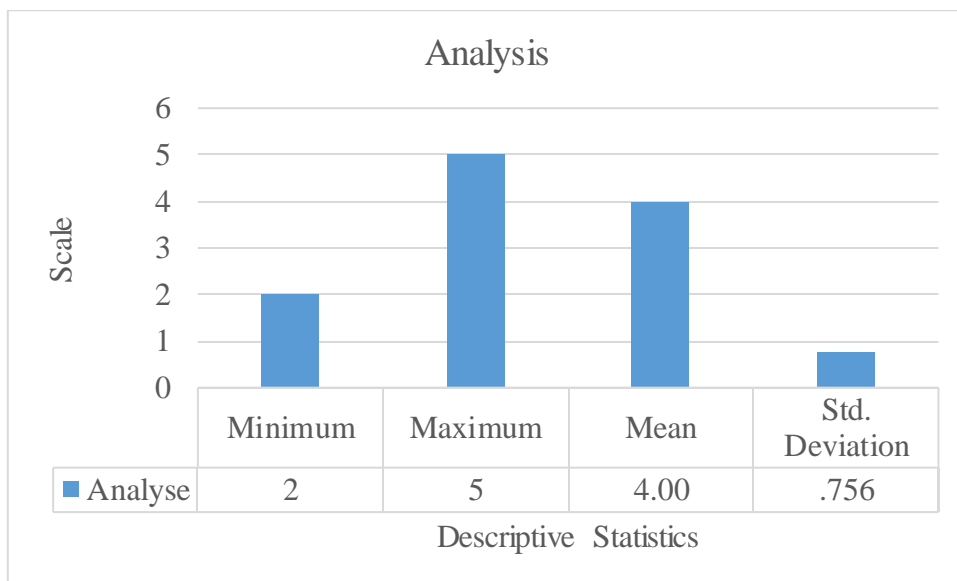
Figure 6.4 Impact of the e-book on analysis ability

Figure 6.4 shows the impact of the e-book on the participants' analysis ability. The participants' ratings ranged from two (i.e., 'disagree') to five (i.e., 'strongly agree'), with an average result of 4.00 (SD = .756). Thus, the e-book was rated as having a good impact on the participants' analysis ability which, in turn, supported higher-order thinking.

An independent sample t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' analysis ability. There was no significant difference in the results for the impacts of the gaming technology (M = 4.13, SD = .834) and the e-book (M = 4.00, SD = .756): t(28) = .459, p = 0.650. Table 6.3 and Figure 6.5 present the results of the t-test which show that gaming technology and the e-book had similar impacts on the participants with regard to their analysis ability. The results suggest that both technologies can support and enhance participants' higher-order thinking, with gaming technology being slightly more effective.

Table 6.3 Results of the independent sample t-test for analysis ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Analyse	Gaming Technology	15	4.13	.834	.215
	E-book	15	4.00	.756	.195

		Levene's Test for Equality of Variances		t-Test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Analyse	Equal variances assumed	.643	.429	.459	28	.650	.133	.291	-.462	.729
	Equal variances not assumed			.459	27.735	.650	.133	.291	-.462	.729
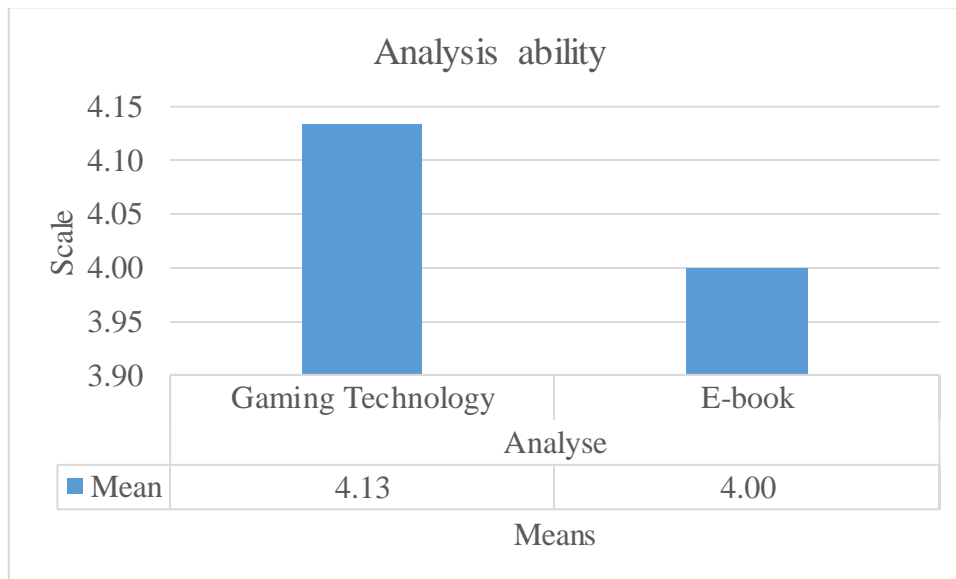
Figure 6.5 Results of the independent sample t-test for analysis ability

Next, the participants' critical thinking and problem solving abilities were measured and explored, as presented below. Figure 6.6 shows the cognition factor and sub-factors that form the framework in order to explore the influence of gaming technology and e-books on participants' opinions with regard to the sub-factors
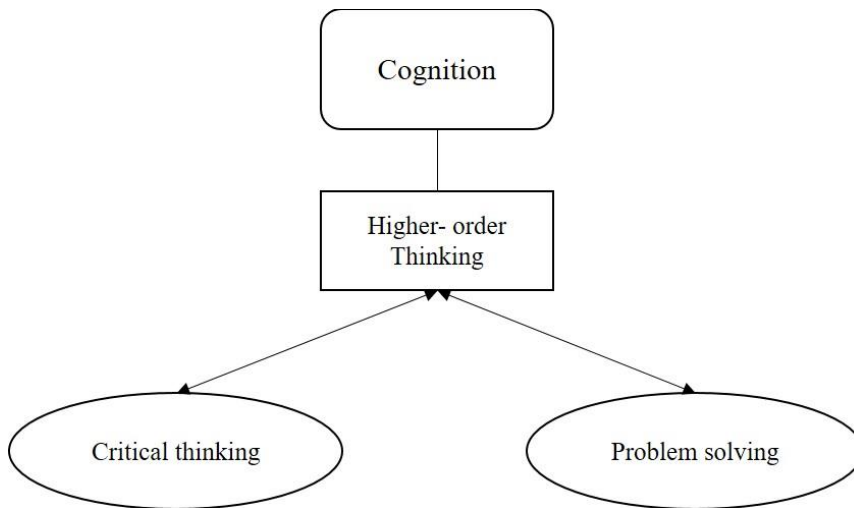
Figure 6.6 the cognition factors

6.2.1 Critical thinking

Critical thinking was measured using closed-ended questions. In particular, five sub-factors of critical thinking were measured: recognition of assumption, induction, deduction, interpretation and evaluation. Then, all of these sub-factors were combined to find the average impacts of gaming technology and the e-book on critical thinking. Figure 6.7 presents the critical thinking factor and its sub-factors.
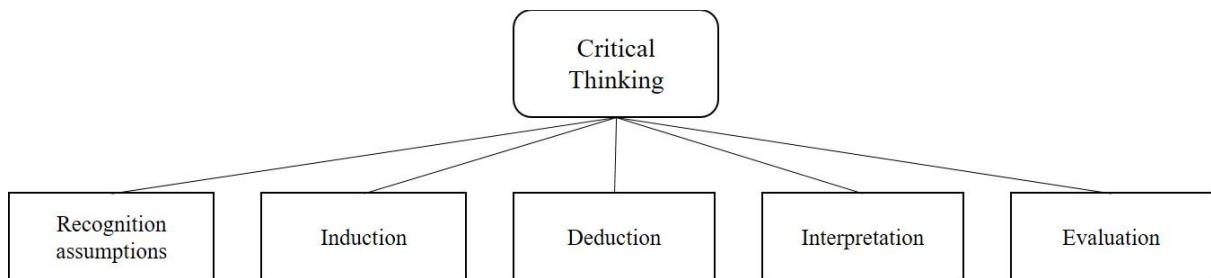
Figure 6.7 The critical thinking factor and sub-factors

6.2.1.1 Recognition of assumption

The recognition of assumption ability was measured for both the gaming technology group and the e-book group via the following question:

Q: Were you able to enhance your ability to assume and identify the appropriate research methodology in order to undertake the correct research steps and processes, as specified in the tasks?

The gaming technology group results for recognition of assumption, as rated by the participants, ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree') with an average of 4.40 (SD = .828). Figure 6.8 shows the results.

Recognition of assumption

	Minimum	Maximum	Mean	Std. Deviation
■ Recognition of assumption	2	5	4.40	.828

Descriptive Statistics
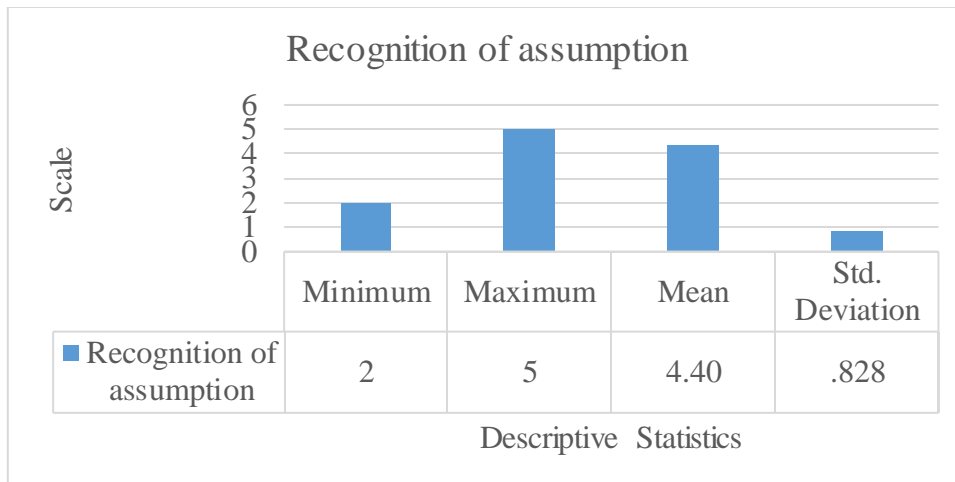
Figure 6.8 Impact of gaming technology on recognition of assumption ability

In brief, gaming technology was rated as having an excellent impact on the participants' assumption recognition ability and their ability to navigate through the gaming process in order to achieve their task.

The recognition of assumption ability of the e-book group was also measured. The participants' results ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average response of 3.80 (SD = .775). Figure 6.9 shows the results, which indicate that the participants rated the e-book as having a good impact on enhancing their ability to identify the appropriate research methodology for each task scenario.
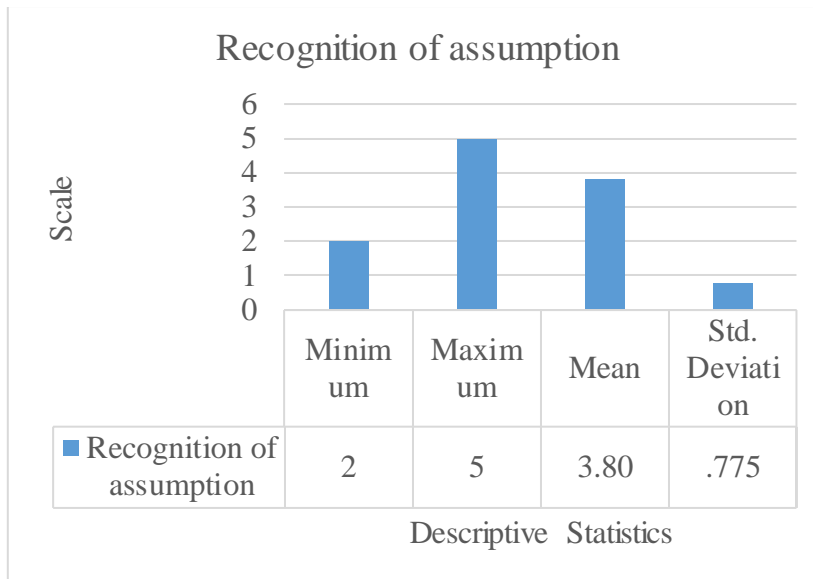
Figure 6.9 Impact of the e-book on recognition of assumption ability

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' recognition assumption ability. There was a significant difference in the results for the impacts of gaming technology (M = 4.40, SD = .828) and the e-book (M = 3.80, SD = .775): t (28) = .2.049, p = 0.050. Table 6.4 and Figure 6.10 present the results of the t-test, which show that gaming technology impacted on the participants' recognition assumption abilities more than the e-book. These results suggest that gaming technologies support participants' ability to assume and identify the best solutions for their tasks.

Table 6.4 Results of the independent samples t-test for recognition assumption ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Recognition of assumption	Gaming Technology	15	4.40	.828	.214
	E-book	15	3.80	.775	.200

		Levene's Test for Equality of Variances		t-Test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Recognition of assumption	Equal variances assumed	.188	.668	2.049	28	.050	.600	.293	.000	1.200
	Equal variances not assumed			2.049	27.876	.050	.600	.293	.000	1.200
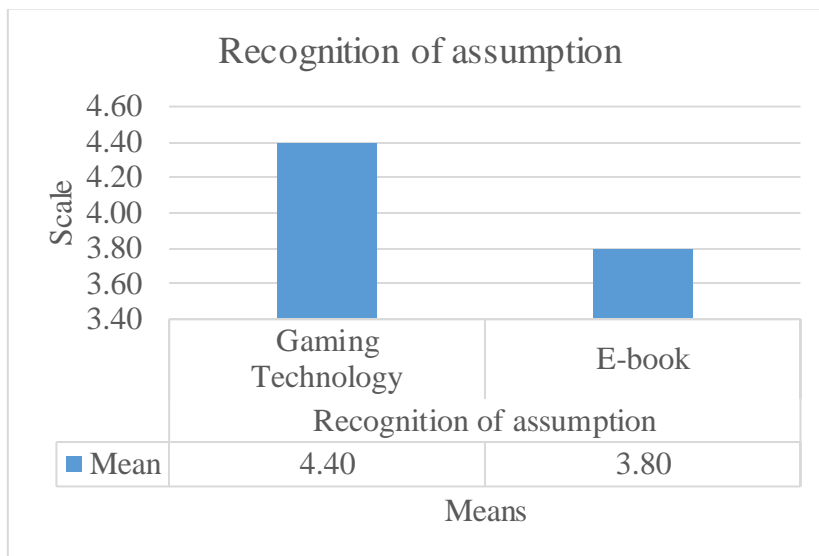
Figure 6.10 Results of the independent samples t-test for recognition assumption ability

Subsequently, the research measured the impact of gaming technology and the e-book on the participants' induction ability (a sub-factor of critical thinking).

6.2.1.2 Induction

In order to measure the participants' induction ability, the following question was asked:

Q: Were you able to enhance your ability to find the appropriate research methodology to undertake the research, as specified in the tasks?

The results for the gaming technology group, as rated by the participants, ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 4.27 (SD = .799). Figure 6.11 shows the results.

Figure 6.11 Impact of gaming technology on induction ability

Hence, gaming technology was rated as having an excellent impact on the participants' induction ability which, in turn, supports their critical thinking. In this research, gaming technology was able to help the participants identify the most appropriate research methodologies for each task scenario. Thus, gaming technology supported the participants' induction ability.

The same question was asked in relation to the impact of the e-book on the participants' induction ability. The rating results ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 3.80 (SD = .775). Figure 6.12 shows the results.

Figure 6.12 Impact of the e-book on induction ability

Hence, the participants rated the e-book as having a good impact on the induction element of critical thinking. The e-book helped the participants identify the most appropriate research methodology for each task scenario. Thus, the e-book supported the participants' induction ability.

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' induction ability. There was no significant difference in the results for the impacts of gaming technology (M = 4.27, SD = .799) and the e-book (M = 3.80, SD = .775): t(28) = 1.624, p = 0.116. Table 6.5 and Figure 6.13 present the results of the t-test which show that gaming technology and the e-book had similar impacts on the participants' induction ability. The results suggest that both technologies may support and enhance participants' ability to choose the most appropriate action for their tasks, with gaming technology being slightly more beneficial.

Table 6.5 Results of the independent samples t-test for induction ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Induction	Gaming Technology	15	4.27	.799	.206
	E-book	15	3.80	.775	.200

	Levene's Test for Equality of Variances		t-Test for Equality of Means							
									95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Induction Equal variances assumed	.020	.889	1.624	28	.116	.467	.287	-.122	1.055
Equal variances not assumed			1.624	27.974	.116	.467	.287	-.122	1.055
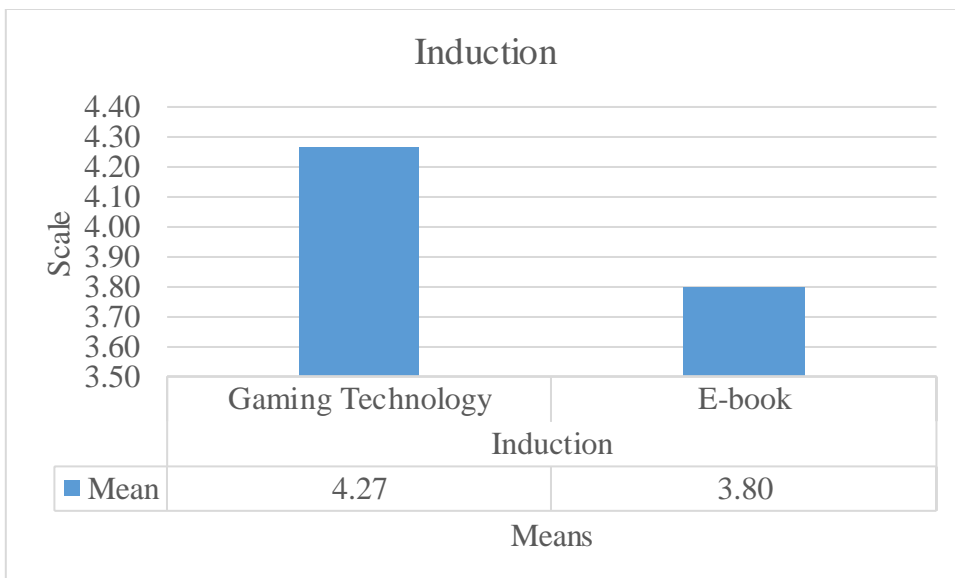
Figure 6.13 Results of the independent samples t-test for induction ability

Subsequently, the participants' deduction ability was tested and measured.

6.2.1.3 Deduction

In order to evaluate the participants' deduction ability, the following question was asked:

Q: Were you able to enhance your ability to use reason to create the type of research methodology specified in the tasks?

The gaming technology group results, as rated by the participants, ranged from a minimum of one (i.e., 'strongly disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 4.13 (SD = 1.302). Figure 6.14 shows the results.
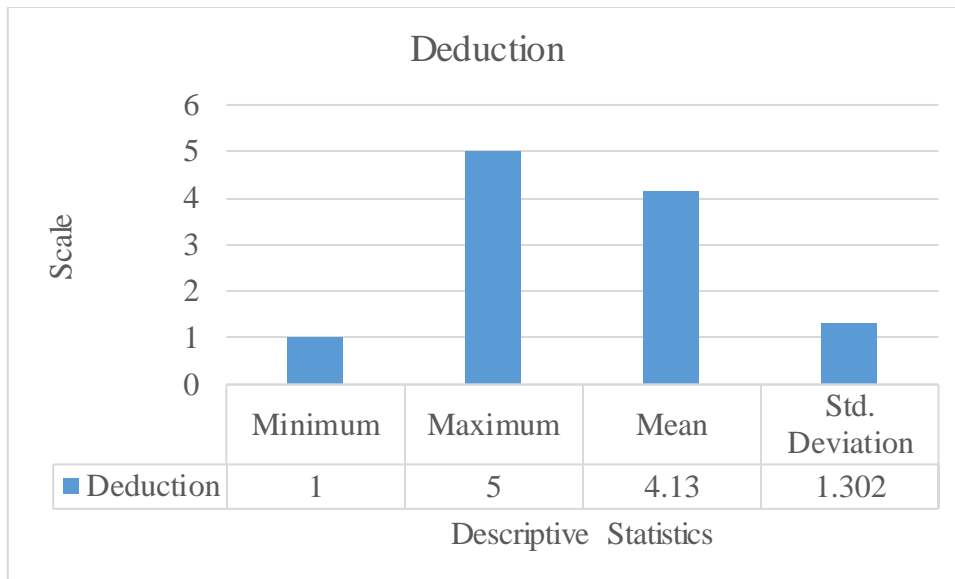
Figure 6.14 Impact of gaming technology on deduction ability

Thus, gaming technology was rated as having an excellent impact on the participants' deduction ability. It helped the participants use reason for each step in order to perform the tasks and this, in turn, supported their deduction ability.

The same question was asked of the e-book group participants. Their rating results ranged from a minimum of four (i.e., 'agree') to a maximum of five (i.e., 'strongly agree'), with an average of 4.47 (SD = .516). Figure 6.15 shows the results.
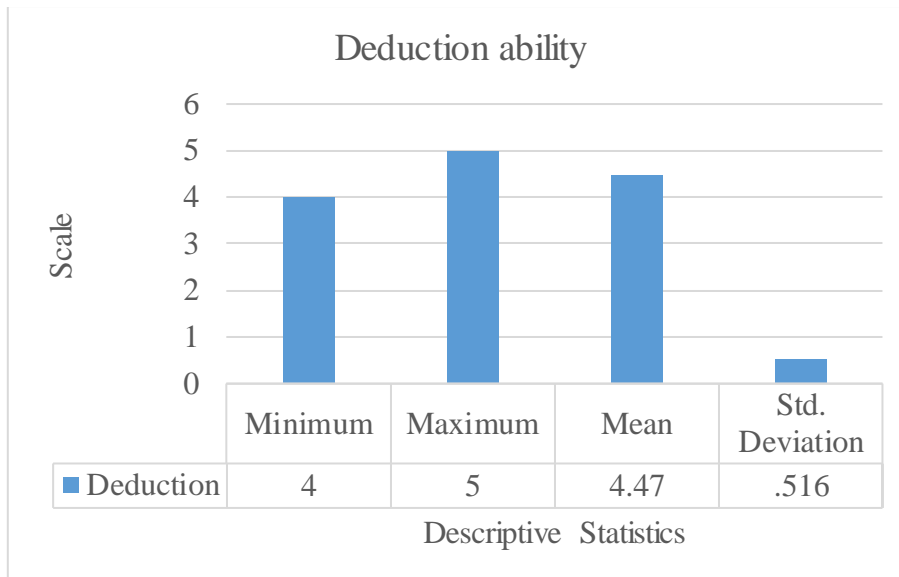
Figure 6.15 Impact of e-books on deduction ability

Thus, the e-book was rated by the participants as having an excellent impact on their deduction ability. The e-book helped the participants use reason for each step as they performed the tasks, thus supporting their deduction ability.

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' deduction ability. There was no significant difference in the results for the impacts of gaming technology (M = 4.13, SD = 1.302) and the e-book (M = 4.47, SD = .516): t (28) = -.922, p= 0.365. Table 6.6 and Figure 6.16 present the results of the t-test, which show that gaming technology and the e-book had better impacts on the participants' deduction ability. The results suggest that both technologies may support and enhance participants' ability to use reasoning in each step of a task, with e-books being slightly more beneficial.

Table 6.6 Results of the independent samples t-test for the recognition of deduction ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Deduction	Gaming Technology	15	4.13	1.302	.336
	E-book	15	4.47	.516	.133

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Deduction	Equal variances assumed	8.204	.008	-.922	28	.365	-.333	.362	-1.074	.407
	Equal variances not assumed			-.922	18.298	.369	-.333	.362	-1.092	.426
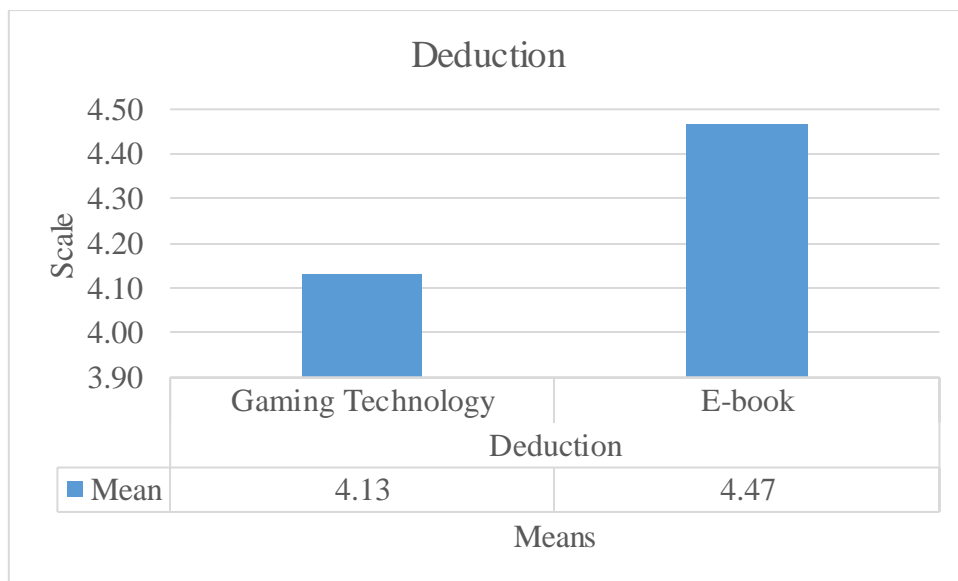
Figure 6.16 Results of the independent-samples t-test for recognition of deduction ability

Subsequently, the participants' interpretation ability was measured in order to determine and test the technologies' impact on the participants' ability to recognize the relationship between the layers of the research methodology within the tasks.

6.2.1.4 Interpretation

In order to evaluate the participants' interpretation ability, the following question was asked:

Q: Were you able to enhance your ability to determine the relationship between the layers of the research methodology that helped to perform the research, as specified in the tasks?

The gaming technology group results, as obtained from the participants' ratings, ranged from a minimum score of three (i.e., 'neutral') to a maximum score of five (i.e., 'strongly agree'), with an average of 4.13 (SD = .743). Figure 6.17 shows the results.
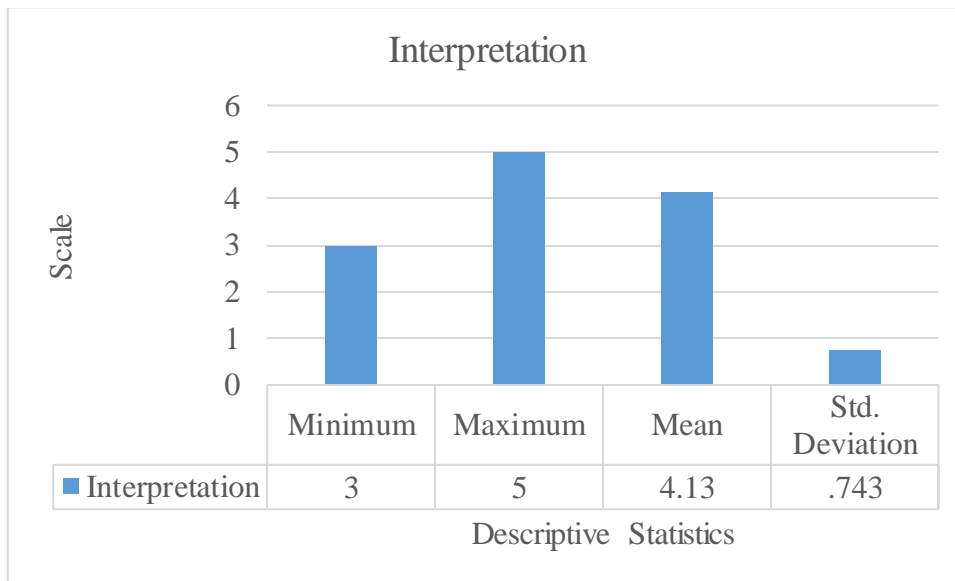
Figure 6.17 Impact of gaming technology on interpretation ability

Therefore, gaming technology was deemed to have an excellent impact on the participants' interpretation ability. Gaming technology helped the learners determine the relationships among the research methodology concepts and this, in turn, supported their interpretation ability.

The interpretation abilities of the e-book group were measured by asking the same question. The rating results ranged from a minimum score of two (i.e., 'disagree') to a maximum score of five (i.e., 'strongly agree'), with an average score of 4.13 (SD = .990). Figure 6.18 shows the results.
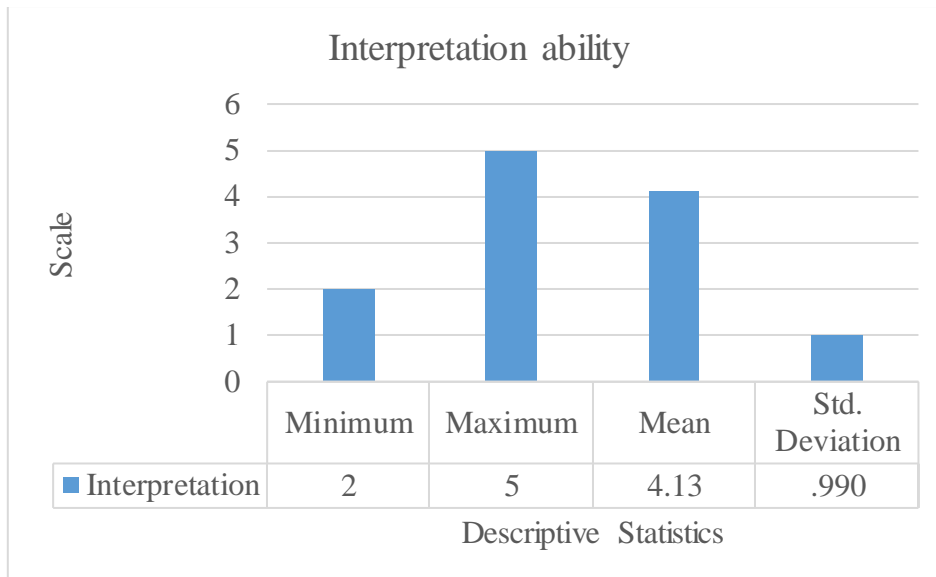
Figure 6.18 Impact of the e-book on interpretation ability

Therefore, the e-book was rated by the participants as having an excellent impact on interpretation. The e-book helped the learners determine the relationships among the concepts of the research methodology, which, in turn, supported their interpretation ability.

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' interpretation ability. There was no significant difference in the results for the impacts of gaming technology (M = 4.13, SD = .743) and the e-book (M = 4.13, SD = .990): t(28) = 0.00, p = 1.00. Table 6.7 and Figure 6.19 present the results of the t-test which show that gaming technology and the e-book had the same impact on participants' interpretation ability. These results suggest that both technologies may support and enhance participants' ability to determine the relationships among the layers of the research methodology in a task.

Table 6.7 Results of the independent samples t-test for interpretation ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Interpretation	Gaming Technology	15	4.13	.743	.192
	E-book	15	4.13	.990	.256

		Levene's Test for Equality of Variances		t-Test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Interpretation	Equal variances assumed	.303	.586	0.000	28	1.000	0.000	.320	-.655	.655
	Equal variances not assumed			0.000	25.971	1.000	0.000	.320	-.657	.657
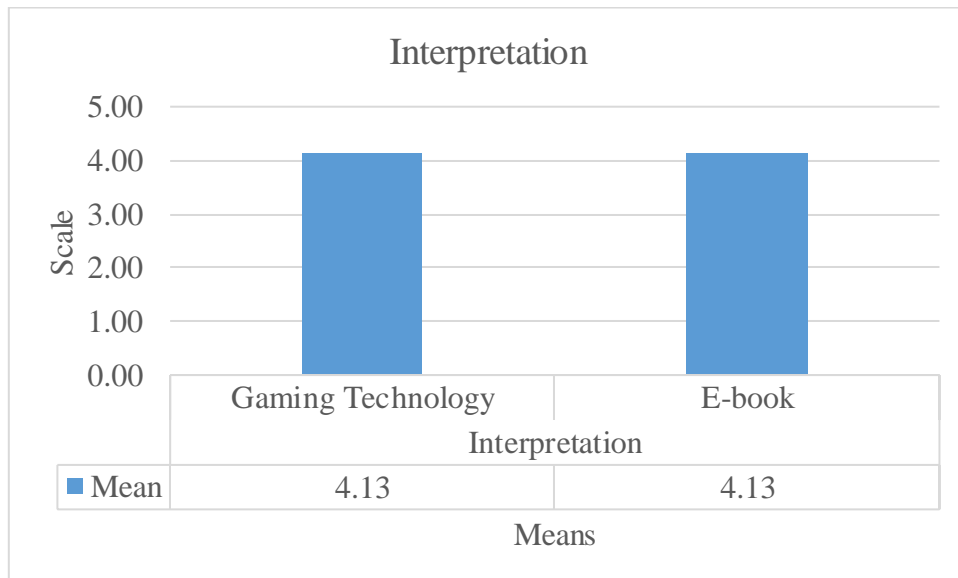
Figure 6.19 Results of the independent samples t-test for interpretation ability

6.2.1.5 Evaluation

In order to evaluate the participants' evaluation ability, the following question was asked:

Q: Were you able to rationalise and assess which type of research methodology should be used to undertake the research and perform the task?

The results of the gaming technology group, as rated by the participants, ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 4.27 (SD = .961). Figure 6.20 shows the results.
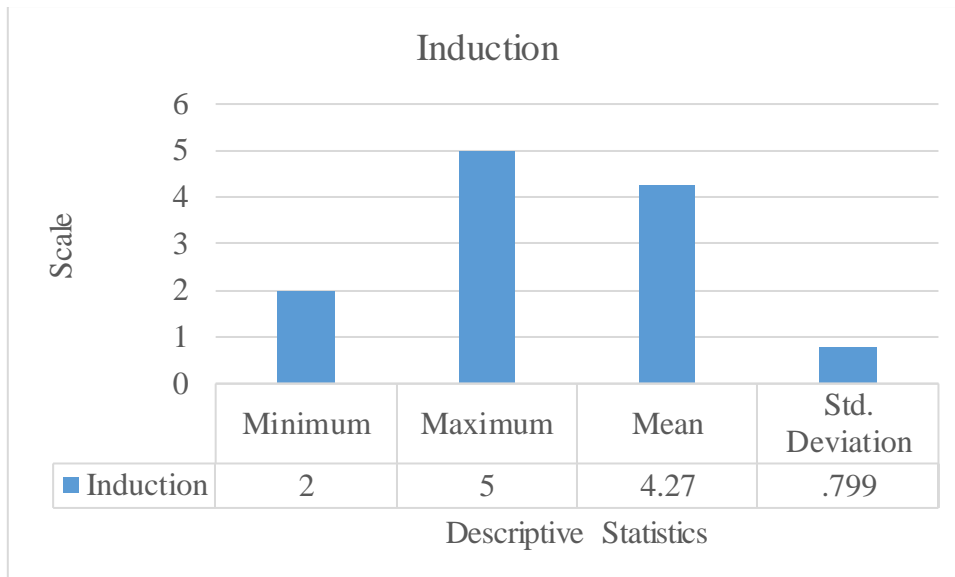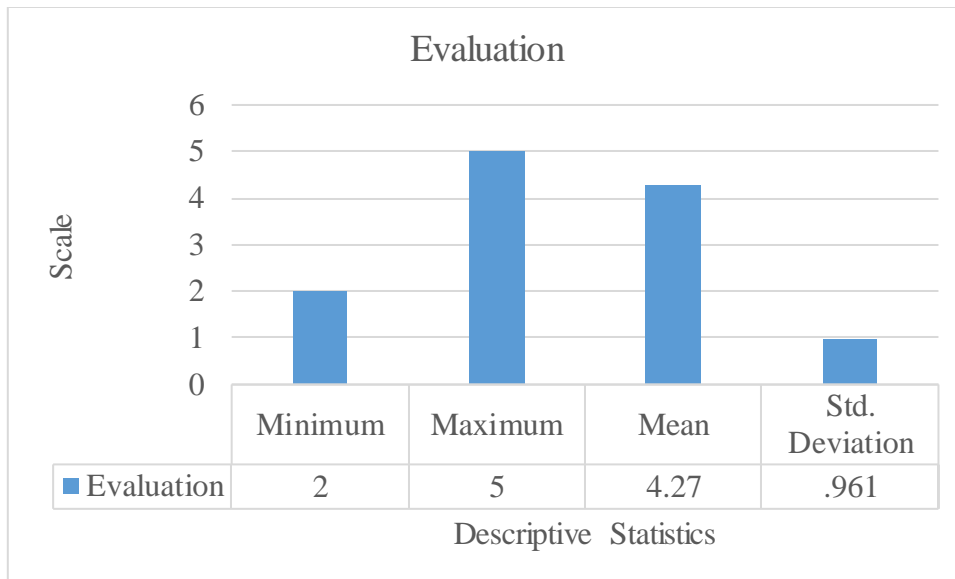

Figure 6.20 Impact of gaming technology on evaluation ability, as rated by the participants

In short, gaming technology was rated as having an excellent impact on the participants' evaluation ability. Gaming technology helped the participants evaluate their choice of research methodology in each scenario and choose the most appropriate research methodology for each case. Thus, gaming technology supported the participants' evaluation ability.

The same question concerning evaluation ability was asked of the e-book group. The results ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 4.07 (SD = .884). Figure 6.21 shows the results.
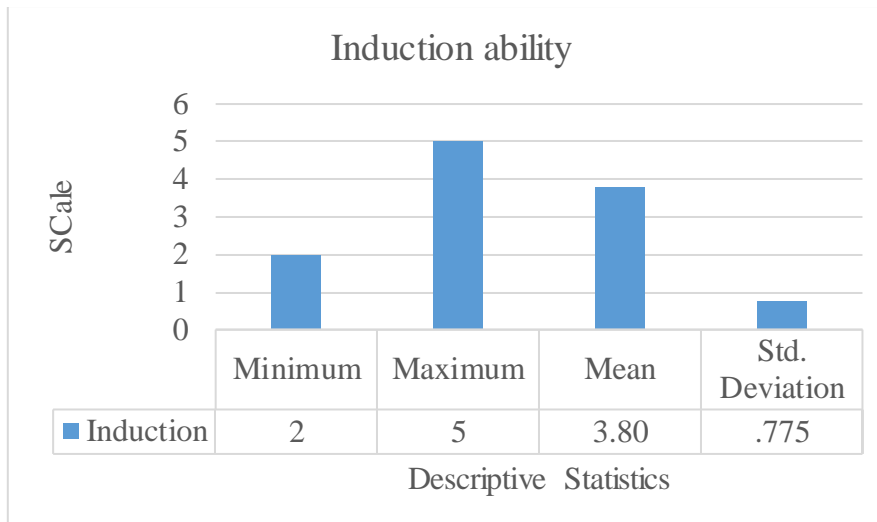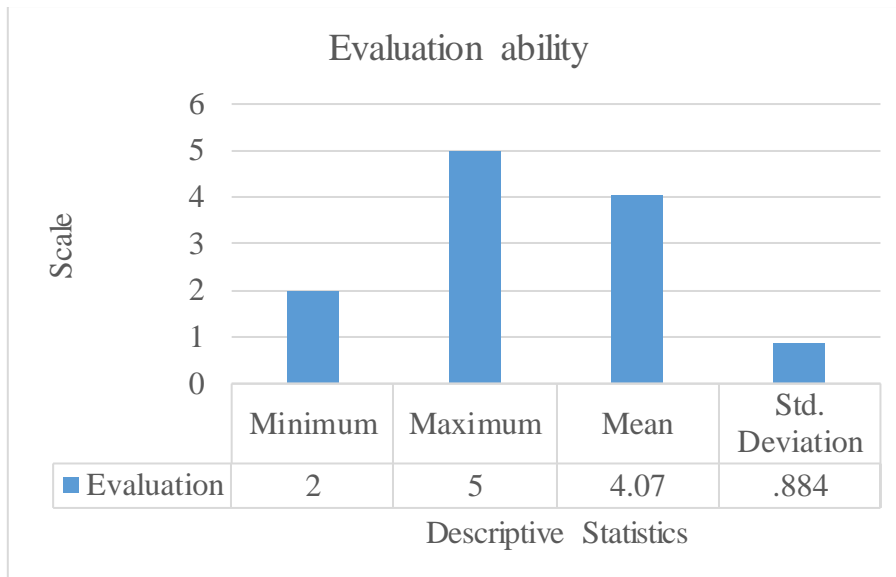
Figure 6.21 Impact of the e-book on evaluation ability

In short, the e-book was rated by the participants as having an excellent impact on their evaluation ability. The e-book helped the participants to evaluate the research methodologies in each scenario and to choose the most appropriate research methodology for each case. Therefore, the e-book supported the participants' evaluation ability.

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' evaluation ability. There was no significant difference in the results for the impacts of gaming technology (M = 4.27, SD = .961) and the e-book (M = 4.07, SD = .884): t(28)= .593, p= 0.558. Table 6.8 and Figure 6.22 show the results of the t-test which show that gaming technology and the e-book had similar impacts on the participants' evaluation ability. These results suggest that both technologies may support and enhance participants' ability to rationalise and assess their process in order to perform tasks, with gaming technology being slightly more beneficial.

Table 6.8 Results of the independent samples t-test for evaluation ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Evaluation	Gaming Technology	15	4.27	.961	.248
	E-book	15	4.07	.884	.228

		Levene's Test for Equality of Variances		t-Test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Evaluation	Equal variances assumed	.605	.443	.593	28	.558	.200	.337	-.491	.891
	Equal variances not assumed			.593	27.805	.558	.200	.337	-.491	.891
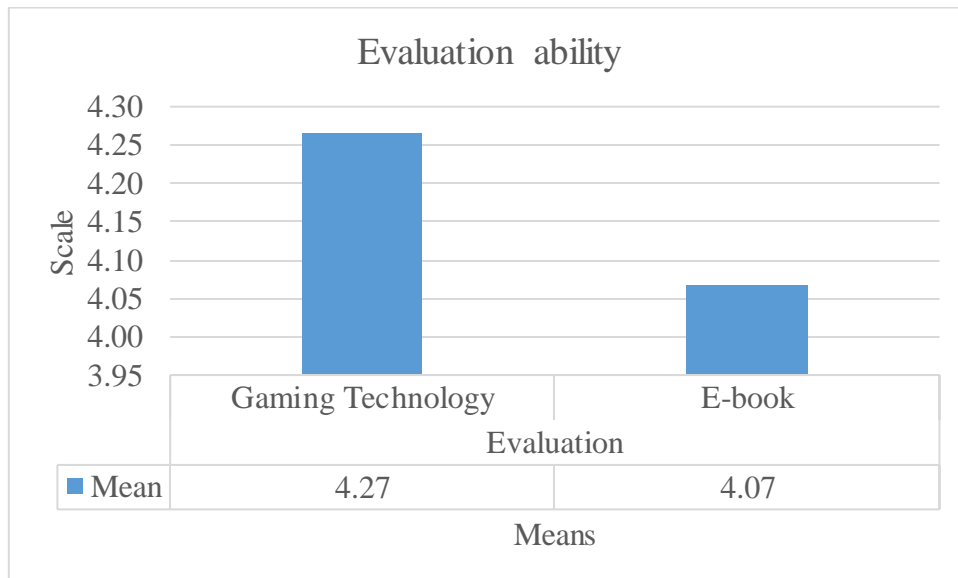
Figure 6.22 Results of the independent samples t-test for evaluation ability

Finally, the sub-factors of critical thinking (i.e., recognition assumption, induction, deduction, interpretation and evaluation) were combined to determine the average rating for the factor of critical thinking regarding the impact of gaming technology on the critical thinking of the participants. The rating results ranged from a minimum of 2.20 to a maximum of 5.00, with an average of 4.24 (SD = .7219). Figure 6.23 shows the results. Hence, gaming technology was rated as having an excellent impact on critical thinking.
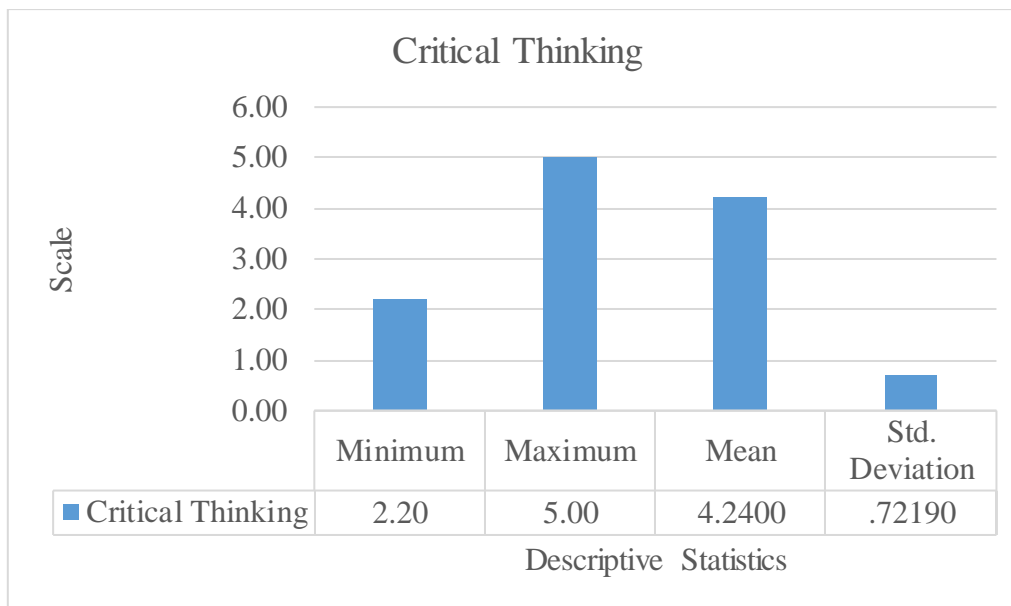
Figure 6.23 Impact of gaming technology on critical thinking

In conclusion, the results suggest that gaming technology supports and encourages critical thinking (via performing tasks in the game and using all of the gaming technology features).

The same process was utilized with the e-book group, such that the results for the sub-factors of critical thinking were combined in order to determine the overall impact of the e-book on the critical thinking of the participants. The rating results ranged from a minimum of 2.80 to a maximum of 5.00, with an average of 4.0533 (SD = .53166). Figure 6.24 shows the results. Hence, the e-book was rated by the participants as having a good impact on critical thinking ability.
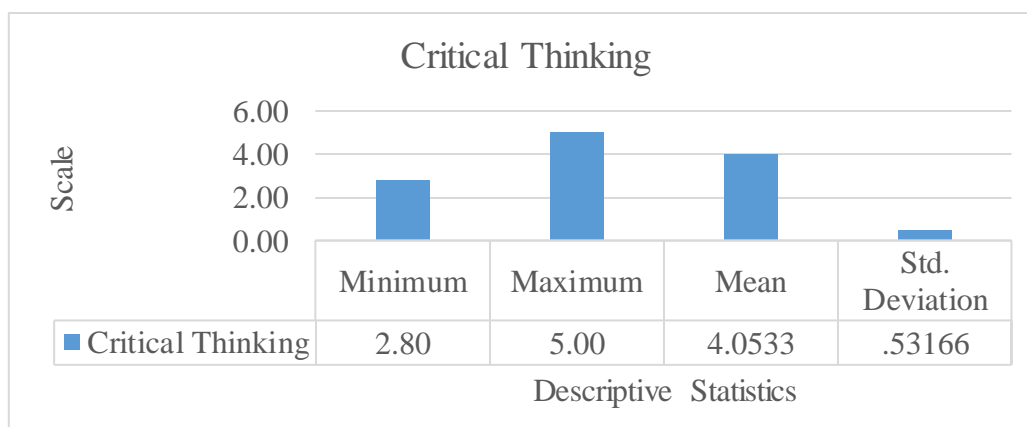
Figure 6.24 Impact of the e-book on critical thinking

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on critical thinking. There was no significant difference between the results for the impacts of gaming technology (M = 4.24, SD = .7219) and the e-book (M = 4.0533, SD = .53166): t(28) = .806, p = 0.427. Table 6.9 and Figure 6.25 present the results of the t-test which show that gaming technology and the e-book have similar impacts on participants' critical thinking. The results suggest that both technologies may support and enhance participants' critical thinking, with gaming technology being slightly more useful in this regard.

Table 6.9 Results of the independent samples t-test for critical thinking

	Group	N	Mean	Std. Deviation	Std. Error Mean
CRT	Gaming Technology	15	4.2400	.72190	.18639
	E-book	15	4.0533	.53166	.13728

		Levene's Test for Equality of Variances		t-Test for Equality of Means							
										95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
CRT	Equal variances assumed	1.026	.320	.806	28	.427	.18667	.23149	-.28752	.66085
	Equal variances not assumed			.806	25.735	.427	.18667	.23149	-.28941	.66274

	Gaming Technology	E-book
■ Mean	4.2400	4.0533
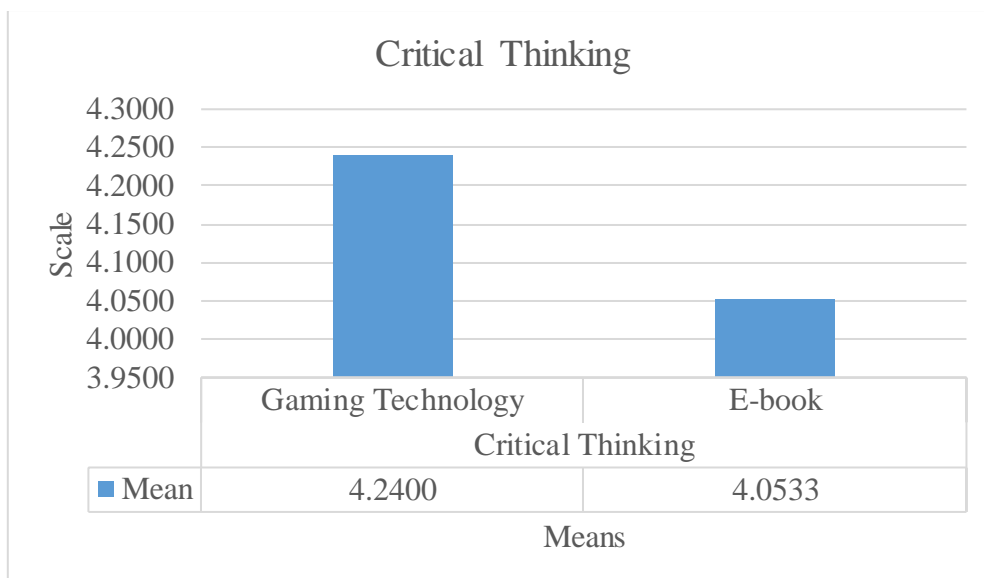
Figure 6.25 Results of the independent samples t-test for critical thinking

In conclusion, both technologies -gaming technology and the e-book - had positive impacts on the participants' critical thinking. These two technologies can be used concurrently in universities to enhance students' critical thinking even further. Moreover, gaming technologies can be used in academic libraries to support e-books and give students and library customers the opportunity to view demonstrations of the types of knowledge they need to acquire, as well as allowing them to practice this knowledge in order to develop their skills and improve on experiences learnt from e-books.

Next, the impacts of the two technologies on the participants' problem solving ability were measured.

6.2.2 Problem solving

Problem solving ability was evaluated based on one closed question and two open questions designed to measure the participants' satisfaction. Then, an explanation as to how these technologies (i.e., the game and the e-book) enhanced the participants' problem solving ability was developed.

First, the problem solving factor was measured via the following closed question:

Q: Did learning through the gaming technology/e-book encourage problem solving that assisted you in overcoming the challenges faced in creating the research methodology?

The results for the gaming technology group, as rated by the participants, ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 3.80 (SD = 1.014). Figure 6.26 shows the results.

|	Minimum	Maximum	Mean	Std. Deviation
Problem Solving	2	5	3.80	1.014
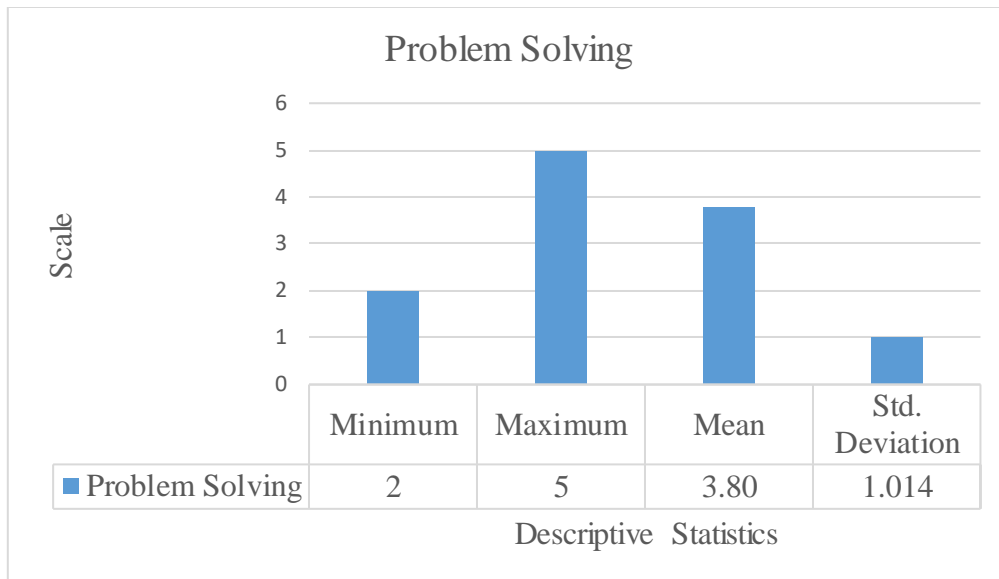
Figure 6.26 Impact of gaming technology on problem solving ability

Thus, gaming technology was rated as having a good impact on participants' problem solving ability. Gaming technology supported and encouraged the participants' problem solving ability for learning and also helped the participants solve their tasks' problems. The content analysis presents the factor, the sub-factors and the elements.

The same question was asked of the e-book group. The rating results ranged from a minimum of two (i.e., 'disagree') to a maximum of five (i.e., 'strongly agree'), with an average of 3.87 (SD = .743). Figure 6.27 shows the results.
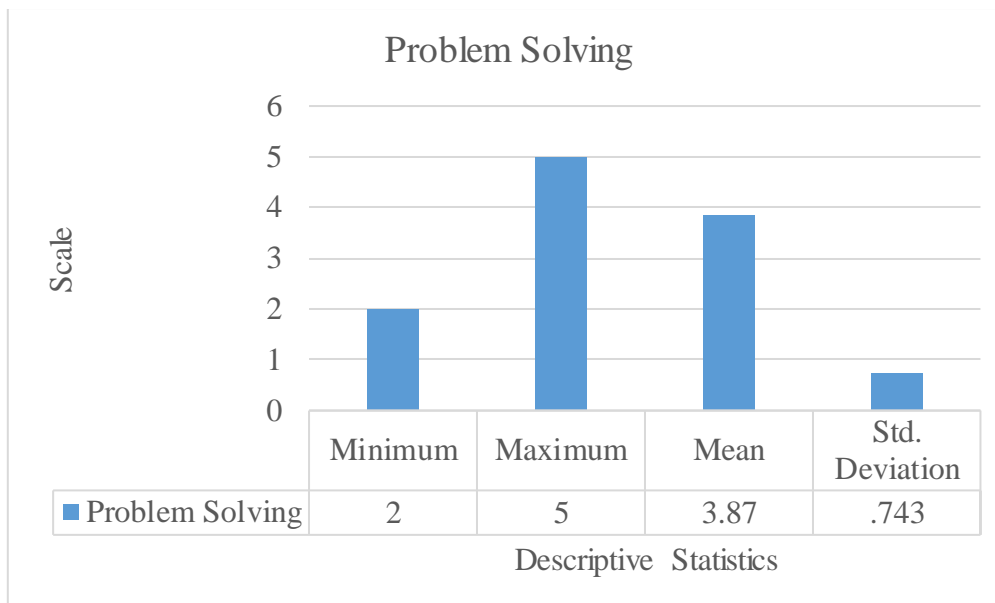
Figure 6.27 Impact of the e-book on problem solving ability

Thus, the e-book had a good impact on the participants' problem solving abilities. E-books support and encourage problem solving abilities within the learning field and help participants solve tasks' problems. The content analysis presents the factor, the sub-factors, and the elements related to the participants' problem solving abilities.

An independent samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' problem solving ability. There was no significant difference in the results for the impacts of gaming technology ($M = 3.80$, $SD = 1.014$) and the e-book ($M = 3.87$, $SD = .743$): $t(28) = -.205$, $p = 0.839$. Table 6.10 and Figure 6.28 present the results of the t-test which show that gaming technology and the e-book had similar impacts on the participants' problem solving ability. The results suggest that both technologies can support and encourage participants' problem solving ability and, thus, assist them in overcoming the challenges faced in performing tasks, with e-books being slightly more beneficial in this regard.

Table 6.10 The results of the independent-samples t-test for problem solving

	Group	N	Mean	Std. Deviation	Std. Error Mean
Problem Solving	Gaming Technology	15	3.80	1.014	.262
	E-book	15	3.87	.743	.192

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Problem Solving	Equal variances assumed	2.369	.135	-.205	28	.839	-.067	.325	-.732	.598
	Equal variances not assumed			-.205	25.671	.839	-.067	.325	-.734	.601
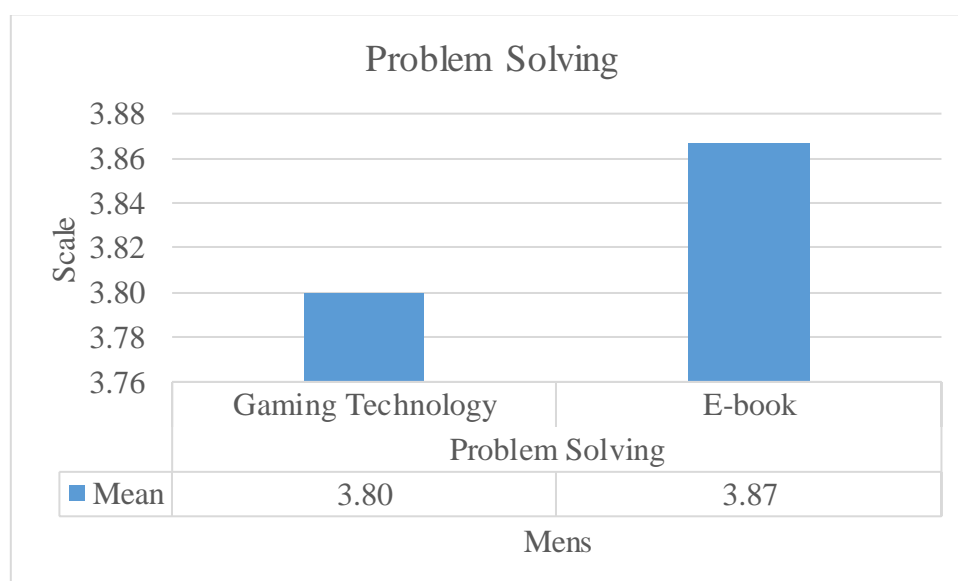
Figure 6.28 Results of the independent samples t-test for problem solving

The second process involved asking open questions to collect more information about these technologies (i.e., the game and the e-book) in order to support the participants' problem solving ability.

The content analysis demonstrated the problem solving process. Figure 6.29 shows the problem solving sub-factors.
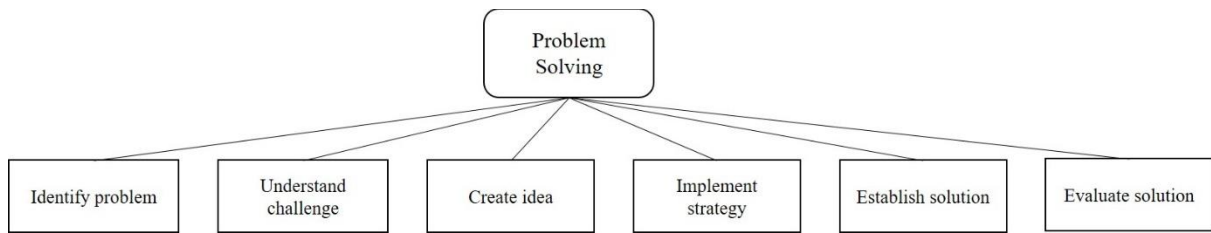
Figure 6.29 The problem solving factor and its sub-factors

The open questions asked were:

Q: What were the processes that you used and the steps that you took in order to create the research methodology and, thus, undertake the research and perform the tasks? Explain each step. Why did you use these steps and processes?

The responses to these questions showed the steps used to perform the tasks in the experiments. Table 6.11 shows these steps for both groups.

Table 6.11 Content analysis for problem solving ability

Sub-factor	Gaming technology	E-book
Identifying problems	Reading the game's scenarios and identifying the problem issue(s)	Reading the scenarios and then deciding the steps
Understanding the challenges	Understanding the nature of the research and the challenges and obstacles in the game	Understanding the challenges by gaining a good understanding of the problem in the tasks' scenarios
Creating ideas	Establishing ideas for identifying the research philosophy and, based on these ideas, identifying the other layers. (Some participants used their background experiences, such as their knowledge, skills, and experience to create solutions.)	Deciding the best research methodology for solving the problems in the scenarios

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Sub-factor	Gaming technology	E-book
Establishing strategy	Distinguishing the research methodology needed to pass through the game and win	Participants did not provide any strategies that they used or followed to achieve the tasks. However, from the researcher's observations, most of participants used step-by-step solutions to perform the tasks.
Implementing solutions	Testing solutions through the game	Applying and implementing the research methodology for each scenario
Evaluating solutions	Trying these solutions and steps in the game and getting feedback from the system regarding the solutions that the participants chose, which worked and which resulted in a win	Comparing their steps with the information in the e-book. Sometimes, the participants had problems in following the steps to negotiate through the scenario. At these points, they were required to either contact an instructor to gain feedback or utilise another technology, such as gaming technology
Other steps	Using the research methodology steps and layers to solve the problems and justifying which research methodology was the best way of undertaking the research and filling in the knowledge gaps by solving problems.	Some of participants used research methodology steps to solve the problems in the scenarios based on the onion models, since these models are tangible, making problem solving steps easier to use, and logical, meaning that they make a lot of sense and make the research easier, less confusing and much more simple.

The content analysis showed that there were no differences between gaming technology and the e-book technology in terms of problem solving ability. Indeed, both technologies can be

used concurrently in universities to support students' problem solving abilities and help them in their academic performance.

In conclusion, both technologies (i.e., games and e-books) have the same impact on cognition and higher-order thinking, based on the analysis and the results.

6.3 Discussion:

Gaming and e-book technology have similar influences on critical thinking ability, as reflected in the statistical analysis results and in the similar factors and elements in the content analysis. Gaming technology and e-book technology have a similar impact on problem solving ability based on the statistical and content analyses. Table 6.12 presents this chapter's results.

Table 6.12 Comparison of all the results from the experiment, the questionnaire and the interview in relation to the studied technologies' impacts on cognition

Independent Variable Cause / Dependent Variable Effect		Analysis Type	Experiment Group Gaming Technology	Control Group E-Book	Comparing the Gaming Technology to the E-book Technology
Cognitive	Critical thinking	Statistical analysis	Excellent satisfaction	Excellent satisfaction	No significant difference between gaming technology and the e-book.
		Content analysis			
	Problem solving	Statistical analysis	Good satisfaction	Good satisfaction	No significant difference between gaming technology and the e-book.
		Content analysis	Identify problem, understand challenges, create ideas, implement strategy, establish solution and evaluate solution	Identify problem, understand challenges, create ideas, implement strategy, establish solution and evaluate solution	Same factors: Identify problem, understand challenges, create ideas, implement strategy, establish solution and evaluate

6.4 Summary

The results of this chapter show that gaming technologies and e-books have similar effects on learner critical thinking and problem solving ability with regard to enhancing participants' cognition, especially in terms of higher-order thinking in order to support academic performance and efficiency.

The next chapter will focus on the cognitive load that the participants felt while playing the game and reading the e-book in order to learn (i.e., in order to process the data in their short-term memory during learning using gaming technology and the e-book).

Chapter 7. The impact of gaming technology on cognitive load

7.1   Introduction

The purpose of this chapter is to measure the impact of gaming technology on participants' cognitive load and compare that impact to the impact upon the e-book participant group. Data was collected through closed questions in order to measure effort, difficulty and performance and the information on all these sub-factors was combined to measure the cognitive load. A t-test was utilised to compare the gaming technology group's and the e-book group's results. This helped in finding a significant difference between the groups in terms of cognitive load.

7.2   Process: Cognitive Load

People use memory processes to gain knowledge, to improve experience and to support skills. They obtain information from the senses such as the vision and hearing. This information is sent to the short-term memory to facilitate the understanding of concepts and to obtain background knowledge and experience in order to process new information with previous knowledge and build up new knowledge. Subsequently, the short-term memory sends the new knowledge to the long-term memory; this procedure supports experience and enhances peoples' skills with the new information stored in the memory (Shunk, 2012; Sweller et al., 2011; Wilson & Wilson, 2012). Figure 7.1 shows the memory process that affects cognitive load.
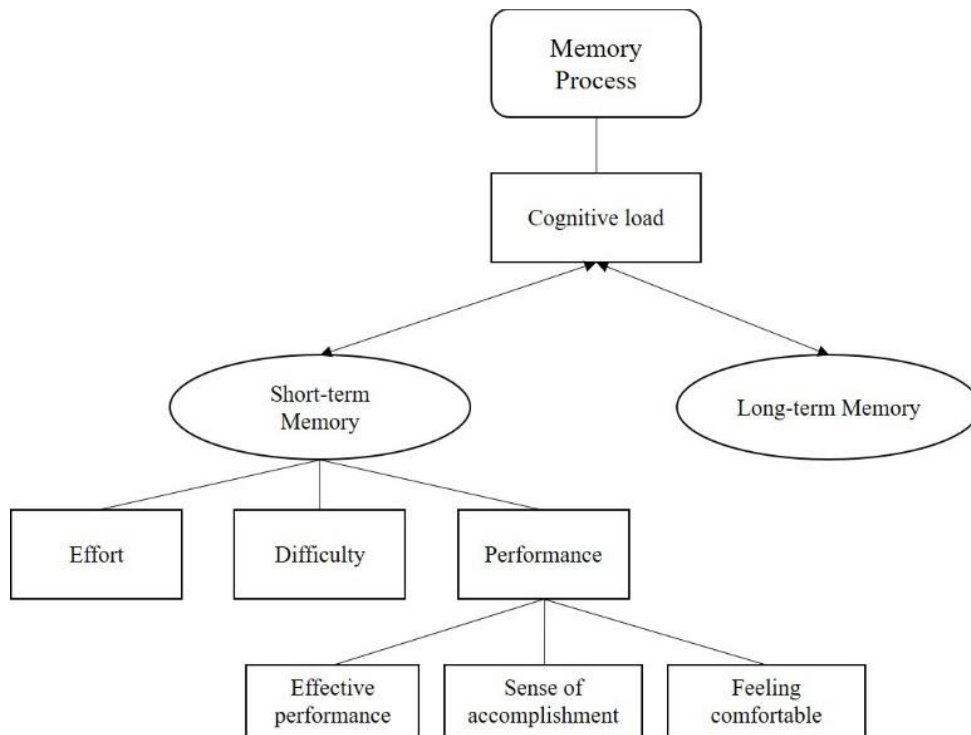
Figure 7.1 The memory process that affects cognitive load.

7.2.1 Short-term memory

Memory processes cause a load on the cognitive area of the brain. Most processes happen in the short-term memory, where cognitive load can take place. Our long-term memory is the storage area for old and new knowledge and experience (Shunk, 2012; Sweller et al., 2011; Wilson & Wilson, 2012).

This research measured the impact of gaming technology and an e-book on learners' cognitive load by measuring effort, difficulty and performance. Content analysis assisted in explaining the memory process during learning. The following table, table 7.1, reflects the cognitive load's evaluation and processing steps.

Table 7.1 Cognitive load: The evaluation steps and process

Sub-factor	Question	Gaming technology	E-book	Comparing gaming technology to the e-book
Effort	Q1: Requires low mental effort	Good satisfaction	Low satisfaction	Not significantly different
	Q2: Rate of mental effort	Low satisfaction	Low satisfaction	Not significantly different
	Total effort	Good satisfaction	Low satisfaction	Not significantly different
Difficulty	Q1: Ease of use	Excellent satisfaction	Excellent satisfaction	Not significantly different
	Q2: Difficulty faced during learning	Good satisfaction	Good satisfaction	Not significantly different
	Total amount of difficulty	Good satisfaction	Good satisfaction	Not significantly different
Performance	Q1: Supports effective performance	Excellent satisfaction	Excellent satisfaction	Not significantly different
	Q2: Gives a sense of accomplishment	Excellent satisfaction	Good satisfaction	Significantly different for gaming technology
	Q3: Feeling comfortable	Excellent satisfaction	Good satisfaction	Significantly different for gaming technology
	Total performance	Excellent satisfaction	Good satisfaction	Significantly different for gaming technology
Cognitive load		Good satisfaction	Good satisfaction	Significantly different for gaming technology

Sense memory transfers knowledge from a human's senses to the short term memory via interacting with a game's environment or an e-book. The short-term memory, when utilising a game or an e-book, processes knowledge that is obtained from the sense memory and retrieves learners' knowledge, background and experience in order to perform tasks which require time and effort.

7.2.1.1 Effort

Initially, cognitive load was measured via asking about the mental effort utilised by the participants during learning about research methodologies through the gaming technology. The effort was measured via two questions.

The first question asked whether learning through gaming technology required a low amount of mental effort. The results showed a minimum of 2, which was 'disagree', a maximum of 5, which was 'strongly agree' and the average was (M=3.13, SD=.915), as shown in Figure 7.2. Hence, gaming technology received a good satisfaction rating in terms of its effect on mental effort. This indicates that a low amount of mental effort was required when going through the game and learning about research methodology.

	Minimum	Maximum	Mean	Std. Deviation
Low Mental effort	2	5	3.13	.915
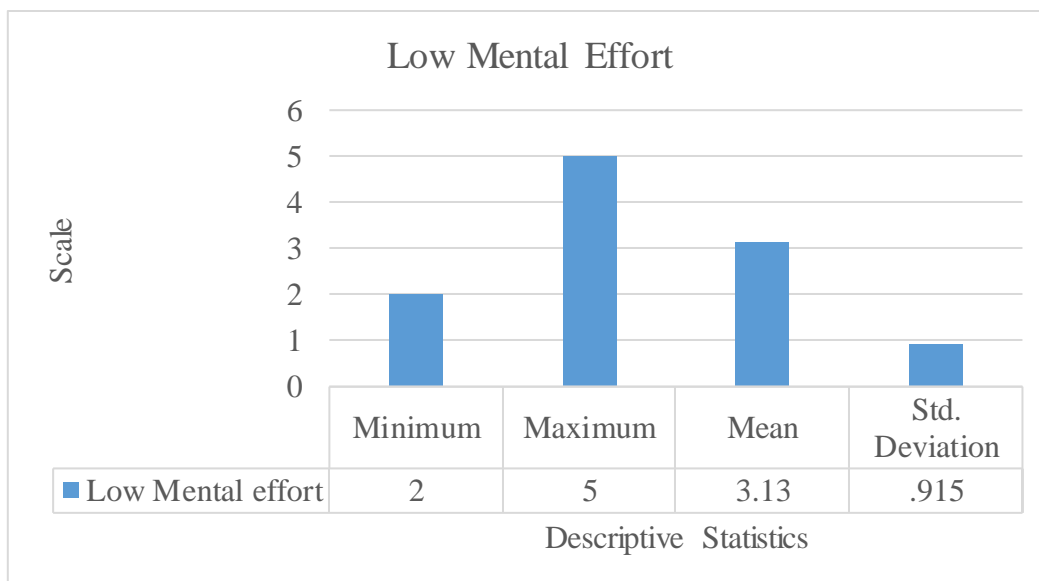
Figure 7.2 Results as to whether or not gaming technology requires a low amount of mental effort.

The second question was about rating the mental effort that participants felt was required during learning through gaming technology. The results showed a minimum of 2, which was 'high', a maximum of 5, which was 'very low' and the average was (M=2.87, SD=.834), as

shown in Figure 7.3. Thus, gaming technology received a low satisfaction rating in terms of the amount of mental effort required.
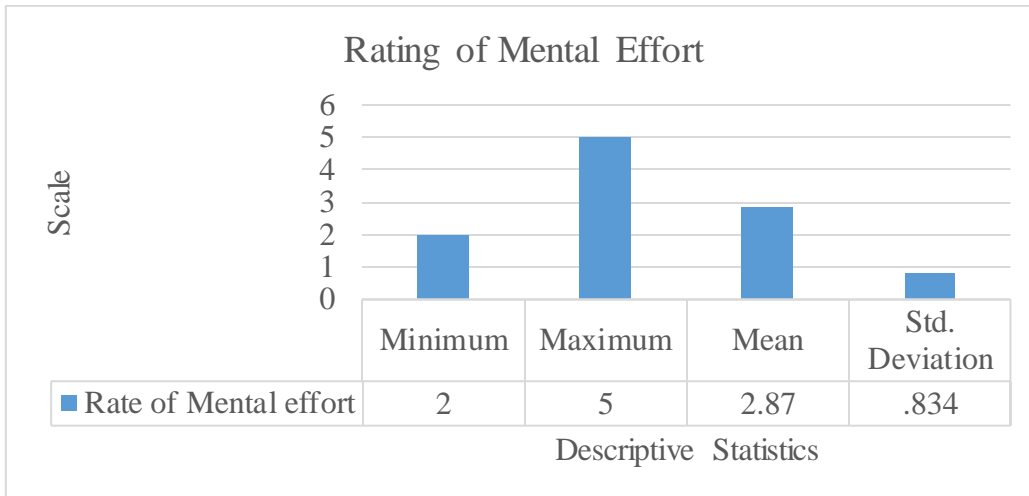
Figure 7.3 The results regarding the mental effort required during learning through gaming technology.

Finally, the responses to the two questions were combined to find gaming technology's impact on mental effort. The results showed a minimum of 2, a maximum of 5, and an average of (M=3.00, SD=.80178), as shown in Figure 7.4. Thus, gaming technology received a good satisfaction rating in terms of its impact on mental effort. Gaming technology helps reduce mental effort and eases the learning of difficult concepts such as research methodologies.
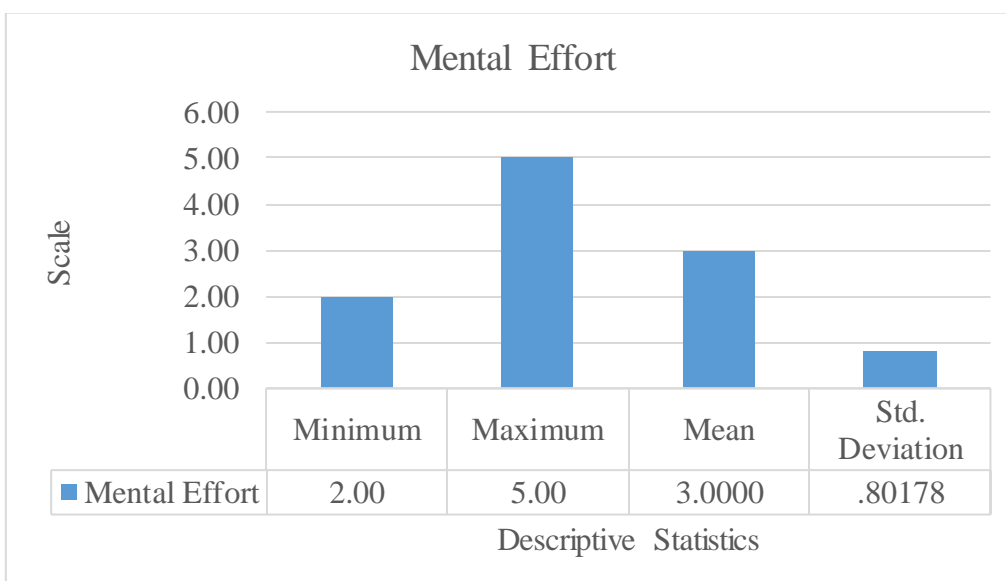
Figure 7.4 The impact of gaming technology on mental effort.

Gaming technology helped reduce mental effort because the concepts and definitions provided within this research were simple, clear, accurate and coherent, especially within the learning and playing modes which provided opportunities to test knowledge and obtain feedback on all the game's features.

The research also measured the e-book's impact on mental effort by asking the same two questions and using the same process. The first question focused on whether or not learning through e-books required a low amount of mental effort. The results showed a minimum of 1, which was 'strongly disagree', a maximum of 5, which was 'strongly agree' and the average was (M=2.67, SD=1.291), as shown in Figure 7.5. Hence, the e-book received a low satisfaction rating regarding mental effort which means that e-books require a high mental effort to perform tasks and gain understanding about research methodologies.

Low Mental Effort

	Minimum	Maximum	Mean	Std. Deviation
Low Mental effort	1	5	2.67	1.291

Descriptive Statistics
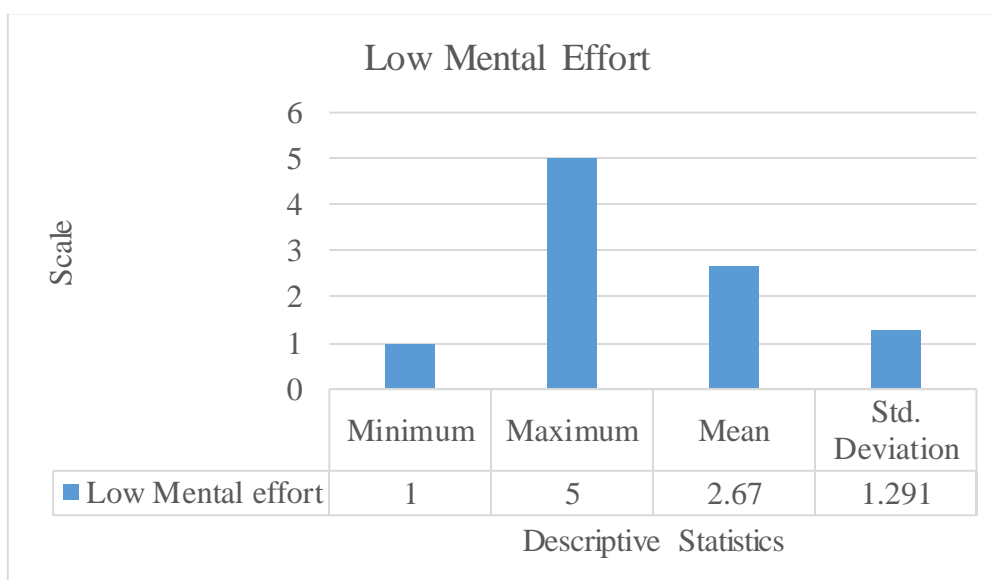
Figure 7.5 Results regarding whether or not e-books require a low amount of mental effort.

The second question concerned rating the mental effort required during learning through the e-book. The results showed a minimum of 1, which was 'very high', a maximum of 4, which was 'low' and the average was (M=2.60, SD=.737), as shown in Figure 7.6. Thus, e-books received a low satisfaction rating in terms of reducing mental effort.
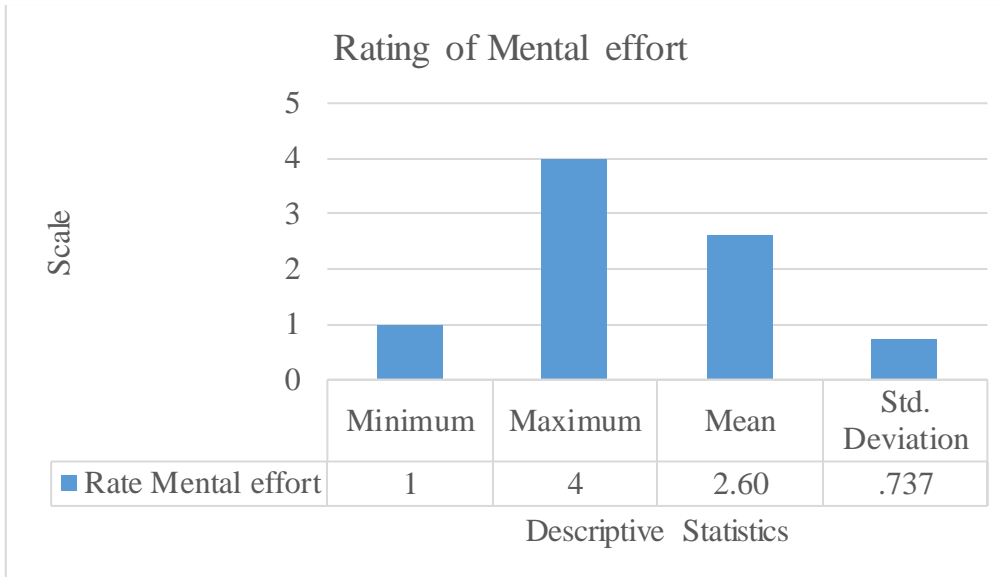
Figure 7.6 Mental effort expended during learning via the e-book.

Finally, the results from the two questions were combined to find the impact of the e-book on mental effort, resulting in a minimum of 1.5, a maximum of 4 and an average of (M=2.6333, SD=.76687), as shown in Figure 7.7. Thus, the e-book received a low satisfaction rating in terms of mental effort. It did not increase the ability to understand difficult concepts such as research methodologies.
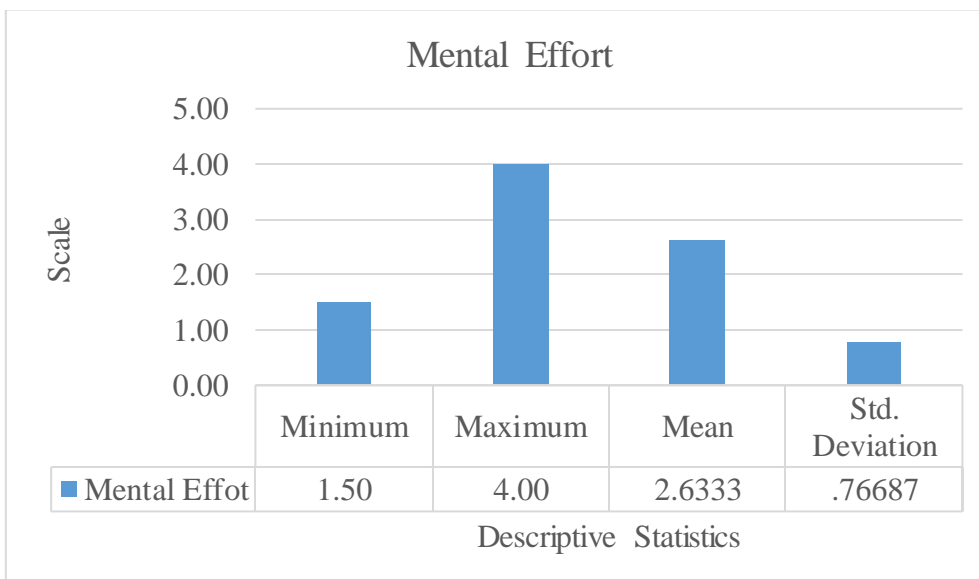
Figure 7.7 The impact of e-books on mental effort.

The first question explored whether learning through gaming technology and the e-book required a low amount of mental effort. A comparison in the responses was then made. An independent-samples t-test was conducted to compare the impact of gaming technology and the e-book on reducing mental effort and/or on requiring a low amount of mental effort. There was no significant difference in the score for gaming technology's (M=3.13, SD=.915) and the e-book's (M=2.67, SD=1.291) impacts: t (28)=1.42, p=.263, as shown in both Table 7.2 and Figure 7.8. These results suggest that gaming technology and the e-book had similar impacts in terms of reducing mental effort, with a slight advantage for gaming technology. Within the descriptive analysis, gaming technology was shown to have a good impact. However, the e-book had a low impact, and the difference was not significant; thus, both technologies can support each other.

Table 7.2 Independent-samples t-test results for causes of low mental effort

	Group	N	Mean	Std. Deviation	Std. Error Mean
Low Mental Effort	Gaming Technology	15	3.13	.915	.236
	E-book	15	2.67	1.291	.333

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Low Mental Effort	Equal Variances Assumed	2.549	.122	1.142	28	.263	.467	.409	-.370	1.304
	Equal Variances not Assumed			1.142	25.238	.264	.467	.409	-.375	1.308
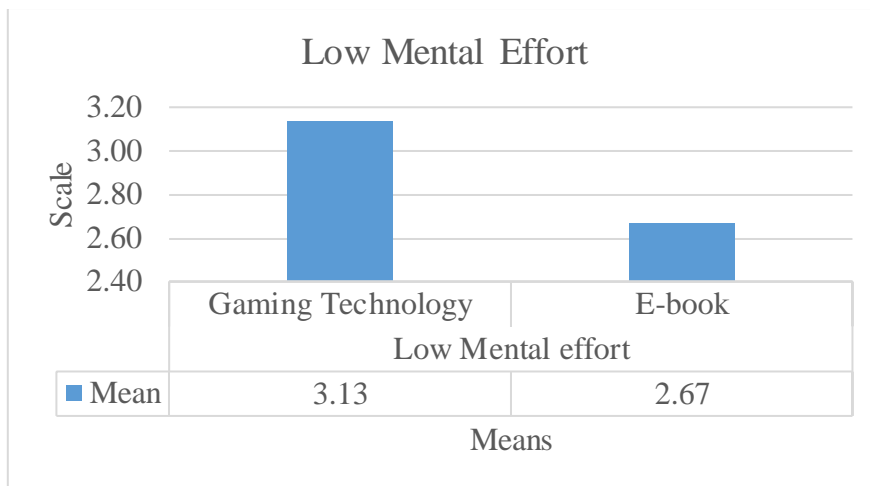
Figure 7.8 The independent-samples t-test results regarding low amount of mental effort

Next, an independent-samples t-test was conducted to compare the impact of gaming technology and the e-book regarding the amount of mental effort required (second question). There was no significant difference in the score for gaming technology's (M=2.87, SD=.834) and the e-book's (M=2.60, SD=.737) impacts: t (28)=.928, p=.361, as shown in both Table 7.3 and Figure 7.9. These results suggest that gaming technology and the e-book had similar impacts on reducing the amount of mental effort required, with a slight advantage for gaming technology.

Table 7.3 The independent-samples t-test results for the amount of mental effort required

	Group	N	Mean	Std. Deviation	Std. Error Mean
Rate of Mental Effort	Gaming Technology	15	2.87	.834	.215
	E-book	15	2.60	.737	.190

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Rate of Mental Effort	Equal Variances Assumed	.040	.843	.928	28	.361	.267	.287	-.322	.855
	Equal Variances not Assumed			.928	27.582	.361	.267	.287	-.322	.856

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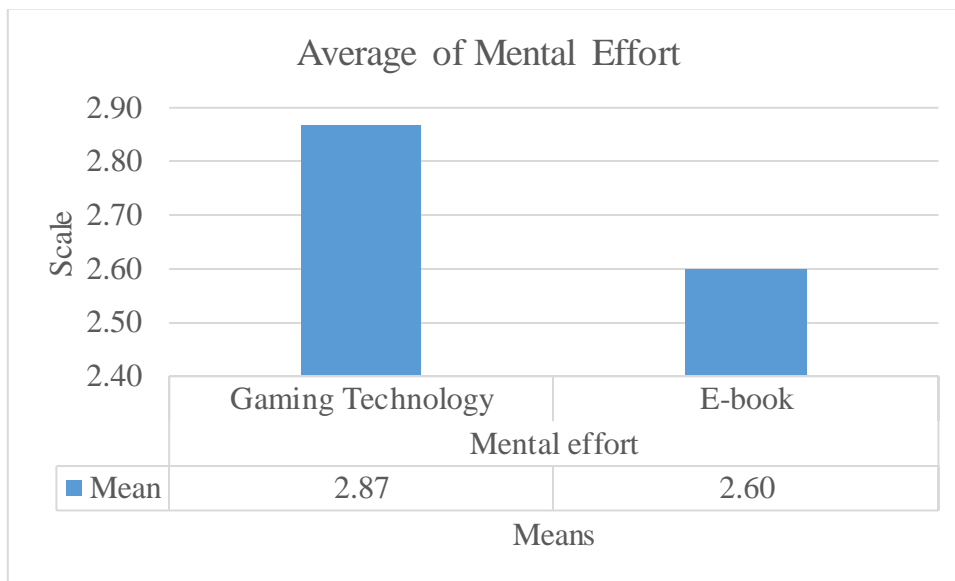
Figure 7.9 The independent-samples t-test results for the average of mental effort required.

Finally, an independent-samples t-test was conducted to compare the impact of gaming technology and the e-book on total mental effort. There was no significant difference in the score for gaming technology's (M=3.00, SD=.80178) and the e-book's (M=2.6333, SD=1.291) impacts: t (28) =1.28, p=.211, as shown in both Table 7.4 and Figure 7.10. These results suggest that gaming technology and the e-book had a similar impact on mental effort, with a slight advantage for gaming technology because, within the descriptive analysis, it had a good impact. However, the e-book had a low impact, and the difference was not significant. Both technologies can support each other in reducing mental effort and encouraging understanding.

Table 7.4 The results from an independent-samples t-test regarding mental effort

	Group	N	Mean	Std. Deviation	Std. Error Mean
Mental Effort	Gaming Technology	15	3.0000	.80178	.20702
	E-book	15	2.6333	.76687	.19801

		Levene's Test for Equality of Variances		T-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Mental Effort	Equal Variances Assumed	.015	.903	1.280	28	.211	.36667	.28647	-.22013	.95347
	Equal Variances not Assumed			1.280	27.945	.211	.36667	.28647	-.22019	.95352
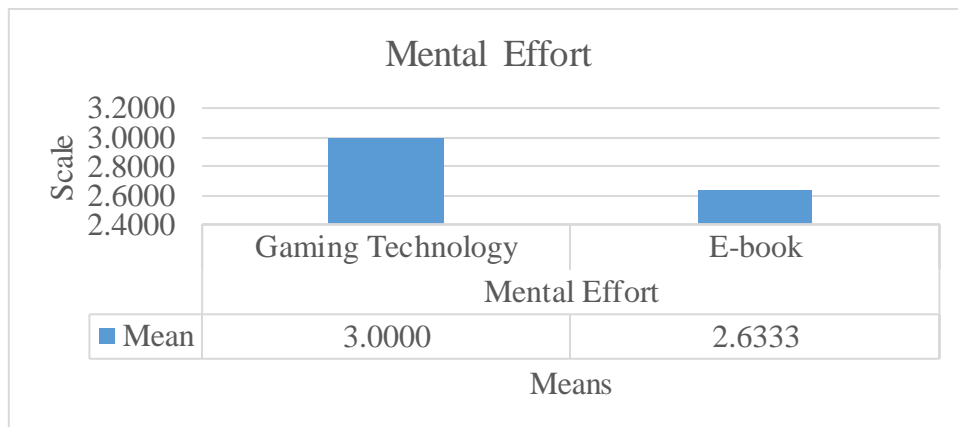
Figure 7.10 Results from the independent-samples t-test regarding mental effort.

7.2.1.2 Difficulty

Difficulty was measured via two questions. The first question asked whether or not gaming technology made it easy to understand difficult concepts such as research methodologies. The results included a minimum of 2, which was 'disagree', and a maximum of 5, which was 'strongly agree' with an average of (M=4.27, SD=.799), as shown in Figure 7.11. Thus, gaming technology received an excellent satisfaction rating in terms of making the learning of complicated concepts easy to understand and in reducing difficulties in comprehension.
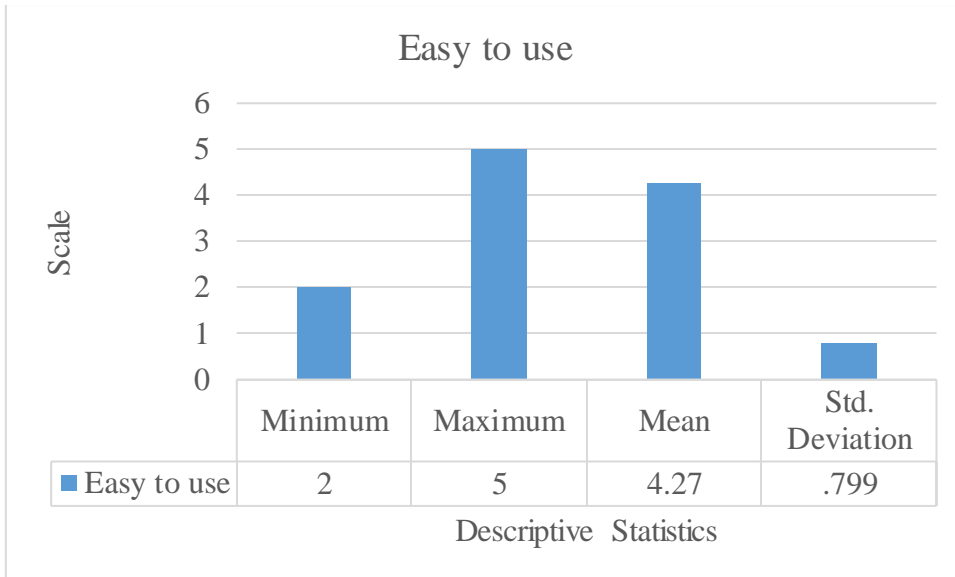
Figure 7.11 Results as to whether or not gaming technology eases the understanding of difficult concepts.

The second question concerned rating the difficulties faced during learning. The results showed a minimum of 2, which was 'high', a maximum of 5 which, was 'very low' and an average of (M=3.60, SD=.910), as shown in Figure 7.12. Thus, gaming technology received a good satisfaction rating in terms of reducing the difficulty of learning complicated concepts such as research methodologies.
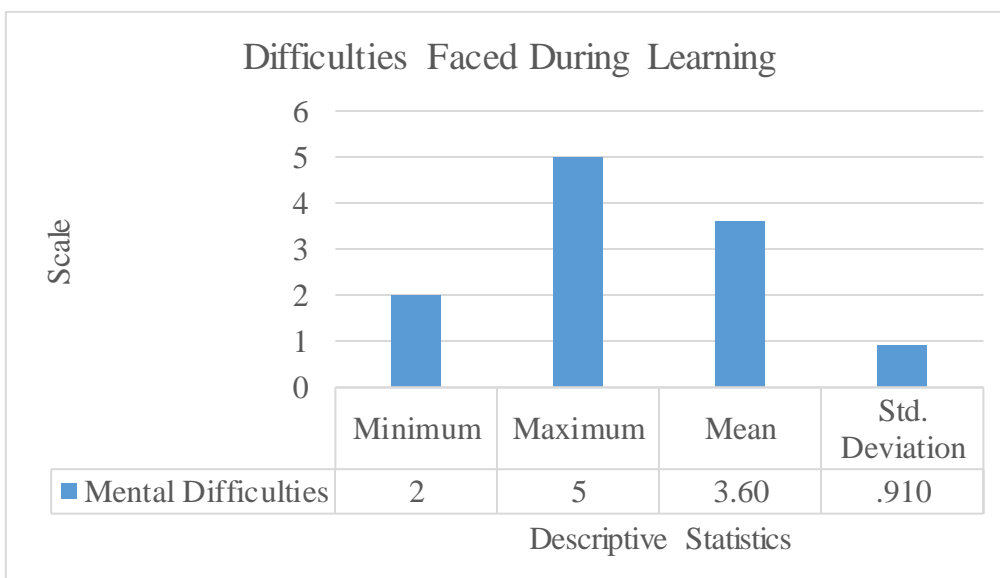
Figure 7.12 Statistics for participants' rating of the difficulties faced while learning via gaming technology.

Finally, the responses to the two questions were merged in order to measure the impact of gaming technology on reducing learning difficulties. The results showed a minimum of 2.5, a maximum of 5 and an average of (M=3.9333, SD=.72866), as shown in Figure 7.13. Thus, gaming technology received a good satisfaction rating in terms of reducing difficulties and making learning easier and more interesting.
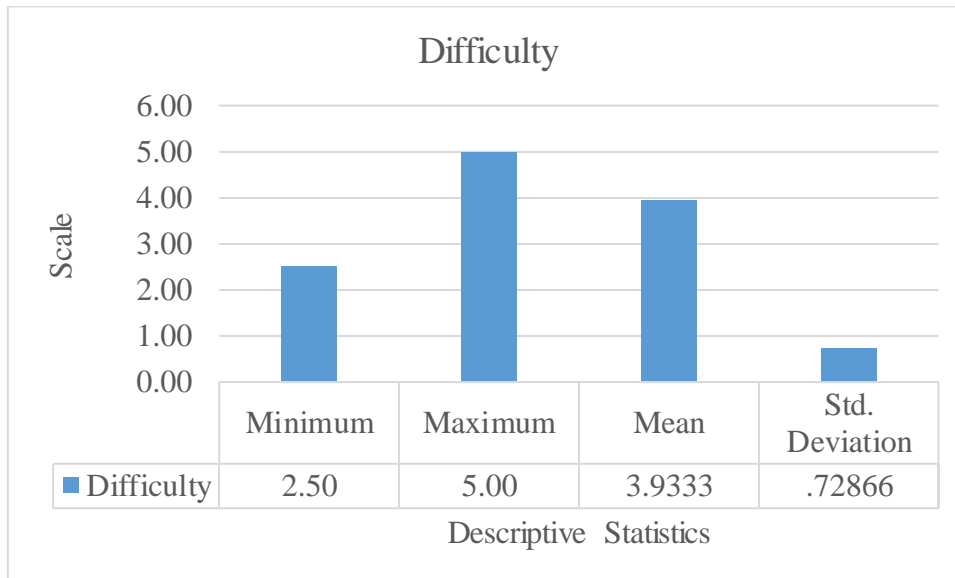
Figure 7.13 Statistics as to whether or not gaming technology reduces learning difficulties.

The researcher used the same questions to measure the e-book regarding difficulty. The first question focused on whether or not the e-book made it easier to understand difficult concepts such as research methodologies. The results showed a minimum of 3, which was 'neutral', a maximum of 5, which was 'strongly agree' and the average was (M=4.07, SD=.704), as shown in Figure 7.14. Hence, the e-book received an excellent satisfaction rating in terms of easing the learning of complicated concepts and reducing possible learning difficulties.

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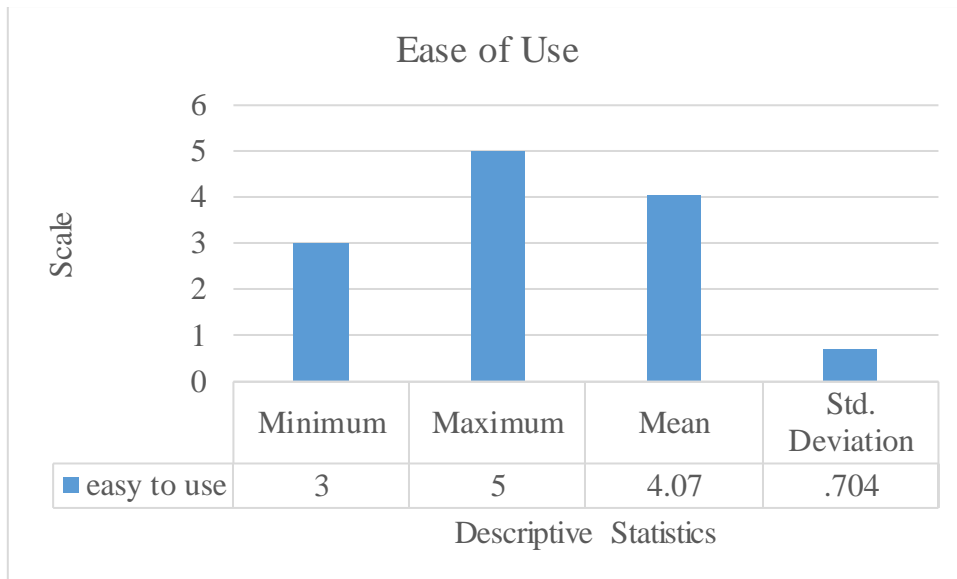
Figure 7.14 Results as to whether or not e-books made it easier to understand concepts.

The second question concerned rating how the e-book reduced difficulties faced during learning. The results showed a minimum of 2, which was 'high', a maximum of 5, which was 'very low' and the average was (M=3.47, SD=.834), as shown in Figure 7.15. Thus, the e-book received a good satisfaction rating in terms of reducing learning difficulties and making difficult concepts, such as research methodologies, easier to understand.
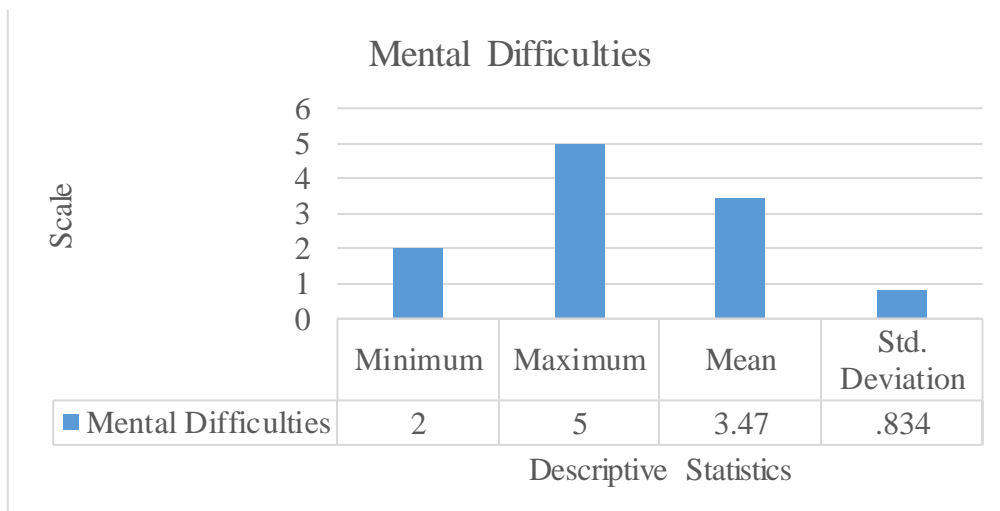
Figure 7.15 The impact of e-books on reducing learning difficulties.

Finally, the results from the two questions were merged to measure the impact of the e-book on reducing learning difficulties. The results showed a minimum of 2.50, a maximum of

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4.50 and an average of (M=3.7667, SD=.62297), as shown in Figure 7.16. Thus, e-books received a good satisfaction rating in terms of reducing difficulty and making learning easier and more interesting.
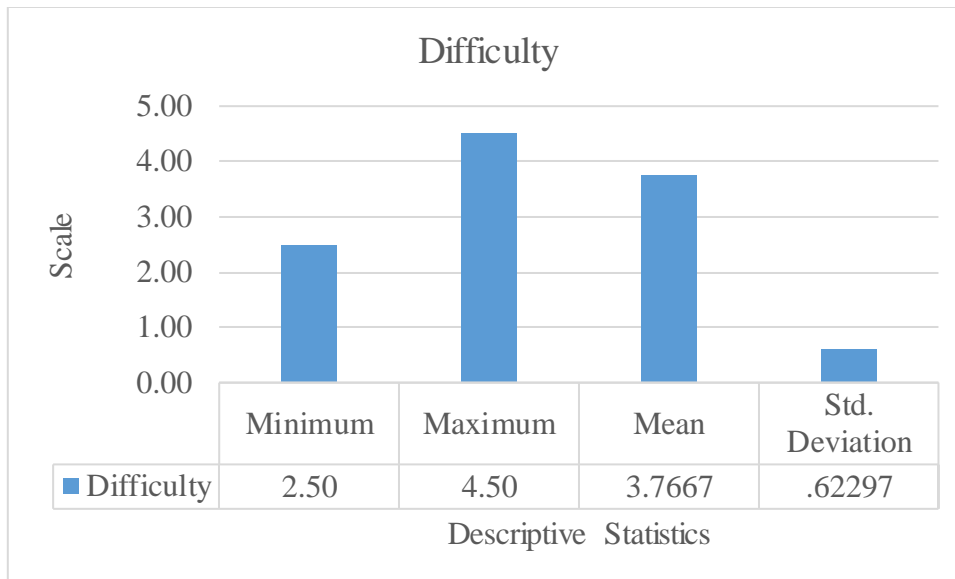
Figure 7.16 The impact of e-books on reducing learning difficulties.

An independent-samples t-test was conducted to compare the impact of gaming technology and e-books in terms of difficulty (that is, by making learning easier through the use of these technologies). There was no significant difference in the score for gaming technology's (M=4.27, SD=.799) and the e-book's (M=4.07, SD=.704) impacts: t (28) =.728, p=.473), as shown in both Table 7.5 and Figure 7.17. These results suggest that gaming technology and the e-book had a similar impact in terms of difficulty and in making complicated information easier to understand, with a slight advantage for gaming technology.

Table 7.5 The independent-samples t-test results concerning the ease of use of gaming technology and the e-book

	Group	N	Mean	Std. Deviation	Std. Error Mean
Ease of Use	Gaming Technology	15	4.27	.799	.206
	E-book	15	4.07	.704	.182

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ease of Use	Equal Variances Assumed	.237	.630	.728	28	.473	.200	.275	-.363	.763
	Equal Variances not Assumed			.728	27.562	.473	.200	.275	-.363	.763
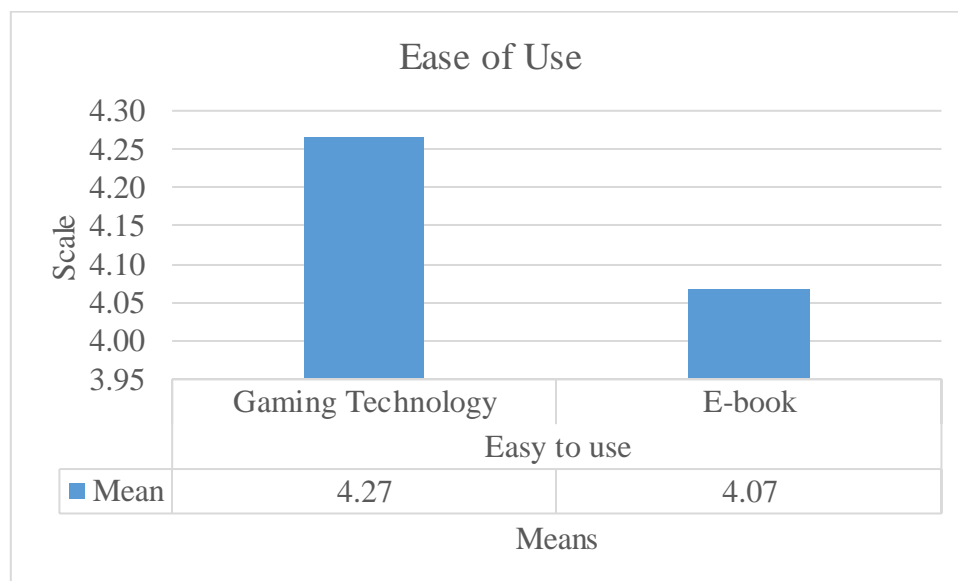
Figure 7.17 The independent-samples t-test results concerning ease of use of both gaming technology and the e-book.

An independent-samples t-test was conducted to compare the impact of gaming technology and the e-book in terms of rating the difficulties faced during learning (second question). There was no significant difference in the score for gaming technology's (M=3.60, SD=.910) and the e-book's (M=3.47, SD=.834) impacts: t (28)=.418, p=.679, as shown in both Table

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7.6 and Figure 7.18. These results suggest that gaming technology and the e-book had a similar impact in that that they both helped reduce the amount of difficulties faced during learning.

Table 7.6 The independent-samples t-test results regarding rating the difficulties faced during learning.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Rate of Difficulties	Gaming Technology	15	3.60	.910	.235
	E-book	15	3.47	.834	.215

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Rate of Difficulties	Equal Variances Assumed	.214	.647	.418	28	.679	.133	.319	-.520	.786
	Equal Variances not Assumed			.418	27.787	.679	.133	.319	-.520	.786
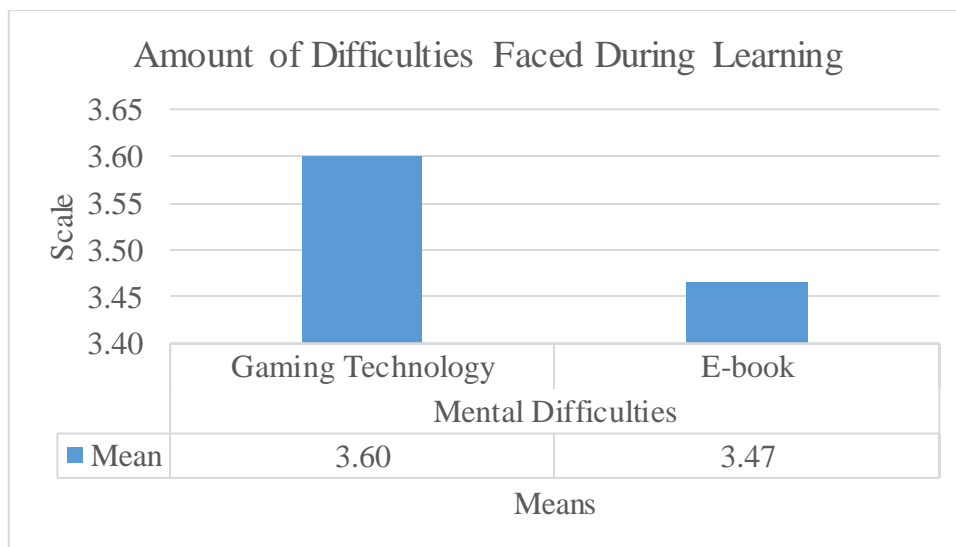
Figure 7.18 The independent-samples t-test results in terms of rating the difficulties faced during learning.

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Next, an independent-samples t-test was conducted to compare the impact of gaming technology and the e-book in terms of overall mental effort There was no significant difference in the score for gaming technology's (M=3.9333, SD=.72866) and the e-book's (M=3.7667, SD=.62297) impacts: t (28)=.673, p=.506, as shown in both Table 7.7 and Figure 7.19. These results suggest that gaming technology and e-books had a similar impact on the amount of difficulty faced during learning. Therefore, both technologies can reduce difficulties during learning and, ideally, both should be utilised for the most positive influence on cognitive load.

Table 7.7 The independent-samples t-test results regarding the amount of difficulty faced during learning.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Difficulty	Gaming Technology	15	3.9333	.72866	.18814
	E-book	15	3.7667	.62297	.16085

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Difficulty	Equal Variances Assumed	.046	.831	.673	28	.506	.16667	.24753	-.34037	.67370
	Equal Variances not Assumed			.673	27.339	.506	.16667	.24753	-.34092	.67426
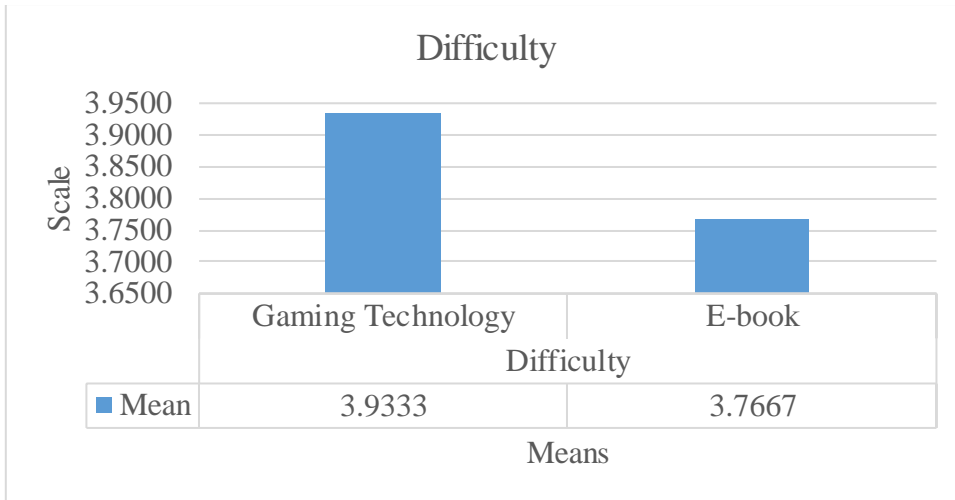
Figure 7.19 The independent-samples t-test results regarding the amount of difficulty faced during learning.

7.2.1.3 Performance

Performance was measured through three questions. The first question concerned whether or not gaming technology supports effective performance. The results showed a minimum of 3, which was 'neutral', a maximum of 5, which was 'strongly agree' and an average of (M=4.27, SD=.709), as shown in Figure 7.20. Hence, gaming technology received an excellent satisfaction rating in terms of supporting effective performance in learning about research methodology and achieving tasks.
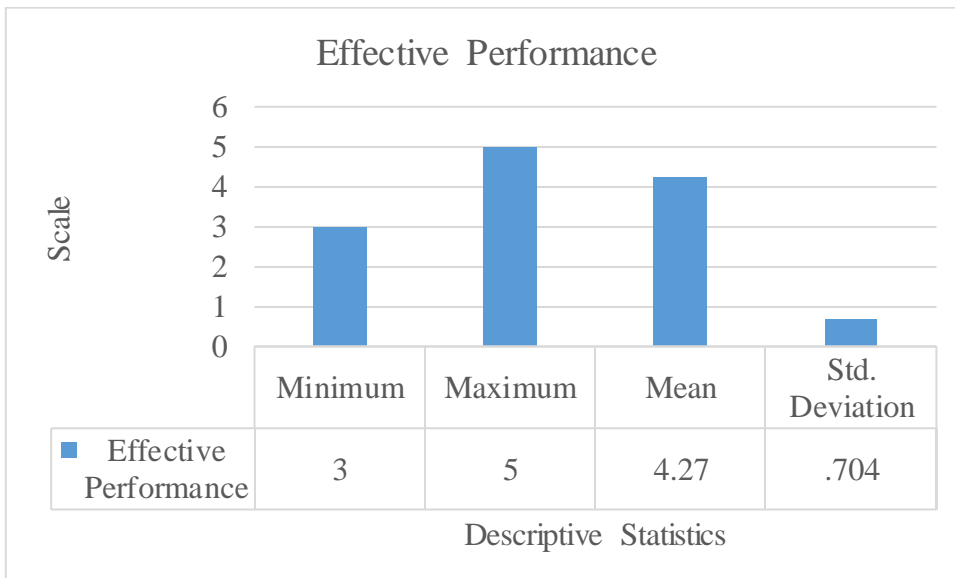
Figure 7.20 Statistics showing whether or not gaming technology supports effective performance.

The second question concerned whether or not gaming technology gave the participants a sense of accomplishment in finishing tasks The results showed a minimum of 3, which was 'neutral', a maximum of 5, which was 'strongly agree' and an average of (M=4.33, SD=.617), as shown in Figure 7.21. Thus, gaming technology received an excellent satisfaction rating in terms of supporting participants' sense of having accomplished learning via the different layers and achieving the task.

Sense of Accomplishment

	Minimum	Maximum	Mean	Std. Deviation
sense	3	5	4.33	.617

Descriptive Statistics
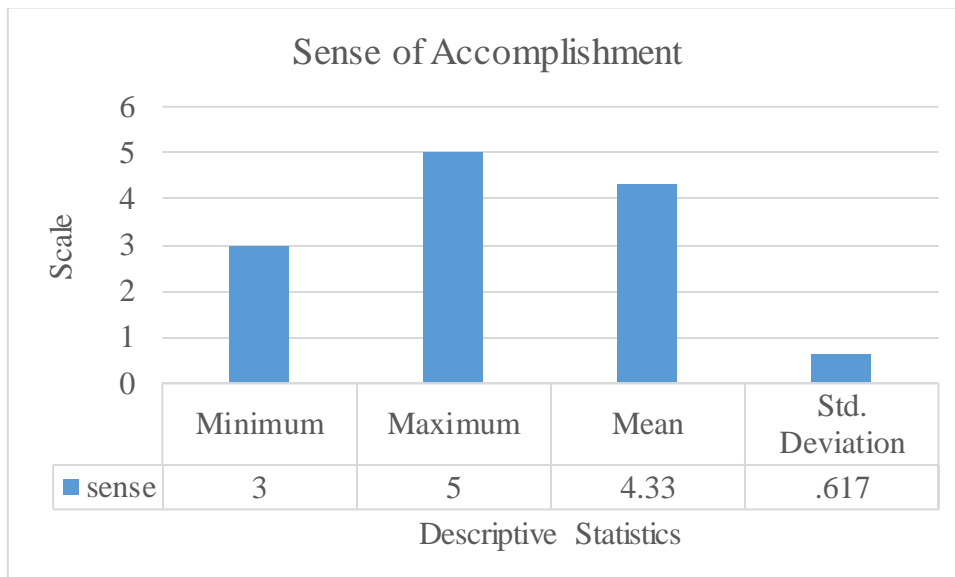
Figure 7.21 Ratings as to whether or not gaming technology participants felt a sense of accomplishment.

The third question concerned whether or not gaming technology made participants feel comfortable after going through the game's challenges and performing tasks. The results showed a minimum of 3, which was 'neutral', a maximum of 5, which was 'strongly agree' and the average was (M=4.27, SD=.704), as shown in Figure 7.22. Thus, gaming technology received an excellent satisfaction rating in terms of making the participants feel comfortable and more intelligent after overcoming the challenges while learning in the game and achieving tasks.
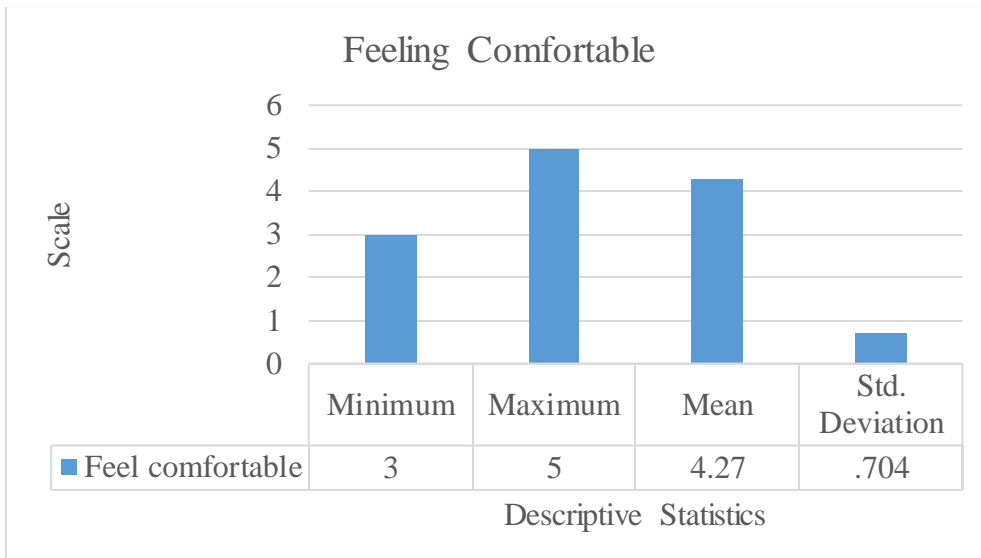
Figure 7.22 Ratings as to whether or not gaming technology made participants feel comfortable after performing tasks.

The responses to all three questions were merged to measure whether or not gaming technology can support performance. The results showed a minimum of 3.67, a maximum of 5 and the average was (M=4.2889, SD=.434), as shown in Figure 7.23. Gaming technology received an excellent satisfaction rating in terms of learning performance; thus, it supports learning performance.
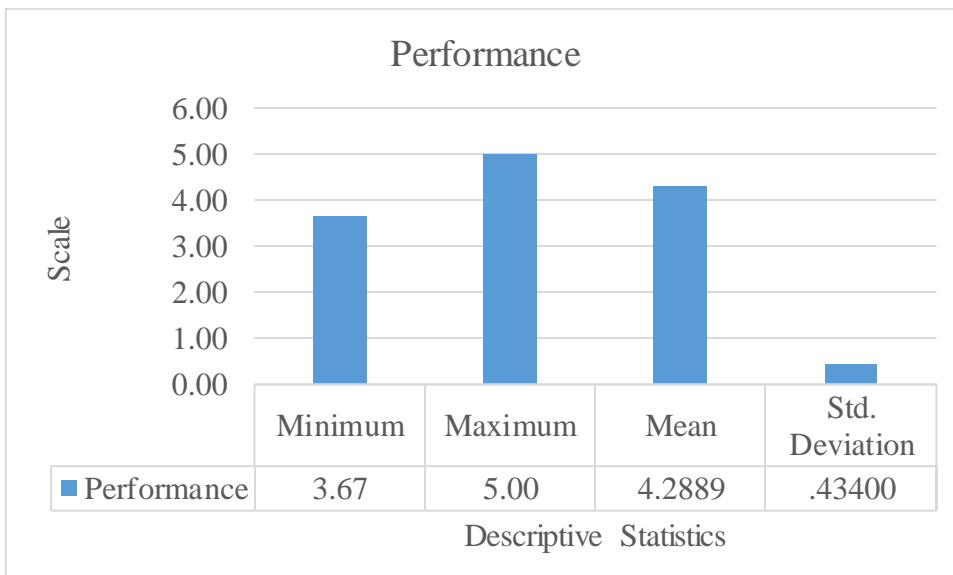
Figure 7.23 Gaming technology's impact on performance.

The researcher used the same three questions to measure performance for the e-book group. The first question concerned whether or not the e-book was supportive of effective performance. The results showed a minimum of 2, which was 'disagree', a maximum of 5 which was 'strongly agree' and the average was (M=4.07, SD=.799), as shown in Figure 7.24. Hence, the e-book received an excellent satisfaction rating in terms of supporting effective performance in learning about research methodologies and achieving tasks.

Effective Performance

	Minimum	Maximum	Mean	Std. Deviation
■ Effective Performance	2	5	4.07	.799

Descriptive Statistics

Figure 7.24 E-books' impact on supporting effective performance.

The second question concerned whether or not the e-book gave participants a sense of accomplishing the task. The results showed a minimum of 2, which was 'disagree', a maximum of 5, which was 'strongly agree' and the average was (M=3.67, SD=.816), as shown in Figure 7.25. Thus, gaming technology received a good satisfaction rating in terms of supporting participants' sense of having accomplished learning via the different layers and in achieving tasks.
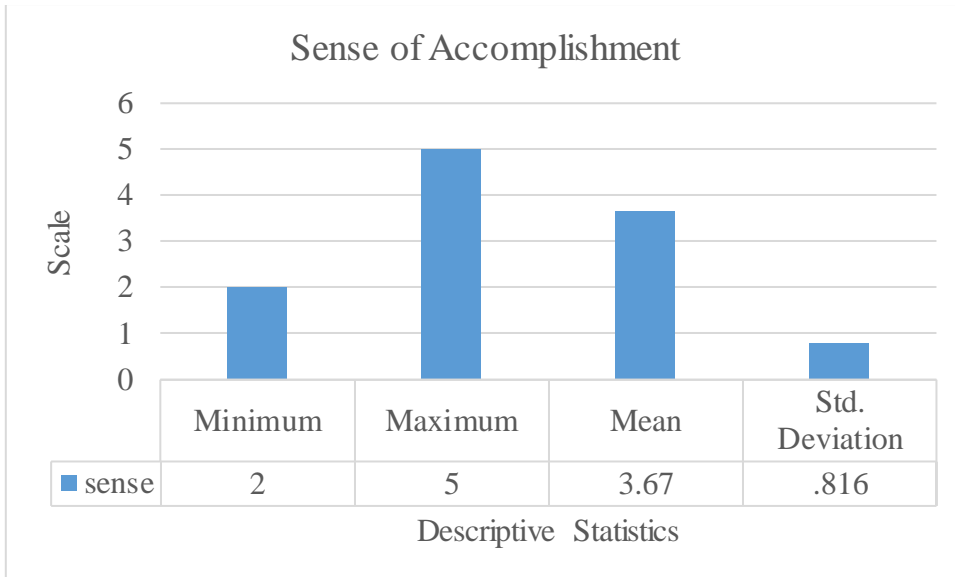
Figure 7.25 The impact of e-books on the participants' sense of accomplishment concerning task performance.

The third question asked whether or not the e-book made participants feel comfortable after going through the game's challenges and tasks. The results showed a minimum of 1, which was 'strongly disagree', a maximum of 5, which was 'strongly agree' and the average was (M=3.53, SD=.915), as shown in Figure 7.26. Thus, the e-book received a good satisfaction rating in terms of supporting the participants in feeling comfortable after overcoming the challenges to learning and achieving tasks.
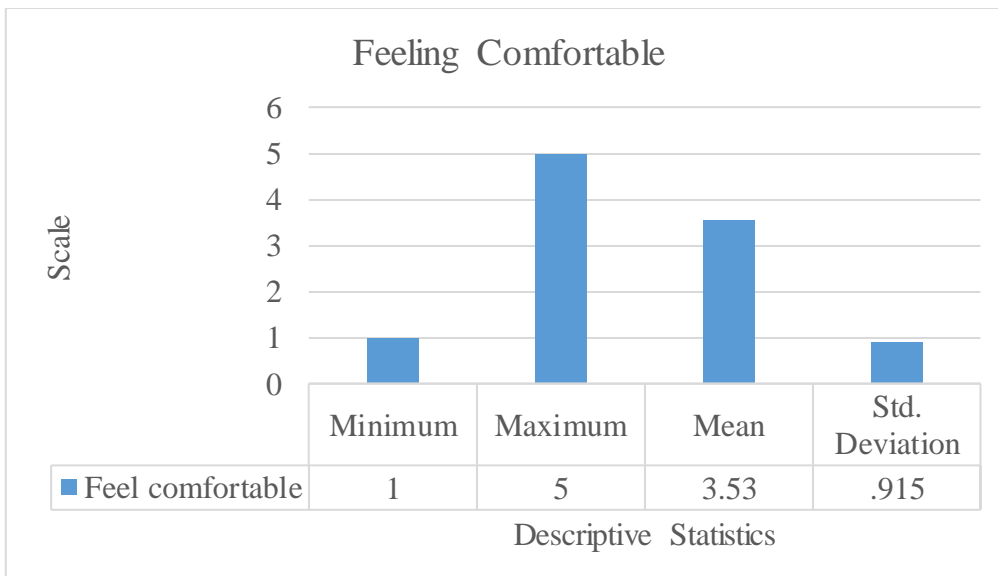
Figure 7.26 The e-book's impact on participants' comfort level after performing tasks.

The responses to all three questions were merged to measure whether or not e-books support performance. The results showed a minimum of 2.33, a maximum of 4.67 and the average was (M=3.7556, SD=.55587), as shown in Figure 7.27. As a result, e-books received a good satisfaction rating in terms of learning performance which suggests that e-books support learning performance and improve performance in the learning process.
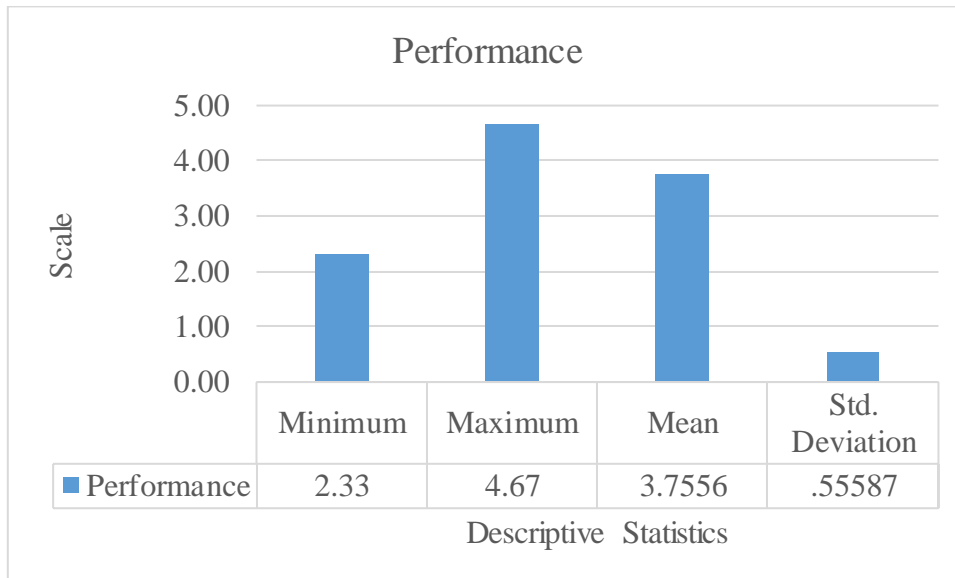
Figure 7.27 E-books' impact on performance.

An independent-samples t-test was conducted to compare the impact of gaming technology and of e-books in terms of effective performance for the first question (gaming technologies/e-books support of the effective performance of tasks). There was no significant difference in the score for gaming technology's (M=4.27, SD=.704) and the e-book's (M=4.07, SD=.799) impacts: t (28)=.728, p=.473, as shown in both Table 7.8 and Figure 7.28. These results suggest that gaming technology and the e-book had a similar impact in terms of effective performance. Both technologies can support effective performance in learning and can help in the understanding of concepts.

Table 7.8 The independent-samples t-test results for effective performance

	Group	N	Mean	Std. Deviation	Std. Error Mean
Effective Performance	Gaming Technology	15	4.27	.704	.182
	E-book	15	4.07	.799	.206

		Levene's Test for Equality of Variances		T-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference		Lower	Upper
Effective Performance	Equal Variances Assumed	.237	.630	.728	28	.473	.200	.275		-.363	.763
	Equal Variances not Assumed			.728	27.562	.473	.200	.275		-.363	.763
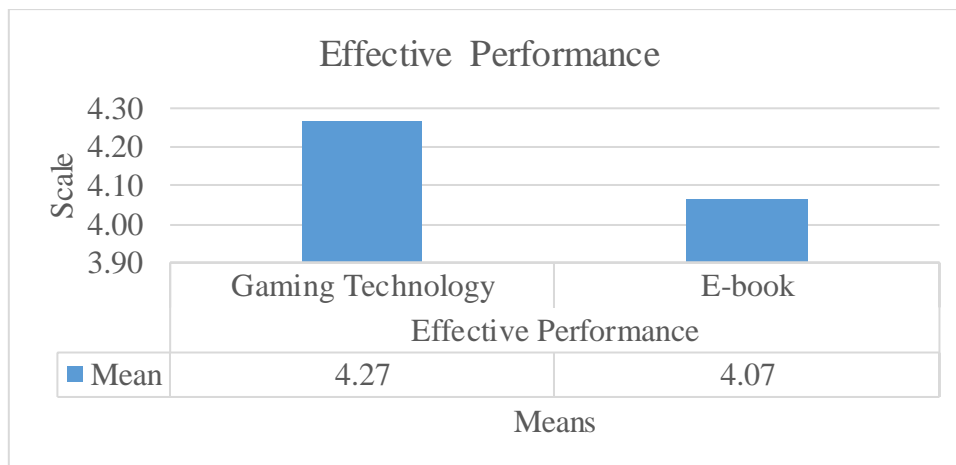
Figure 7.28 The independent-samples t-test results for effective performance.

An independent-samples t-test was conducted to compare the impacts of gaming technology and the e-book on the participants' belief that the process and the learning steps made sense and assisted in rationalising their steps while performing tasks (second question). There was a significant difference in the score for gaming technology's (M= 4.33, SD=.617) and the e-book's (M=3.67, SD=.816) impacts: t (28)=2.523, p=.018, as shown both in Table 7.9 and Figure 7.29. These results suggest that gaming technology was better than the e-book in terms of making sense of the steps that participants used to perform tasks and helping them in both rationalizing the steps and performing tasks.

Table 7.9 The independent-samples t-test results for making sense of the steps to perform tasks.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Making Sense	Gaming Technology	15	4.33	.617	.159
	E-book	15	3.67	.816	.211

		Levene's Test for Equality of Variances		T-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Making Sense	Equal Variances Assumed	.361	.553	2.523	28	.018	.667	.264	.125	1.208
	Equal Variances not Assumed			2.523	26.062	.018	.667	.264	.124	1.210
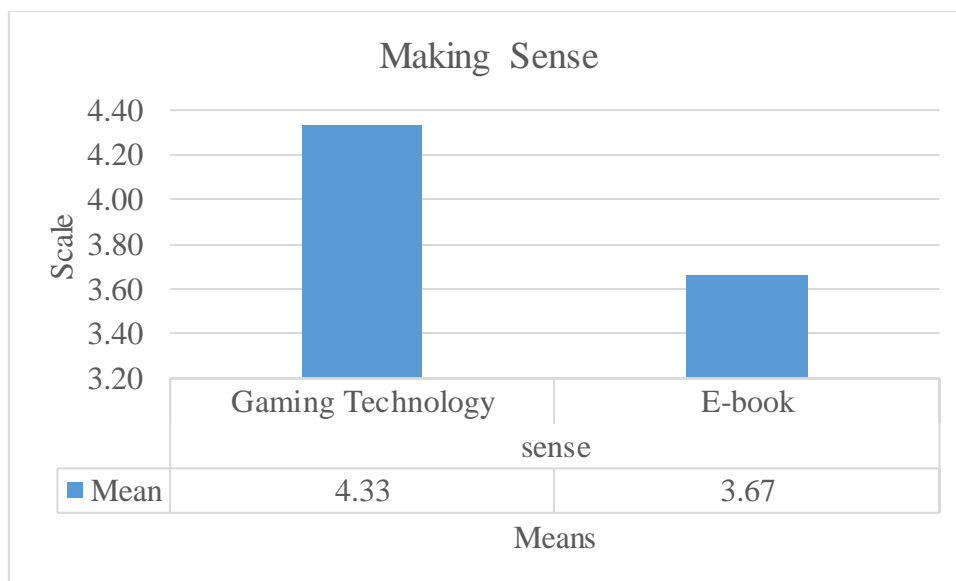
Figure 7.29 The independent-samples t-test results for making sense of the steps to perform tasks.

An independent-samples t-test was conducted to compare the impact of gaming technology and the e-book on learner emotion in terms of whether or not the participants felt comfortable after achieving tasks (third question). There was a significant difference in the score for gaming technology's (M=4.27, SD=.704) and the e-book's (M=3.53, SD=.915) impacts: t

(28)=2.46, p=.020, as shown both in Table 7.10 and Figure 7.30. These results suggest that gaming technology was better than the e-book in making participants feel comfortable after achieving/finishing the tasks because it provided feedback and a score that helped improve feelings of comfort.

Table 7.10 The independent-samples t-test results for feeling comfortable after achieving tasks.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Feeling Comfortable	Gaming Technology	15	4.27	.704	.182
	E-book	15	3.53	.915	.236

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Feeling Comfortable	Equal Variances Assumed	.380	.543	2.460	28	.020	.733	.298	.123	1.344
	Equal Variances not Assumed			2.460	26.263	.021	.733	.298	.121	1.346
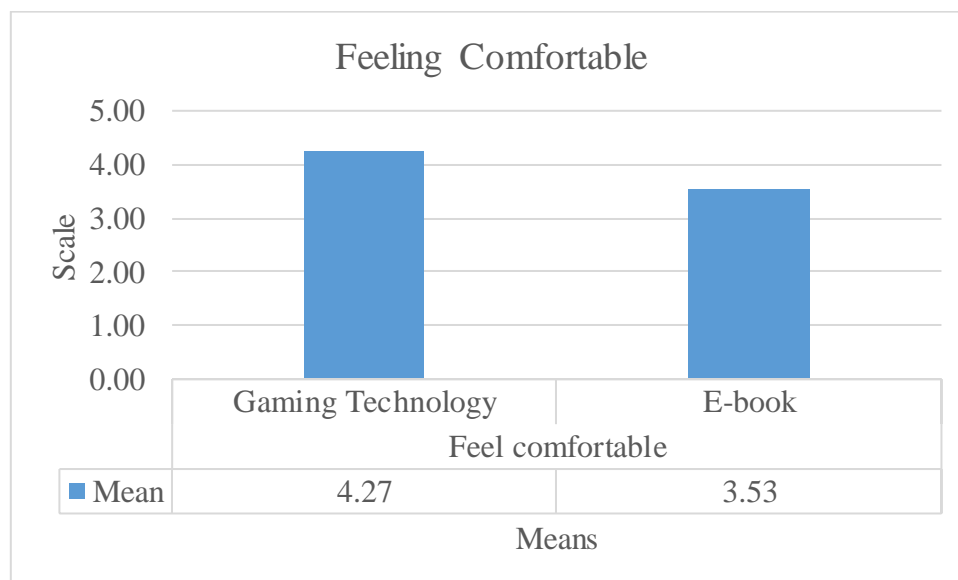
Figure 7.30 The independent-samples t-test results for feeling comfortable after achieving tasks.

Finally, an independent-samples t-test was conducted to compare the impact of gaming technology and the e-book in relation to performance overall. There was a significant difference in the score for gaming technology's (M=4.2889, SD=.434) and the e-book's (M=3.7556, SD=.55587) impacts: t (28)=2.929, p=.007, as shown in both Table 7.11 and Figure 7.31. These results suggest that gaming technology not only supports performance more than e-books but has an excellent influence on academic performance.

Table 7.11 The independent-samples t-test results for supporting performance

	Group	N	Mean	Std. Deviation	Std. Error Mean
Performance	Gaming Technology	15	4.2889	.43400	.11206
	E-book	15	3.7556	.55587	.14353

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Performance	Equal Variances Assumed	.184	.671	2.929	28	.007	.53333	.18209	.16034	.90633
	Equal Variances not Assumed			2.929	26.444	.007	.53333	.18209	.15935	.90732
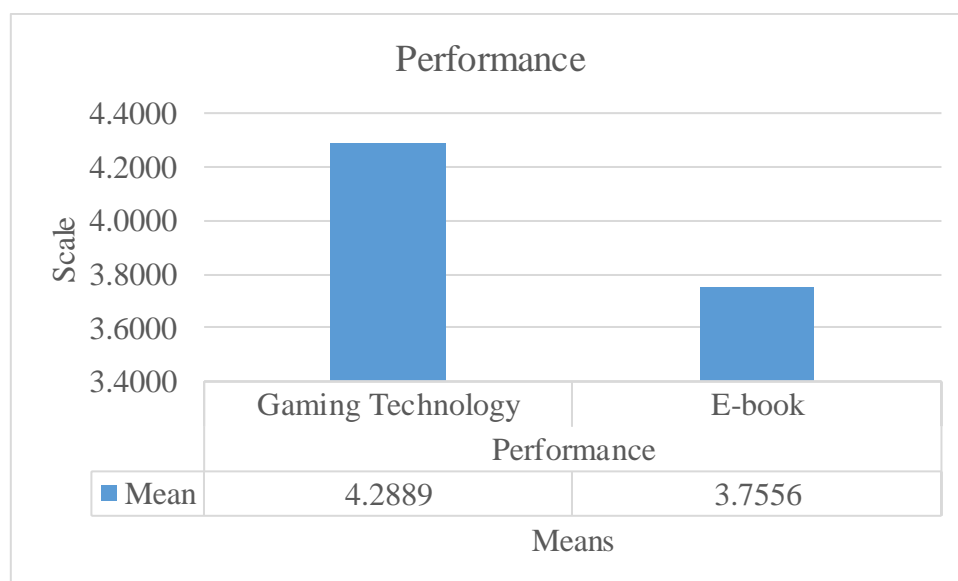
Figure 7.31 The independent-samples t-test results for supporting performance.

7.2.1.4 Cognitive load

Finally, responses to the cognitive load sub-factors were combined to measure the cognitive load within the gaming technology group. The results showed a minimum of 3.14, a maximum of 4.86 and an average of (M=3.1819, SD=.46281), as shown in Figure 7.32. Therefore, gaming technology received a good satisfaction rating in terms of cognitive load. It reduced cognitive load which assisted the participants in acquiring knowledge effectively and, consequently, in gaining a good understanding of research methodologies.
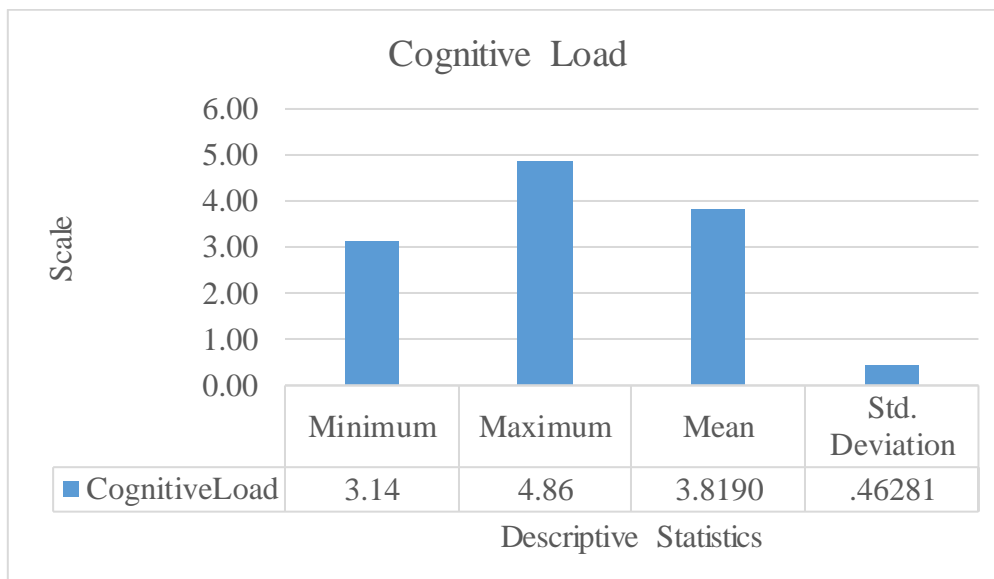
Figure 7.32 The impact of gaming technology on cognitive load.

Cognitive load sub-factors were also combined to measure cognitive load for the e-book group. The results showed a minimum of 2.86, a maximum of 4.29 and an average of (M=3.4381, SD=.35598), as shown in Figure 7.33. As a result, the e-book received a good satisfaction rating in terms of cognitive load. It reduced cognitive load which assisted participants in acquiring knowledge effectively and, subsequently, in gaining a good understanding of research methodologies.

	Minimum	Maximum	Mean	Std. Deviation
■ CognitiveLoad	2.86	4.29	3.4381	.35598

Descriptive Statistics
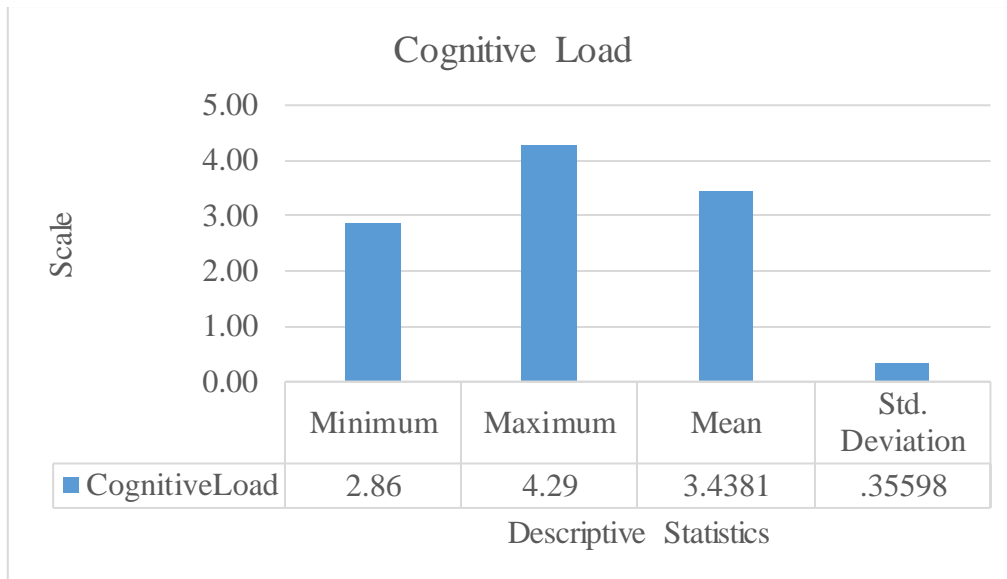
Figure 7.33 The impact of e-books on cognitive load.

Additionally, cognitive load was measured based on all the above questions and results. An independent-samples t-test was conducted to compare the impact of gaming technology and the e-book on the participants' cognitive load. There was a significant difference in the scores for gaming technology's (M=3.8190, SD=.46281) and the e-book's (M=3.4381, SD=.35598) impacts: t (28)=2.527, p=.017, as shown in both Table 7.12 and Figure 7.34. These results suggest that gaming technology has a more positive impact on participants' cognitive load than the e-book. Therefore, gaming technology reduces cognitive load and makes learning easier than e-books.

Table 7.12 The independent-samples t-test results for measuring cognitive load

	Group	N	Mean	Std. Deviation	Std. Error Mean
Cognitive Load	Gaming Technology	15	3.8190	.46281	.11950
	E-book	15	3.4381	.35598	.09191

		Levene's Test for Equality of Variances		T-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Cognitive Load	Equal Variances Assumed	1.231	.277	2.527	28	.017	.38095	.15076	.07214	.68976
	Equal Variances not Assumed			2.527	26.271	.018	.38095	.15076	.07122	.69068
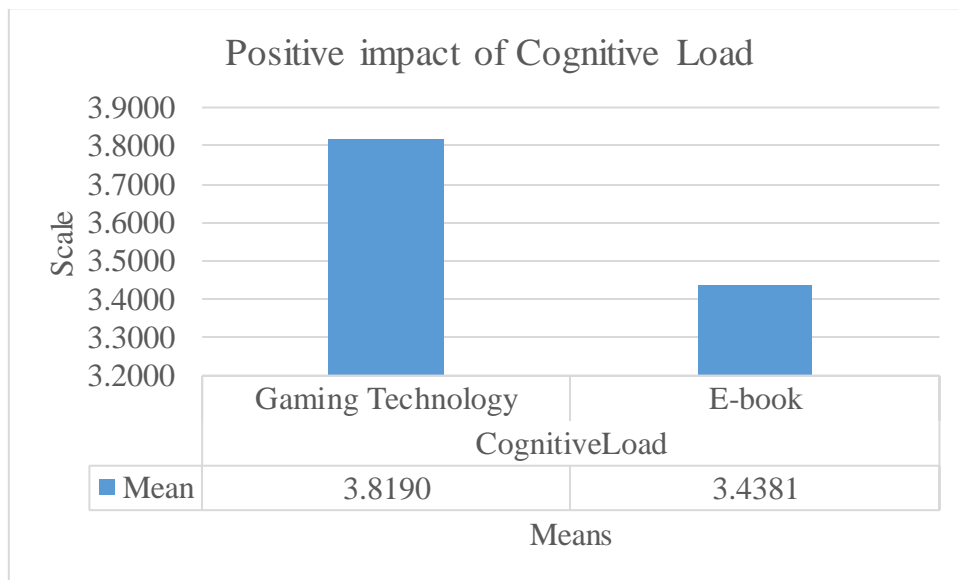
Figure 7.34 The independent-samples t-test results for measuring cognitive load.

In conclusion, gaming technology supported a positive cognitive load which helped the participants access knowledge through their memories effectively. This made gaining knowledge easier and allowed the participants to go through the gaming challenges with a low cognitive load and good understanding.

With gaming technology, when a participant processes knowledge, experience and skills in their short-term memory, they can focus on concepts and definitions more easily, taking less

time because the game's elements and features (such as visual images and verbal learning) capture the participants' concentration and allow them to achieve tasks quickly. The long-term memory's mission can be described via content analysis of the responses to the interview questions and the discussions undertaken between the researcher and the participants.

7.2.2   Long-term Memory

From the literature review, the interview questions and discussions with the participants, this research found that gaming technology enhances a person's memory by utilizing their previous knowledge, background and experience. Additionally, gaming technology can increase experience, and this can be done via several steps in the game. Firstly, a participant goes through the scenarios in the game and his/her short-term memory works to fix the problems in the scenarios. In the second step, the short-term memory calls upon the participant's background knowledge and experience to solve a particular problem because the participant has background information about the research methodology. The game also gives the participant an example to assist with understanding research methodologies clearly and accurately. The participant can use his/her existing knowledge and compare it with the scenarios in the game to find an appropriate and analytical solution. In the third step, the participant utilises a solution in the game and makes sure it is working well. Finally, the short-term memory sends the new information and experience to the long-term memory to store it for future situations. By using gaming technology, all the participants increased their ability and skills in research. GT13 gave the following recommendation: 'I got some experiences about new paths and situations in research, and I needed to use different types of research methodologies in practice that I have not used before'.

Furthermore, the participants in the e-book group also used long-term memory to achieve tasks by utilising previous knowledge, background information and experience. If a participant had good experience and knowledge (in this case, on research methodologies), he/she felt that the tasks were easy and achievable. For example, EB3 stated 'I have the experience regarding undertaking research methodology, and I felt it was easy because I answered most of the questions in the scenarios based on my knowledge and experience'. This participant will save new experiences in his/her long-term memory for future use in order to achieve future tasks.

All in all, gaming technology supported cognitive load more than the e-book and helped students build on their experiences and background.

7.3 Discussion:

The cognitive load had a greater decrease with the gaming technology group because gaming technology can reduce difficulty and effort and can enhance performance more than e-books. Based on the statistical results, there was a similar impact in terms of difficulty and effort for both technologies. In the performance sub-factor, gaming technology had a significant advantage over e-books. The average result of cognitive load shows the greater impact of gaming technology on cognitive load as shown in Table 7.13.

Table 7.13 Comparison of the results from the experiment and the interview responses for cognitive load

Independent Variable Cause		Analysis Type	Experiment Group Gaming Technology	Control Group E-book	Comparing Gaming Technology to the E-book
Dependent Variable Effect					
Memory	Cognitive Load	Statistical Analysis	Good satisfaction	Good satisfaction	There is a significant difference, and gaming technology has a positive impact on cognitive load.

7.4 Summary

The results described in this chapter demonstrate similar impacts by both gaming technology and e-books on participants' challenges and efforts. Gaming technology enhanced learners' performance more than e-book technology. There was a significant difference for gaming technology that made acquiring knowledge and building up the experience more effective. Moreover, the average of cognitive load, after measuring effort, difficulty and performance, shows that gaming technology had a significant advantage over e-book technology; games were more effective in reducing cognitive load. Overall, gaming technology better supports the learner memory process and gaming technology is more effective than e-books in enhancing learning ability.

Chapter 8. Discussion

The purpose of this research was to compare the impact of gaming technology on learning with the impact of an e-book on learning. This was done by, firstly, evaluating the impact of an e-book on the attitude, cognition and cognitive load of the participants and then, secondly, exploring and testing the impact of gaming technology on the attitude, cognition and cognitive load of the participants and, subsequently, comparing the impacts of the two technologies. The secondary data used to create a conceptual framework for effective learning was based on two learning theories: constructivism and the cognitive load theory. Primary data was used to compare and evaluate the impact of gaming technology and e-book on learning. A mixed methods approach was used to collect and analyse data. This research used an experiment strategy. Two platforms (a gaming technology platform and an e-book platform) were designed and developed for the experiment. Several types of data collection methods, including interviews, observation, and a questionnaire, were utilised. In order to obtain the best explanation for the impact of gaming technology as compared with the impact of e-books on learning, this study used 30 Ph.D. students at the University of Salford: 15 students within the e-book group and 15 students within the gaming technology group.

Interviews were conducted and recorded after the experiment to explore the learning themes, factors, sub-factors, and the elements that effect attitude (autonomous learning, curiosity, and motivation), cognition (higher-order thinking, critical thinking and problem solving), and memory (cognitive load) that take place in the short-term memory. Moreover, a questionnaire was used to measure curiosity and the level of autonomous learning and understanding before, and after, the experiment.

Observation data were collected via Snagit software and the FaceReader system. This chapter will discuss the results that were found in the secondary data in the research findings and results with regard to using gaming technology in learning and as an e-resource in an academic library. Furthermore, some ideas gathered from the experiment participants are explored and recommendations are made for future research into learning and academic performance.

8.1   Attitude

This section looks at the impact that gaming technology and the e-book had on the participants and discusses students' attitudes towards learning by using technology that is intended to meet the needs of future learners.

8.1.1   Autonomous learning

Participants were asked to assess their own autonomous stage of learning before and after using gaming technology and the e-book. The results showed an improvement in the autonomous stages in the gaming technology group, but within the e-book group there was very little positive effect.

This study found that people's willingness to use e-books and gaming technology for autonomous learning is based on flexibility. This finding supports other research findings, such as those of Holliday (2016) and Valenti (2015) who found that students engage in online learning because it is flexible and they can study from any place at any time. Moreover, the flexibility of gaming technology and e-books can be further explained as follows: (1) participants are able to study any subject they want to learn, (2) several types of devices, such as tablets, mobile phones and personal computers, can be used for studying, (3) several resources can be used at the same time to make learning effective, (4) learners are given the opportunity to implement any strategy they feel suitable for learning. The flexibility of gaming technology extends to being able to evaluate the level of understanding and then start from that level to save time and effort. Gaming technology is also flexible in that learners are able to move between the learning mode and the playing mode. Such flexibility makes learning easy to accomplish and is in line with the outcomes from other research studies that have found that gaming technology can measure a learner's level of understanding (Neely & Trucker, 2013; Gee, 2005).

Furthermore, in term of willingness, the author found that participants are willing to use e-books because they are flexible, readily available, and provide a diversity of knowledge. Other researchers have found that learners are willing to use e-books because of their 24/7 availability, their flexibility to query information by using key words, as well as the diversity of knowledge available to meet learners' needs (Clay, 2012; Mulholland & Bates, 2014; Renner, 2007; Valenti, 2015; Huer, 2015). This research found that e-books have usability features (such as writing notes and highlighting) that enhance participants' willingness to use them for learning. This finding is in line with the finding of other

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researchers (Chen et al., 2012; Weller, 2013; Cumaoglu et al., 2013; Hanover, 2013; Denoyelles et al., 2015). Other elements that enhance learners' willingness to use an e-book were found (because e-books are a trustworthy resource for learning; they are easy to read and can provide clear illustrations for clear understanding).

This study found more elements that support the use of gaming technology over e-books. Participants in the gaming technology group were willing to use gaming technology for learning because gaming technology is an engaging and interactive environment (incorporating three human senses (sight, hearing and touch)). In addition, gaming technology's usability, availability and diversity enhanced participants' willingness to learn.

The findings showed that students consider gaming technology as an enjoyable tool for learning (which is also in line with other research findings) (Kiili et al., 2014; Squire, 2011).

Participants in the e-book group commented on the side effects (such as eye strain) that e-books have on them. Similar findings were reported in the studies by Renner (2007), Chen et al. (2012) and Waller (2013). On the other hand, none of the participants in the gaming technology group complained about the side effects of gaming perhaps due to their feelings of enjoyment and the immersive nature of gaming technology.

Gaming technology within the study captured the learners' attention and supported their concentration which, in turn, enhanced their willingness to engage in gaming technology for learning. Other research has found that concentration is one of the higher-order thinking situations that is needed to acquire knowledge effectively (Yang & Chang, 2013). Thus, willingness increased when the learners' cognitive needs were met thus enhancing their thinking ability to concentrate on learning.

This research found that both gaming technology and the e-book enhanced learners' confidence to learn independently because both technologies provided a private environment that shielded participants from feeling that they had to impress or from feeling shame because of their mistakes. Not only did both technologies provide a convenient environment for learning, but gaming technology also provided measurement of the participants' accomplishments and feedback on their learning progress and performance. In the same vein, Valenti (2015), Huer (2015), and Neely and Tucker (2013) suggested that online learning provides a private environment that helps participants to be

comfortable and be interested while learning, that measures their progress, and sends feedback about learner performance. Achievement of the game's steps enhances confidence. Moreover, a new element that enhances confidence was discovered in the study: the ability to go back to get more information and review it. Technology provides rich information that can enhance confidence because participants feel they can obtain the information they need for their learning through gaming technology and e-books. This research found e-books provide rich knowledge that can support learner confidence. Hence, using either an e-book or gaming technology for learning has a positive influence on participants to achieve academically.

This study confirmed that autonomous learning requires the setting of goals, making a plan for learning, and using some tactics for learning independently. For example, in the gaming technology group, the participants' goal was to move through the game to perform the tasks and obtain a high score to win; in the e-book group, the target was to undertake the tasks successfully. Participants established their plan and used some tactics, such as note-taking, to perform tasks. This supports what Schunk (2012) explained about independent learning, which was that it requires the setting of goals, making a plan for learning, and using some tactics for learning independently.

In addition, the results of this research show that gaming technology supports the concept of 'learning by doing'; this fact has also been found in other research. Gaming technology provides an active learning environment which supports the concept of learning by doing (McBridge, 2014).

8.1.2   Curiosity

In general, a participant's quest for knowledge is supported by the participant's curiosity. Curiosity was measured before and after using gaming technology and the e-book. The results showed that, in the e-book group, there was no significant difference before and after the experiment. However, in the gaming technology group, there was a significant difference in curiosity between before and after playing the game, which means that gaming technology enhanced participant curiosity.

In addition, based on the responses in the interviews that were conducted, this research found both groups' curiosity was enhanced by increasing interest. When participants feel the need for knowledge, this encourages them to learn. This fact supports the results from other research that found curiosity is aroused if interest is high and if learners have a

deprivation that leads them to dig for information (Arnone, 2003; Loewenstein, 1994). However, this research found that gaming technology provided an interactive environment which made understanding easy and, additionally, that such an environment also enhances curiosity. This is in line with Grolitz's (1987) results which emphasised that a learner needs a comfortable environment to arouse curiosity. Indeed, both technologies had a positive effect but gaming technology aroused more curiosity than the e-book and curiosity, in turn, affects participants' motivation.

8.1.3 Motivation

Gaming technology supports participants' motivation was an aspect that was confirmed by the undertaken study. Kapp (2012) also suggested that gamification enhances users' motivation to acquire knowledge. Moreover, this research found that emotion and intrinsic motivation were supported because gaming technology is interesting and fun, which encourages motivation. Annetta (2008), Kiili et al., (2014), Pivec and Dziabenko (2004), Squire (2011), and Buchanan and Vanden Elzen (2012) pointed out that, because gaming technology is fun, there is increased interest which supports participants' motivation.

The e-book utilised also held participants' interest because it provided new knowledge for the participants. Performing tasks helps to support participants' interest. The tasks in the experiment helped to enhance interest because the participants in the e-book group felt it was related to their needs. Thus, e-books need to utilise other technologies to be more interesting and enhance learning.

This research measured the influence that the e-book and gaming technology had on the participants by using the FaceReader system which monitored participants using both technologies. The participants' emotions were observed and this provided an explanation of the way participants felt while learning, Achieving the learning and the tasks within the game and the e-book helped to enhance the positive emotions of the participants and, additionally, reduced the negative emotions, thus making learning more effective.

Furthermore, participants in both groups had a goal to perform the tasks as well as the need to learn research methodology. The gaming technology group showed more self-reliance because the e-book group felt they needed support from lecturers or a teacher for difficult concepts.

In addition, this study found both groups used several types of habits when it came to thinking, such as thinking out loud, linking, memorising, and imagining, which showed that both technologies motivated the participants to use their thinking habits and abilities to perform tasks.

In addition, the study results show that gaming technology had an impact on the learners' emotions. For example, gaming technology stimulates participants' desire to learn because gaming technology promotes participants in engaging in the learning environment. When participants perform each level in the game, they are encouraged and motivated by achieving that level (and obtaining high scores) to play and learn more. Gee (2005) found the same result in his study indicating that gaming technology motivates participants to learn. As such, gaming technology can be an effective tool to support stimulation and that helps to enhance motivation.

Moreover, this study showed gaming technology enhances intrinsic motivation because of the satisfaction it provides through: (1) the novelty of gaming technology in learning as a new tool and resource to teach research methodology; (2) the reduction in difficulty and the ability to make concepts easy to understand, and (3) personal interests. The e-book also demonstrated good satisfaction on novelty, difficulty, and personal interest.

This research also found:

- that gaming technology provides a challenge that has a positive effect on participants' extrinsic motivation: a well-designed game supports personal interests. Other research has found that a well-designed game and game challenge enhance participants' motivation (Kiili et al., 2014; Squire, 2011; Gee, 2005; Mayo, 2005). A gaming technology environment needs to have a suitable challenge that is built based on the target audience's ability and needs.

- that gaming technology has extrinsic motivation based on three elements: (1) the challenge; (2) a high score that leads to winning, and (3) the feeling of victory or the realization at the end of the tasks that more learning is needed. Moreover, previous research has shown that gaming technology has an extrinsic motivation that is not found with e-books because gaming has a challenge and a score (Kiili, 2005; Ciampa, 2014; Mozelius, 2014; Kapp, 2012; Nicholson, 2012; Zichermann & Cunningham, 2011). As a result, gaming technology has a greater advantage than the e-book with regard to enhancing motivation.

- that both gaming technology and the e-book had a good level of participant satisfaction that encouraged participants' efforts to learn and study. Given the need to acquire a clear and coherent understanding about research methodology, participants were supported to put in the effort to study, which enhanced their understanding and cognition.

8.2 Cognition

This research found that:

- gaming technology has a significant difference on participant understanding after playing the game (when a comparison was made from before and after the game), and this means that gaming technology has an ability to enhance cognition and help learners to achieve an effective outcome by improving higher-order thinking, such as critical thinking and problem solving. Previous research has also found that gaming technology can develop understanding, can help to acquire knowledge effectively, and can support the higher-order thinking that is needed for academic performance (Gee, 2005; Tobias, 2011; Mayo, 2009; Hays, 2005; Clark et al., 2014; Roses et al., 2003). All in all, gaming technology has the benefits of supporting cognition and encouraging learning achievement.
- that gaming technology helped to develop learners' skills through trying out certain learning skills to accomplish tasks, and that the e-book was useful for acquiring knowledge and obtaining more details. Other research has shown that gaming technology can be used to develop medical skills of students on medical programmes and that it has been found to be more effective than an e-book (Jeffries, 2005; Heather, 2010; Rieber et al., 2009; Abou-Elhamd et al., 2010).
- that gaming technology has been used for improving pilot skills where it has been shown to be an effective tool (Bell & Waag, 1998). Gaming technology has also been used for sport training with significant results (Neely & Tucker, 2013). Indeed, gaming technology can be an effective tool to enhance skills.

Other research has found that gaming technology causes confusion and this can lead to the use of other resources (Gee, 2005; Van Eck, 2015). However, in this study, it was found that gaming technology helped learners to focus on their subject and avoid any confusion. This means that gaming technology can capture a learner's attention and concentration, and be effective in supporting understanding. This study found ways to avoid the confusion

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such as through good design for gaming environments via coding the elements which allows the games to be utilized for learning. The study's gaming platform used the flow theory and other elements to create the game's environment. Based on the flow theory a game design framework was established to build a 'Research Methodology Game'. Subsequently, the game's storyboard and characteristics were provided to build the game environment. Appropriate technology was used that supports learners' abilities; for instance, in this research, the 'Research Methodology Game' environment used several types of technologies such as 2D, 3D, animation, video and audio to make the learning environment more comfortable. Moreover, it was felt that the game ideas and the concept of the 'Research Methodology Game' should meet the learners' needs, improve their willingness to learn, capture their attention and enhance their concentration. Finally, the game's challenges needed to be balanced to avoid both anxiety and boredom during game-play; this was also a consideration during the design of the 'Research Methodology Game'.

8.2.1 Problem solving

The study found that gaming technology has good participant satisfaction with regard to enhancing problem-solving ability. Other research has shown that gaming technology enhances problem-solving skills for participants in multiple ways by providing challenges through different scenarios wherein each scenario needs a special solution using different strategies that cannot be used in real life (Gee, 2005; Friedl & O'Neil, 2013; Van Eck, 2015).

An analysis of the problem solving approach found that participants in both groups (e-book and gaming technology) used same steps solving problems.

8.2.2 Critical thinking

This research found that gaming technology can support participants' critical thinking and help them to achieve well academically. This is in line with the result that Yang and Chang (2013) found, namely that gaming technology can enhance critical thinking and academic performance. All in all, with a well-designed game, gaming technology can have a positive influence on cognition.

8.3 Cognitive load

The participants within both groups used their background and previous experience to perform the tasks. Schunk (2012) also emphasised this fact; that the memory process for

learning utilises the retrieval of information from long-term memory to take it to short-term memory to accomplish tasks and process new knowledge.

This study found that gaming technology has a positive impact on reducing cognitive load which helps memory to process information successfully, and it also supports participants' memory processes within learning. Moreover, Kiili et al. (2014) also found that gaming technology can support participants' memory performance and reduce cognitive load and thus help memory to process knowledge. Hence, gaming technology provides an environment that helps memory to process knowledge effectively between all memories (long-term, short-term, and sensory) in order to learn.

8.4   Relationship between e-book and gaming technology

While collecting data for this research, some participants gave an opinion that games help in learning, but are not useful for everything because learners need to read to develop and expand their knowledge by learning more details in-depth and gaining advanced knowledge about the concept they want to learn. Thus, other classic tools for learning, such as attending lectures and sessions, have a part to play in learning. For example, participant GT8 stated 'Gaming technology supports learning effectively. However, sometimes a learner needs more details and he requires reading besides getting support and assistance from an instructor and supervisor'.

Other participants stated 'Gaming technology is more beneficial for first-year students because it helps them to build their background and get basic knowledge about research methodology and arrange their thoughts and, based on that background, learners can learn in depth to understand more about research methodology and understand complicated concepts about research methodology'.

That led to the realization that if e-books were linked to other technologies (such as gaming technology) it would be fruitful for learning. This fact supports other research results which have found that e-books will be more useful if linked with quizzes, videos, and websites in order to develop e-books to be a more interactive tool and e-resource for learning (Denoyelles et al., 2015; Rickman et al., 2009; Waller, 2013). This fact supports the need for building a relationship between e-book technology and gaming technology.

Moreover, the results of this research show that building a relationship between e-books and gaming technology to enhance learning can be undertaken by using gaming technology

to build upon participants' background knowledge and by using e-books to provide more details and to encourage understanding. Some research has shown that e-books can use other technologies as a means to support understanding, such as multimedia and online dictionaries (Rockinson-Szapkiw, Courduff, Carter & Bennett, 2013; Schomisch, Zens & Mayr, 2013). Thus, both technologies can enhance learning by supporting each other to make learning more interesting and fruitful and to enhance academic performance.

8.5   Using gaming technology as an e-resource in an academic library

This research:

- has emphasised the use of gaming technology as a future learning tool for the 21st century. Gaming technology can furnish a solution to provide an effective learning environment for the new generation and pave the way for future of learning. Gaming technology can meet the needs of the new generation who have grown up with technology for learning. This belief is supported by Valenti (2015) who pointed out that the new generation has a need for new tools for learning, such as gaming technology. Hence, gaming technology can be a learning tool for universities and can be used in an academic library as an e-resource to support other resources, as well as supporting academic performance.

- has found that using gaming technology for learning services as a tool and as e-resource in an academic library is important. Miltenoff (2015) suggested that academic libraries have a significant role to play in using gaming technology for learning. This view is supported by Nicholson (2013), Nielsen (2104), Gantt & Woodland (2013), and Walsh (2014) who pointed out that games can be used to encourage engagement with libraries and that this engagement could affect learning performance as well as providing support for courses, classes and sessions to enhance participant experience. All in all, gaming technology can be an effective tool and e-resource for online learning and as a learning service in academic libraries.

- has found that gaming technology and e-books enhance performance and help to support understanding knowledge by learning through a system. This supports previous research that has found that online learning provided through an academic library in a university enhances participants' understanding, increases knowledge (through devices such as mobile phones) and improves students' performance

(McCormick & Pevear, 2013; Subramaniam, Nordin, & Krishnan, 2013, Cobb, 2013; Uzoka & Ijatuyi, 2005; Saeed, 2006; Valenti, 2015). Hence, gaming technologies are essential in an academic library for online learning and as an e-resource to support academic performance.

- has found that participants are open to the idea of adding gaming technology to library services for educational purposes and as an e-resource in an academic library because of the advantages gaming technology brings to supporting learning attitude, cognition and memory. The research of Uzwyshyn et al. (2013) and Daluba and Maxwell (2013) suggested that academic libraries should be improved to meet 21st-century needs by using new technology, providing new learning services and new resources that can support learning, and using new tools and resources that cannot be found in the classroom. Indeed, gaming technology can play a significant role in academic learning and can support e-learning in the future to enrich learning.

Students in universities are open to using gaming technology for learning. This encourages their engagement with the university library which, in turn, enhances their academic performance (Walsh, 2014). Moreover, the results of this research support this view because all the participants in the gaming technology group accepted using technology for e-learning. Thus, gaming technology can become an effective e-resource for online learning and should be part of an academic library system.

Walsh (2014) found that gaming technology used in an academic library enhanced student engagement with the library and thus supported their academic performance. In this study using gaming technology in learning had excellent participant satisfaction which, the students explained, was due to how gaming technology helped them to learn effectively and supported their performance.

Moreover, using gaming technology in learning encourages the use of academic library resources because, based on this research, participants responded to gaming technology as it built up their background knowledge which, in turn, will lead participants to find more details out through reading. Also, based on this study, gaming technology can support academic performance as an e-resource in an academic library. In brief, gaming technology has the ability to be an effective e-resource that supports e-learning.

This study found that gaming technology should become a significant tool and e-resource for future learning in universities and especially within academic libraries. This supports other research that suggests that gaming technology will have a significant role in learning in the future. This will lead to more research being undertaken on gaming technology in order to develop an effective learning environment in the future based on valid frameworks and theories.

8.6   Summary

This study showed that gaming technology has a greater effective and positive influence on the participants' attitude, cognition and cognitive load when compared to the influence on the participants by the e-book. Attitude focuses on three behaviours that are important for future learning: autonomous learning, curiosity, and motivation. Gaming technology enhances the autonomous learning stage and provides factors and elements that can be used to enhance independent learning in the future. Moreover, curiosity was aroused by using gaming technology and this research provides several factors and elements that help to enhance participants' curiosity.

Furthermore, gaming technology enhances motivation via its support of the motivation sub-factors. One reason why gaming technology supports learning is that it encourages learners to engage in learning because of the positive emotional influence gaming technology has on learners while undertaking tasks (which assists them in performing and completing tasks). Also, gaming technology enhances both intrinsic and extrinsic motivation, and encourages participants to put more effort into accomplishing tasks.

This research measured higher-order thinking and focused on critical thinking and problem solving. This study found that gaming technology supports higher-order thinking and has the capability to enhance problem-solving ability and encourage participants to use appropriate problem-solving steps to perform tasks. In addition, critical thinking is supported by using gaming technology, as it helps learners to follow the critical thinking elements and steps to perform tasks critically with clear understanding.

With regard to memory process, gaming technology helps learners to use their short-term memory and long-term memory effectively to perform tasks by using previous knowledge and experience to process new tasks and achieve learning in the short-term memory, then send it to storage in the long-term memory. Indeed, this research has shown that gaming technology has a positive impact on reducing cognitive load and supporting learning.

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This research found a relationship between e-books and gaming technology in that gaming technology can be utilised to build up background knowledge about concepts/to introduce a subject and, subsequently, if desired, users can gain more information from e-books. Following this, participants can use gaming technology to practise their knowledge and enhance their experiences and skills; also, participants can test their understanding.

In brief, gaming technology was commonly cited in this research's results as being useful and effective for future learning. Thus, gaming technology can be an effective learning tool and resource in academic libraries in the future. Furthermore, gaming technology can be utilised with other technologies, such as e-books, to enhance understanding and build up participants' knowledge, experience, and skills.

Chapter 9. Conclusion

9.1   Introduction

This chapter concludes the research project, including all its aspects and processes. This chapter also presents a summary of the thesis, reviews its research objectives and evaluates whether they were reached. The contributions of this research are then presented, and areas for future research are recommended.

9.2   Thesis Summary

This research aimed to explore whether game-based learning environments have a greater effect on learner's attitude, higher-order thinking and cognitive load than e-book based learning.

Based on the aim of this research, the author reviewed the learning theories that help to explain the learning process and to assess the learning outcome. The researcher selected the constructivism theory (because it included attitude and the cognition part of the aim) and the cognitive load theory (which was used to measure cognitive load in the use of gaming technology and e-books in learning). Based on constructivism and cognitive load theories this research defined the learning factors that needed to be tested and investigated through this research in order to answer the research question:

- Does gaming technology affect learners' attitudes (autonomy, curiosity and motivation), higher-order thinking (critical thinking and problem solving) and cognitive load over and above the effect caused by e-books?

Based on the research question, the researcher expanded the research query by identifying learning factors for attitude which were autonomous learning, curiosity and motivation (as the important behaviours for learning). Subsequently, critical thinking and problem solving factors were defined for cognition (as the significant ability within academic learning). In addition, cognitive load (that takes place in the short-term memory and gets support from the long-term memory) was measured based on its processing in the short-term memory.

These learning factors led to creating and identifying a conceptual framework to measure the impact of gaming technology and the e-book. Moreover, sub-factors were defined for each factor that was presented in the measurement framework (see section 4.2) in order to

evaluate the impact of gaming technology on learning and compare that to the e-book's impact.

The experiment platform established the 'Research Methodology' game and the e-book which explained research methodology based on Saunder's research onion. This research designed a gaming technology environment based on the flow theory and other gaming technology elements. The 'Research Methodology Game' was set up as the basis for assessing the impact of gaming technology on learning. Moreover, an e-book platform was established to explore if e-books influence learning. Subsequently, these technologies were compared to find the differences between gaming technology and e-books in terms of their effects on learning, to uncover the relationship between them, and to find ways of enhancing future learning environments.

These platforms were used for the experiment and were the main strategy for collecting data. Several type of data collection techniques were utilised to collect data such as a questionnaire, semi-structured interviews and observations (undertaken using a FaceReader system and Snagit software).

The data analysis techniques, utilising statistical analysis and content analysis, were used to find appropriate results and to explain the impact of gaming technology on learning and compare it to the impact from the e-book.

The results of this study show that gaming technology is an effective learning tool and that it has a more positive impact on learners' attitudes than e-books as it enhances autonomous learning, curiosity and motivation. Gaming technology and e-books have the same effect on cognition, critical thinking and problem-solving ability. Gaming technology has a more positive impact on cognitive load than e-books in terms of reducing cognitive load.

9.3   Research Assessment

This part of the conclusion discusses the research objectives identified in Section 1.4. These objectives were achieved successfully and met the research aims and targets.

Objective 1: To investigate the learning factors impacted upon by gaming technology and e-book technology by defining a framework that provides a basis for measuring learners' attitudes, higher-order thinking and cognitive load, both subjectively and objectively.

In order to define the framework, learning theories were reviewed in order to select the appropriate learning theories that could help to evaluate and to assess the learning gained through using gaming technology and the e-book by defining learning themes, factors and sub-factors that could assist in comparing gaming technology's and the e-book impact's on learning and to answer the research question. The constructivism learning theory was selected in order to assess:

- Attitude: the factors within 'attitude' that enhance learning via using technology were identified:
  - autonomous learning: identified as the role of learning in the future via utilising technology for learning.
  - curiosity: selected as an attitude factor for learning because it enhances the learner's desire to learn and to fill in the gaps in knowledge of the learner.
  - motivation: one of most important factors to encourage people to go through a learning system and acquire knowledge.
- Cognition: a focus on higher-order thinking which is important for learning in the universities. Cognition includes:
  - critical thinking: it is important for students in universities to use the information and knowledge that they have gained and to synthesise new knowledge, discovery and exploration within their field.
  - problem solving: is the significant ability for learning via using various steps to go through problems and find solutions. This increases ability to analyse problems, create solutions and evaluate solutions thus enhancing understanding.

Moreover, the cognitive load theory was used to measure the cognitive load that takes place in the short-term memory. Information is transferred from the senses' memory to the short-term memory and information is also transferred from the long-term memory to the short-term memory so that new information can be processed with previous knowledge in order to create new knowledge and, subsequently, the new knowledge is stored in the long-term memory for future use. These processes impact on the workload in the short-term memory.

Based on the learning factors, the conceptual framework was assembled in order to evaluate the impact of gaming technology on learning and compare it to the impact produced by the e-book.

After defining the factors there is then a need to define the sub-factors within each factor. The sub-factors in the measurement framework explain the manner of collecting and analysing the data in order to evaluate the impact of gaming technology and e-book on learning (this is shown in section 4.2.)

Objective 2: To design and establish a technology-based learning environment to compare the learning differences via e-books versus gaming technology.

This goal was approached by selecting an important learning objective which could be learnt by using gaming technology and an e-book. It was decided to chose research methodology (utilising an explanation of Saunder's research onion) as the learning objective because research methodology is important for PhD students; they need an understanding of it in order to succeed in their study in university.

Initial data about research methodologies was collected and then explained in a simple and flexible way to make learning about them easy. Firstly, the research methodology concepts were presented in an easy-to-read format (and supported by some explanatory pictures and tables) in order to create an e-book platform. The e-book platform was established in Microsoft Word and a PDF format so it could be used on different type of devices.

Secondly, the gaming technology platform was established based on the information used in the e-book platform and by using gaming design theory and design elements. The flow theory was also used to create the gaming technology platform as well as some important elements to help make the learning environment interesting. As explained in chapter 4, these elements are: balanced challenge; feedback; clear goals; performance and awareness; tasks; control; loss of self-consciousness; an altered sense of time; interactivity; visual learning; verbal information; gaming rules; fantasy; fun; learning, and practice. These elements were employed to increase the game's 'fun' and to make the gaming environment interesting and fruitful.

Next, the storyboard was created for the gaming platform which included the steps, screens, and technologies that are used in the gaming environment such as 3D, video and

animation. Moreover, the researcher defined the game's characteristic and established a scenario and the task, while pursuing the aim of making learning interesting and enjoyable.

Finally, the 'Research Methodology Game' platform was created by using Unity gaming environment in order to help students effectively understand and learn about research methodologies through an interactive learning environment.

Objective 3: To explore gaming technology's impact on learning by conducting experiments to compare outcomes when using game-based learning versus e-books.

After establishing the e-book and gaming technology environments, an experiment was run using two groups: an e-book group and a gaming technology group. Each group had 15 participants who were Ph.D. students at the University of Salford. Several data collection techniques were used to test and explore the impact of gaming technology and e-book on learning outcomes, such as attitude (autonomous learning, curiosity and motivation), cognition (critical thinking and problem solving) and cognitive load. The data collection techniques used were questionnaires, interviews and observations. Based on the experiment strategy and the data collection techniques, several learning factors (such as autonomous learning, curiosity and understanding levels) were measured before and after using these technologies. All of the data that were collected were utilised to compare gaming technology's influence to that of the e-book's influence.

These measurements indicated that learning through gaming technology (as compared to learning via the e-book) results in a significant difference in curiosity and autonomous learning. The e-book did not present a significant difference regarding these two factors. Moreover, the results of this research showed that gaming technology enhances autonomous learning, moving users from a lower stage to a higher stage of independent learning. In contrast, the e-book did not provide this experience. Gaming technology also provided more elements than the e-book that enhanced the willingness sub-factor and the confidence sub-factor of autonomous learning. Curiosity was also enhanced via gaming technology, and not via the e-book. The factor motivation helped contribute to a feeling of excellent satisfaction by the participants for both platforms. However, gaming technology supported more factors and sub-factors because it stimulated participants to learn. It also offered extrinsic motivation, which was not applicable with the e-book (see chapter 5). Regarding cognition, this research found that both technologies had the same impact on higher order thinking (critical thinking and problem solving - see chapter 6). The impact on

cognitive load revealed that gaming technology positively impacts and reduces cognitive load, more so than do e-books (see chapter 7).

Thus, gaming technology presents advantages over e-books. Gaming technology is an effective learning tool that has a more positive influence than e-books on learners' attitudes, as it enhanced autonomous learning, curiosity and motivation. Gaming technology and e-books report the same effect on cognition, critical thinking and problem solving. Finally, gaming technology has a more positive influence than e-books on cognitive load.

9.4   Research Contributions

The aim of this research was to explore whether game-based learning environments have a greater effect than e-books-based learning on learners' attitudes, higher order thinking skills and cognitive loads. The following contributions were made while fulfilling this aim.

- Establishment of a conceptual framework. The framework resulting from this research demonstrates and presents the important factors that are needed to evaluate the technological environment for learning (such as gaming technology and e-books) and to assess these technologies' impact on attitude (autonomous learning, curiosity and motivation), cognition (critical thinking and problem solving ability) and cognitive load.

Through primary and secondary research this research proved that:

- Gaming technology enhances autonomous learning, curiosity and motivation and gaming technology has a more positive impact on learners' attitudes than an e-book.

- Gaming technology reduces the cognitive load and has a positive influence on cognitive load, more so than an e-book.

- Gaming technology and e-books have a similar impact on critical thinking and problem solving ability.

9.5   Future Research Recommendations

This work can be extended through further research as presented below:

- **Test the social interaction aspects of the constructivism learning theory.** This factor was excluded in this research; however, examination of this can be achieved by defining the social interaction factors and sub-factors that need to be measured through a gaming technology environment. This requires the creation of a gaming platform that will allow several users to play the same game simultaneously and share their ideas with each other (e.g. which steps and missions should be followed to perform tasks). This would enable researchers to measure the impact of the learning experience on social interactions and learning outcomes.

- **Test different levels of challenges and their impact on learning.** A gaming platform can be created that has several levels of difficulty. For instance, level one may present easy challenges for first-year learners in a university. The second level would feature moderately difficult challenges suitable for second-year users. The third level would provide difficult challenges appropriate for third- and fourth-year students. With this approach, game researchers could test and explore how progressing challenges in a game impact on the learning outcome. This could also lead to providing a guideline for defining challenges in games in order to increase enjoyment and discovery in relation to positive learning outcomes.

- **Measure cognitive load.** Cognitive load can be measured using objective factors, such as functional near-infrared spectroscopy (fNIR), and these results can be compared to learners' responses via the questionnaire. This would help researchers evaluate the impact of such technologies on cognitive load. The outcome of this assessment can help educators create learning environments that can reduce students' cognitive load and encourage learners to acquire knowledge, improve their skills and enhance their educational experiences. Cognitive load can also be used to explore the impact of technology on learners' long-term memory. Thus, researchers could explore how technology can improve participant experience and how that experience can enhance learning outcomes.

- **Test the impact of an immersive environment on learning outcomes.** Research could be conducted to explore the impact of immersive virtual environment in cultivating learner attitudes, cognition and social interactions. The outcomes could compared with the results from the non-immersive gaming platforms.

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Appendix1- Session attendant & Publishing:

NO	Date	Session
1	12/02/2013	Information Management for The Web
2	05/03/2013	Research Ethics
3	15/05/2013	Writing Thesis
4	12/06/2013	Constructive Research
5	18/06/2013	Critical Thinking in research
6	20/06/2013	Classification, Indexing, and retrieval in heterogeneous document
7	28/06/2013	Grounded Theory Methodology
8	23/09/2013- 02/12/2013	Wordscope 10 weeks workshop
9	23/10/13	Writing a Critical Analysis of the Literature
10	25/10/13	Introduction to Endnote X7
11	21/11/13	Doing literature review
12	26/11/13	Academic writing style
13	19/02/2014	Introduction to Research Philosophy
14	19/03/2014	Critical thinking and critical writing at doctoral level
15	16/04/2014	Preparing for the interim assessment & Internal Evaluation
16	23/04/2014	Interview in qualitative research
17	30/04/2014	Structuring your research
18	07/05/2014	Location and Using Archives for research
19	14/05/2014	Guide to Getting Published
20	14/05/2014	Constructive Research
21	29/05/2014	Validity and Reliability in quantitative research
22	21/01/2015	Content Analysis
23	22/04/2015	Thesis writing
24	29/06/2015	Introduction to Nvivo and the literature review
25	30/06/2015	Introduction to SPSS
26	20/01/2016	The Collection, Analysis, Interpretation and Presentation of Data in Quantitative Research

Publishing:

1- Poster (Use of game-based learning to enhance higher-order thinking). Dean's Annual Research showcase proceedings. 18th June 2014. Media City UK, University of Salford).

2- Publish paper: Design 3D On-Line Gaming Environment for Learning how to Design Green Building. International Conference on Institutional Leadership and Learning & Teaching (ILLT). London-UK, September 2015.

3- Conference attendants: The Future of Smart Cities conference. Manchester- UK. April 2016.

Appendix 2- Melbourne A State- Trait Curiosity Inventory

Directions:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of statement to indicate how you generally feel.

There is no right or wrong answer.

Don not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

No	Trait	Strongly disagree	Disagree	Neural	Agree	Strongly agree
		1	2	3	4	5
1	I think learning about Research Methodology is interesting and exiting					
2	I am curious about Research Methodology					
3	I enjoy taking Research Methodology apart to 'see what makes them tick'					
4	I feel involved in what I do					
5	My spare time is filled with interesting activities					
6	I like to try solve problems that puzzle me					
7	I want to probe deeply into Research Methodology					
8	I enjoy exploring new places					
9	I feel active					
10	New situations capture my attention					
11	I feel inquisitive					
12	I feel like asking questions about what is happening					
13	The prospect of learning about new research methodology excites me					
14	I feel like searching for answers					
15	I feel absorbed in Research Methodology					
16	I like speculating about Research Methodology					
17	I like to experience new sensations					
18	I feel interested in Research Methodology					
19	I like to enquire about any Research Methodology I do not understand					
20	I feel like finding out more about Research Methodology.					

Directions:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of statement to indicate how you feel right now, that is, at this moment.

There is no right or wrong answer.

Don not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

No	State	Strongly disagree	disagree	Neural	Agree	Strongly agree
		1	2	3	4	5
1	I want to know more					
2	I feel curious about what is happening					
3	I am feeling puzzled					
4	I want Research Methodology to make sense					
5	I am intrigued by what is happening					
6	I want to probe deeply into Research Methodology					
7	I am speculating about what is happening					
8	My curiosity is aroused					
9	I feel interested in Research Methodology					
10	I feel inquisitive					
11	I feel like asking questions about what is happening					
12	I need to learn more about Research Methodology					
13	I feel like finding out more about Research Methodology					
14	I feel like searching for answers					
15	I feel absorbed in what I am doing					
16	I want to explore possibilities					
17	My interest has been captured					
18	I feel involved in what I am doing					
19	I want more information					
20	I want to enquire further					

Appendix 3- How to play game?

Playing the Research Methodology Game need for some instruction about playing game and using different screen features. This part of game design included below some instructions/information about each screen:

Main Menu:

- Learn Mode - go into learning mode. If this is the first time (or you have reset the game), present Question 1 first
- Play Mode - go into play mode. If this is the first time (or you have reset the game), present Question 1 first
- About - display the about game screen
- Options - display the options screen
- Exit Game - exit the game

Figure 1. Main Menu screen

About Screen:

- There are 3 screen of information, press Next/Previous to advance through the screens
- Press Close to return to the main menu
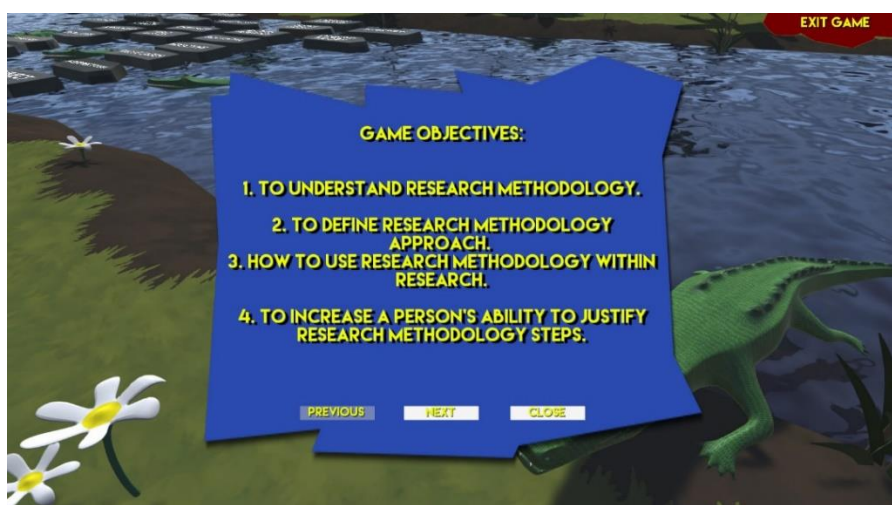
Figure 2. About Screen

Options Screen:
- Effects Volume - adjust the slider to change the volume of the effects (the water sound). Select/Deselect the tick box to unmute/mute the effects
- Speech Volume - adjust the slider to change the volume of the video speech. Select/Deselect the tick box to unmute/mute the speech
- Master Volume - adjust the slider to change the overall volume of both combined. Select/Deselect the tick box to unmute/mute the entire sound
- OK button - Save any changes done here
- Cancel button - Don't save any changes done here
- Reset button - Reset the game to the beginning - Note - there is no confirmation and the reset will occur even if you hit cancel
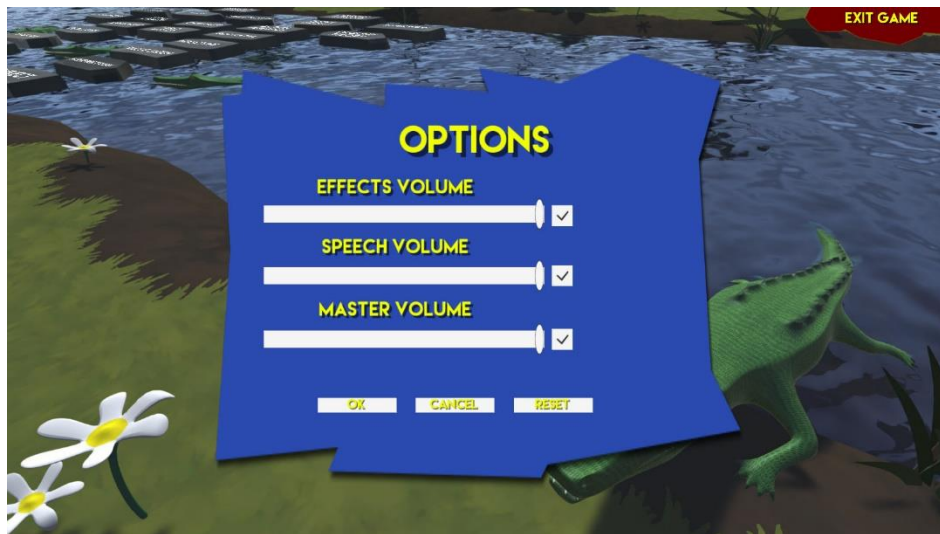
Figure 3. Option screen

Question 1 Screen:
- Presented on first play/learn when first loaded or after a reset
- Click the tick box that corresponds to your understanding
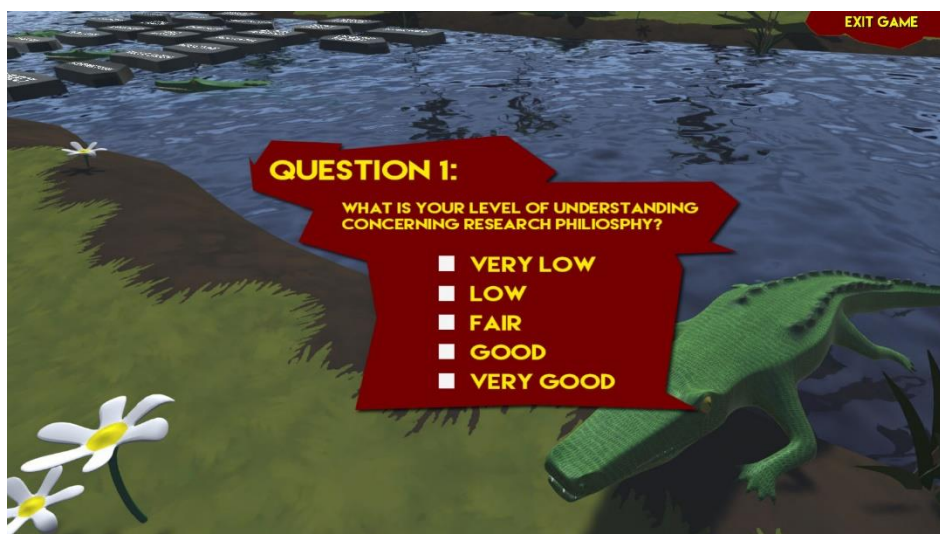
Figure 4. Question 1 screen

Play Mode:
- Click Switch to Learning to go to Learn Mode
- Click Main Menu to go back to the main menu
- Click the Question Header (e.g., Question 1) at the top in blue to hide/show the question text
- Click one of the Scenario buttons to change to that Scenario
- The tick box next to the scenario buttons show which one you have already done
- You can click a stone on the layer in front of the character or on the same row as the character
- The stone highlights blue to show it is selectable
- The stone highlights red when you have chosen correctly
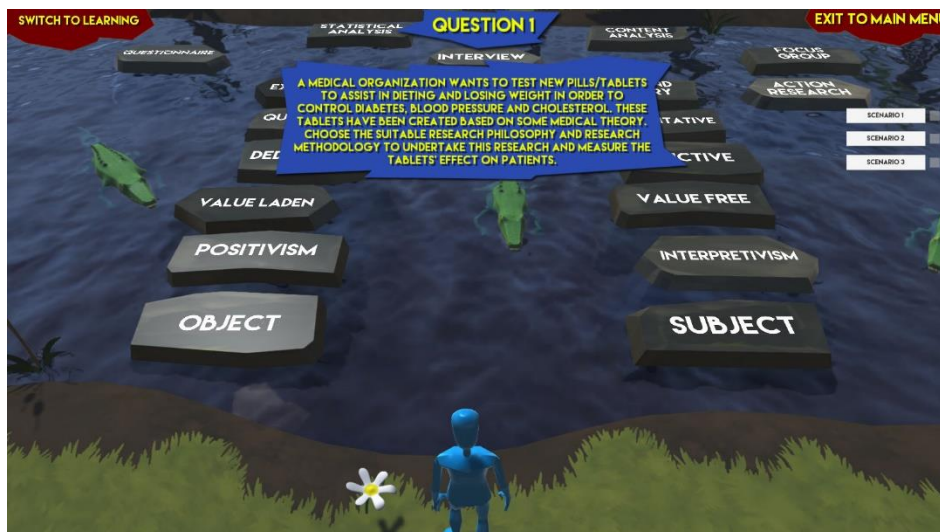
Figure 5. Play mode screen

Learn Mode:
- Click any of the stones or category headings to display the video information window
- Click Switch to Playing to go to Play mode
- Click Main Menu to go to the main menu

Figure 6. Learn mode screen

Video Screen:

- Circle button restarts video
- Play button (right arrow) plays the video
- Pause button (two vertical lines) pauses the button
- Stop button (square) stops the video
- Double click the video window to make it full screen
- Double click the fullscreen video to return to the video window
- Click the close button (X) in the top right to close the video window
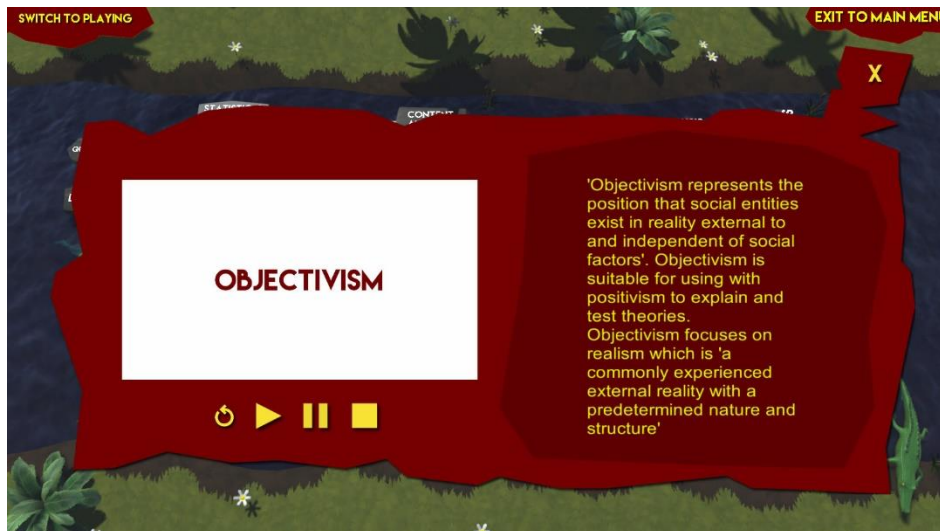
Figure 7. Video screen

Justification Screen:

- Appears after completion of each Scenario
- Only the choices you made will be visible here
- Click in the field name next to each choice to type your justification
- Click done when complete

Figure 8. Justification screen

Question 2 Screen:
- Appears after justification screen
- Select the tick box choice that matches the outcome
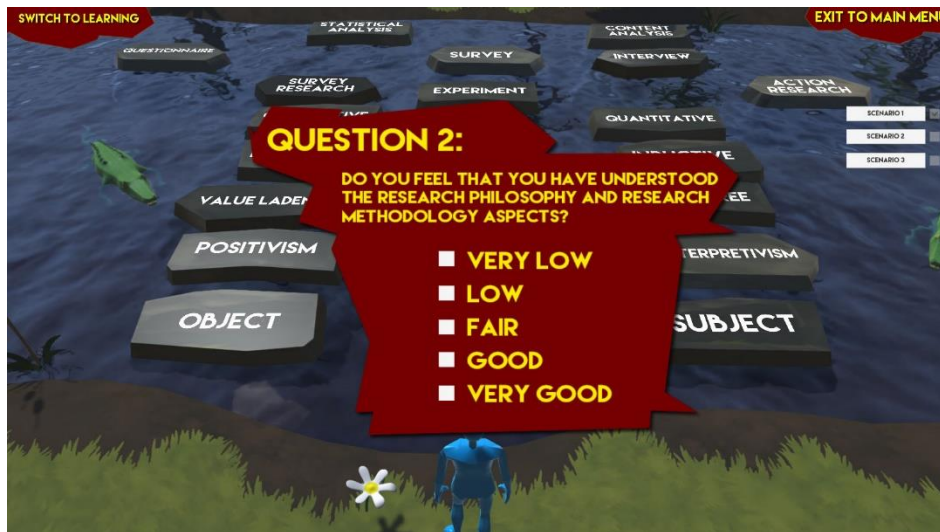
Figure 9. Question 2 screen

Final Grade:
- Appears after Question 2
- Calculated based on each category having 5 points, you lose one for each wrong choice in that category, complete score is a percentage of points
- After clicking Done, Word document report is generated, saved in Documents folder and loaded.
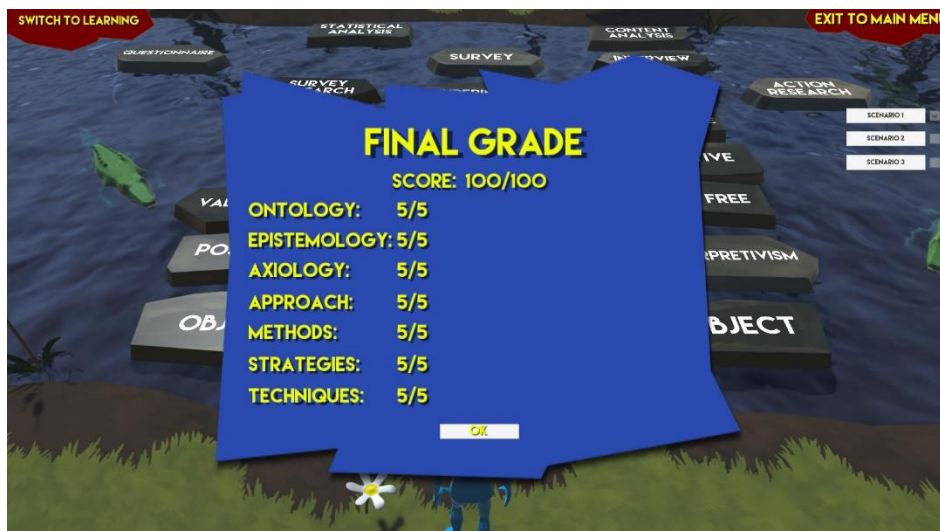
Figure 10. Final grade screen

Appendix 4- Independent learning stage question before and after doing experiment

Which statement describes your ability (before/ after) performing task in e-book?

☐ I cannot gain knowledge without support from instruction or teacher by providing me with lecture, direction and specific task.

☐ I am interested to achieve task and I have confidant to learn and make effort to achieve task; but I need for direction and support from instructor to guide me.

☐ I am able to achieve task but I need for motivation and confidant to perform task.

☐ I do not need for direction and support because I have confident and ability to plan and achieve the task.

Appendix 5- Interview questions

General Questions

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
The use of (gaming technologies/e-books) in education is useful and enriches learning.					
(Gaming technologies/e-books) enhance interactive learning.					
(Gaming technologies/e-books) enhance the concept of learning by doing.					
(Gaming technologies/e-books) develop learners' knowledge, experience and skills.					
(Gaming technologies/e-books) help users to arrange their thoughts.					
(Gaming technologies/e-books) make acquiring knowledge, experience and skills easy.					

Autonomous Learning

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
Learning through (gaming technologies/e-books) enhances autonomous learning.					

Explain why you have answered as you have.

How did learning through gaming technologies encourage autonomous learning in the understanding of Research Methodology concepts?

Did gaming technologies enhance your willingness to learn independently? Why? How?

Did gaming technologies enhance your confidence to learn independently? Why? How?

What goals and plans did you set to learn about research methodology in order to prepare yourself for conducting the task?

Curiosity

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
Learning about research methodology through (gaming technologies/e-books) incited your curiosity to learn.					

- Did you want to explore how to create your research methodology? Why?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You got interested in learning more about research methodology through using (gaming technologies/e-books)					

- Were you prepared to spend a considerable amount of time exploring research methodology concepts?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
Learning about research methodology through (gaming technologies/e-books) helped me to understand how I can create a correct research methodology and filling the gap of knowledge about research methodology.					

- Did you feel you needed to learn more in order to ensure you understand research methodology concepts? Why?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
Learning through (gaming technologies/e-books) motivated you to gain new knowledge, experience and skills in the area of research methodology					
Learning through (gaming technologies/e-books) encouraged you to gain a good understanding of research methodology in order to undertake research.					

Describe your emotions when you started learning about research methodology.

Did you believe that you could successfully accomplish learning about research methodology? Why?

What were your targets when you set off to learn about research methodology?

Did you have a willingness and interest to learn about research methodology by (gaming technologies/e-books)? Why?

Did you use any special habits or strategies thinking to learn about research methodology? What are these habits or strategies?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
Learning about research methodology through (gaming technologies/e-books) is new and is a novel way to improve knowledge and learn a new skill.					

Statements	Very high	High	Normal	Easy	Very easy
	1	2	3	4	5
Rate the difficulty of learning about research methodology					

Did you feel you would like to spend more time learning more about research methodology? Why?

Statements	Strongly dis agree	Disagree	Neutral	agree	Strongly agree
	1	2	3	4	5
I had personal interest in learning about research methodology					

What enhanced your interest in learning about research methodology? Why?

Statements	Very high	High	Normal	Low	Very low
	1	2	3	4	5
Rate the effort it takes to learn about research methodology					

Did you feel you needed more effort to learn about research methodology? Why?

Critical thinking

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You were able to analyse the information that you learned from the (gaming technologies/e-books) and develop the research methodology, as specified in the task.					

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You were able to enhance your ability to assume and identify the appropriate research methodology in order to undertake the correct research steps and process, as specified in the task.					

What assumptions did you make in identifying the research methodology to undertake the research?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You were able to enhance your ability to find the appropriate research methodology to undertake research, as specified in the task.					

How did you decide on what type of research methodology to use to undertake the research? Why?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You were able to enhance your ability to use reason to create the research methodology type, as specified in the task.					

Why did you use your specific type of research methodology? What were your reasons for using this type of research methodology to undertake the research and perform the task?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You were able to enhance your ability to determine the relationship between the research methodology layers that helped to perform the research, as specified in the task.					

What is the relationship between the layers of research methodology used to undertake the research?

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
You were able to rationalise and assess what type of research methodology should be used to undertake the research and perform the task					

What are your arguments for using these types of research methodology when undertaking the research and achieving the task?

Problem solving

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
Learning through (gaming technologies/e-books) encouraged problem solving that assisted in overcoming the challenges faced in creating the research methodology.					

What was the process you used, and the steps you took, in order to create the research methodology and thus undertake the research and perform the task? Explain each step.

Why did you use these steps and processes?

Cognitive load

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
(Gaming technologies/e-books) require a low mental effort to accomplish the task.					
(Gaming technologies/e-books) are easy to use when accomplishing the task.					
(Gaming technologies/e-books) support the effective performance of the task.					

Statements	Very high	High	Normal	Easy	Very easy
	1	2	3	4	5
Rate the mental effort that you required to learn and accomplish the task.					
Rate the difficulties that you met to learn and accomplish the task.					

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
(Gaming technologies/e-books) make you overly aware of your own thoughts during learning and achieving the task, and may, therefore, cause distracted thoughts or headaches.					
(Gaming technologies/e-books) give you a sense of accomplishment when working through the different stages in learning and achieving the task.					
(Gaming technologies/e-books) make you feel comfortable and more intelligent after overcoming the challenges and different stages in learning and achieving the task.					

Final question

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	1	2	3	4	5
I support using (gaming technologies/e-books) for educational purposes and training in order to develop learners' skills, thinking and experiences.					
I support using (gaming technologies/e-books) in Academic library as e-resource for educational purposes and training in order to develop learners' skills, thinking and experiences.					

Explain why you have answered as you have. (Last question)