How Can Digital Educational Games Be Used to Improve Engagement with Mathematics in the Classroom?

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How Can Digital Educational Games Be Used to Improve Engagement with Mathematics in the Classroom?

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ABSTRACT

Digital games are part of everyday childhood and adolescence. The debate has moved from whether young people should play digital games, to how they might best benefit from gameplay, including through education. Mathematics is under threat in Nigerian primary education: pupils report it to be boring and difficult, and teachers say pupils are not engaged. Research shows that even when pupils are achieving academically in mathematics, engagement with the subject is low. Previous research suggests digital games can help engage reluctant learners, but most of the studies have been carried out in developed countries where technology is widely used and classroom practices are different. The overall aim of this study is to see how games can be used to provide an engaging experience for pupils in the Nigerian mathematics classroom.

Using mixed methods approaches, two background studies on an engagement framework and a modified Technology Acceptance Model (TAM) was used to inform the development of a prototype digital educational game *SpeedyRocket*. This was used over two weeks with 60 pupils and 9 teachers in Ado-Ekiti, Nigeria. Pupils were randomly assigned to treatment and control groups. Evaluation was carried out through a combination of a questionnaire, classroom observation and teachers' focus groups. The quantitative results demonstrate significant improvements in the reported engagement of pupils with mathematics in the classroom after two weeks of using *SpeedyRocket*. In addition to this, the use of the game changed the dynamics of the classroom – learners played more active roles in the learning process, communicating and collaborating unlike before. Teachers as well saw the usefulness of the game although remained concerned about the inadequacy of resources, training, support, and availability of time. Overall this research demonstrates that if carefully designed and implemented, digital educational games can improve engagement with subjects that pupils may find boring and uninteresting as well as breakdown barriers to interaction and engagement in the traditional classroom.

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Dedication

This thesis is dedicated to all my former students in Nigeria. Although you called me teacher, I was the one who was learning. Thank you!

Also to all the teachers out there, using limited resources to light up fires and empower young minds, this is for you.

Thanks for all you do!

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To God, the giver of life, my source and my all, you alone deserve the glory and honour. Thank you for daily loading me with benefits from the beginning of my existence through the course of the PhD and to this very moment.

Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges the opinions and ideas as cited from the work of others.

The ethical clearance and approval needed for this study were obtained. The Northumbria University Ethics Committee granted the clearance and approval to carry out this research.

I declare that the word count of this Thesis is words: 55, 997

Name: Opeyemi Dele-Ajayi

Signature:

Date:

1 CHAPTER ONE - INTRODUCTION

1.1 Overview of research and problem statement

Over the last few years, digital game-based learning has continued to gain attention and interest among game designers, educators and researchers. This has been partly due to advancements in technology and computer capabilities making technology so ubiquitous that even mobile devices are now sufficiently powerful to accommodate and run sophisticated digital games. Another reason is that people, especially teenagers and young people, now play games more than ever before (Barr, 2017). The video game industry has surpassed both the music and video industry in sales (Hollingdale and Greitemeyer, 2014), with the global market expected to grow from $101 billion in 2016 to an estimated $128 billion by the end of 2020, with mobile gaming comprising 42% of that (Global Games Market Report, 2017). Therefore instructors and educators are exploring game-based learning as new teaching methods that offer strong potential for providing effective and engaging educational experiences for learners.

Simulation, which is a form of game-based learning, has been widely used in many sectors from business (Poonnawat et al., 2015) to nursing (Koivisto et al., 2017). It has been found to be particularly effective in teaching complex concepts in science and engineering (Benitti and Sommariva, 2015; Braghirolli et al., 2016). Apart from its suitability to teach complex scientific information, simulation also offer learners some level of control and ownership of the learning process and therefore fosters better understanding and retention of concepts (Podolefsky et al., 2013). In simulations, learners learn by doing, and that allows them to relate to and understand complex concepts better (Ramasundarm et al., 2005). Mathematics is an example of a subject that contains abstract and complex concepts. It is a very important subject not just to the general development of problem solving skills, but also to long-term careers in engineering and science. Despite its importance, the problem of decreasing interest from pupils in primary school to secondary school, particularly in Nigeria, has been widely reported and researched (Adebule et al., 2016; Ajai and Imoko, 2015; Perry et al., 2016).

Despite the many possibilities offered by game-based learning, its potential has not been fully realised. This could be due to various factors. One is that digital games in themselves do not have a positive image. For example research has shown concerns about how games encourage antisocial characteristics (Greenfield, 2014; Calvert et al., 2017), reinforced gender biases (Pietri et al., 2017; Lynch et al., 2016), and can potentially lead to aggressive behaviours (Gabbiadini et al., 2016; Kneer et al., 2016). In addition to these concerns, there is a significant shortage of experimental empirical studies on what actual value digital games offer to learning, especially in formal settings (Moser, 2016; Connolly et al., 2012). This lack of evidence has meant that there is little concrete information to guide research and practice of game-based learning implementation including the effective engagement of stakeholders in the process. This has resulted in research about the value of game-based learning producing contradictory results (Chung-Yuan et al., 2017; Tsai and Pai, 2012; Crocco et al., 2016).

One other major challenge with digital educational games is that they tend to focus too much on learning and then they miss out on the fun 'play' part (Girard et al., 2013; Graesser, 2017), which is the main reason why young people play digital games in the first place. Young et al. (2012) suggest that many of the so-called 'digital educational games' are too focused on the educational content, created around traditional drill and practice methods and stress the memorisation of facts, thereby doing very little to engage and stimulate interest from the players.

The research into how digital educational games should be built for teaching and learning in the classroom is challenging. While there are studies into how digital educational games can be made engaging for young people, the games they play for entertainment are increasingly sophisticated. Indeed, advances in the technology, interaction models, and design trends of entertainment games proceed at a rate beyond that which can be achieved by research into educational games.

This evolution of entertainment video games means that the research into how their concepts can contribute to digital educational games is a sophisticated one. It is therefore imperative for new studies to investigate recent games and their players to determine what may be useful for the designers of digital educational games.

Another challenge digital educational games face is that of use. Digital games, as informal learning tools, need deeper investigation before they can be used effectively in formal settings like a traditional classroom. As suggested by Perrotta et al. (2013), research into game-based learning should focus not only on features and content, but also specifically on the development – who it is being developed for, and why it is being developed. These are the reasons for this study. The research questions that guided this study are presented in section 1.2 below.

1.2 Research Questions and Objectives

The aim of this research is to see how digital games can be used to provide an engaging experience for pupils in the mathematics classroom. The research questions and objectives are as follows:

RQ1: How can digital educational games be designed and developed to engage players? To answer this are the following objectives

> **R-OBJ1:** To identify factors that are essential for young people's engagement in digital games.
>
> **R-OBJ2:** To propose a framework to guide the development of engaging digital educational games from the above investigation.

RQ2: How can the intention to adopt and integrate digital educational games by teachers in Nigeria be understood?

> **R-OBJ3:** To identify factors that influence Nigerian teachers' intention to adopt and integrate digital educational games in the classroom
>
> **R-OBJ4:** To propose a model based on the results of **R-OBJ3**
>
> **R-OBJ5:** To statistically test the hypothesis developed in **R-OBJ4**

RQ3: What is the effect of digital educational games on the engagement of pupils in the mathematics classroom in Nigeria?

> **R-OBJ6:** To identify/observe any differences in the traditional classroom experience and the digital games' classroom experience of pupils in Nigeria

1.3 The Position of the Researcher in the Current Study

Research, especially those that employ qualitative data collection and analysis methods is a subjective practice. This is because no researcher comes to a topic/subject with a clean slate.

It is therefore responsible and ethical on the part of the researcher to present their preconceptions and influences on the study. Mansfield (2006) explains reflection as “an examination of the filters and lenses through which you see the world”. The reflection of the researcher helps them to explore and understand what they bring to this research and how their personal history influences it. I am pro-technology. I have a substantial amount of experience designing and developing desktop and mobile applications. However, during the course of my professional career, I also taught Information Technology in a couple of secondary schools in Nigeria. My technical expertise coupled with my experience in the classroom fuelled my desire to do this research. I wanted to find out if technology could be used to provide an engaging experience to young people in the classroom. Understandably, my experience with technology meant that I could easily use it and I could also easily identify its place in the classroom.

In addition to this, my personal philosophy and value system had its influence on this research. I believe that human input is key to the success of any experience. I believe that the voices of the teachers are not only the ones that should be heard in the classroom. I believe that learners (no matter their age, gender, background, ability or disability) have a right to be heard, to participate, and to contribute to their learning process. The research described in this thesis is influenced by these beliefs and also by the constructivist perspective.

I agree with the notion that knowledge cannot be wholly objective but that it is often constructed through experiences and interaction with others.
The researcher took a constructivist position to the current study. The researcher believes that the acquisition of knowledge by a learner is not entirely objective but that learners construct knowledge consciously by themselves – individually and socially. That stance that knowledge is not independent of the meaning attributed to experience by/of the learner or a community of learners guided the data collection methods and analyses in this research as they take into account participant’s experience and beliefs.

However, the researcher beliefs that even though the person of the researcher influences the intervention, methods, and analysis, research should be conducted rigorously and ethically and justifications should be provided for decisions made. For the two background studies conducted as part of this research – game engagement framework and technology acceptance model, the researcher collected qualitative data in addition to the quantitative data in order to explore and focus on individuals' experiences and feelings with the aim of triangulating the findings of this research.

The main site for this research is Ado-Ekiti, Nigeria. The researcher for several reasons chose this site - the first and major being the ease of access. I had previously lived in Ado and I know the area well. I ruled out other locations and cities due to the amount of time I knew could potentially be spent on making contacts and obtaining approval to get into schools. Also, with Nigeria being a multicultural country with over 500 languages, I envisaged that I may have to speak the local language of the region during the course of the fieldwork and I wanted to be sure I could communicate properly in the local dialect if need be. This familiarity also helped my understanding of the dynamics of the research site as I have taught and I have been taught in the region before.

1.4 Scope of This Research

As mentioned earlier, the aim of this research is to consider how digital educational games can be used to provide an engaging experience for pupils in the mathematics classroom. This is not a novel research here especially in developed countries. The use of digital games and other technologies in the classroom has been widely considered and researched, albeit with varying results and conclusions. However in developing countries, it is mostly unheard of or at best underutilised. Furthermore, the concept of engagement is multi-faceted and at such needs to be clarified in the context of this study.

In this study, engagement is explored in two dimensions: engagement in the digital educational game (fun and engagement) and engagement in the subject of the digital educational game; in this case mathematics. The latter is otherwise referred to as having a positive attitude towards the subject the game is used for in the classroom; being motivated and interested in learning it. In this study, these two dimensions represent the totality of an engaging experience in the mathematics classroom using digital educational games: engagement with the game and engagement with the subject.

1.5 Curriculum and its Role in Education

In basic terms, the curriculum encompasses everything that students learn in school. However, according to UNESCO (2018) it is much more than subjects that are taught and set out within the textbooks. It is a 'systematic and intended packaging of competencies (i.e. knowledge, skills and attitudes that are underpinned by values) that learners should acquire through organised learning experience both in formal and non-formal settings". This implies that the curriculum is expected to satisfy and reflect the needs of a society by incorporating its educational aims and purposes.

What makes a quality curriculum is a pertinent question. Stabback (2016) presented a comprehensive summary of four categories for judging the quality of a curriculum as part of a report for UNESCO. The categories are presented in Figure 1.1:

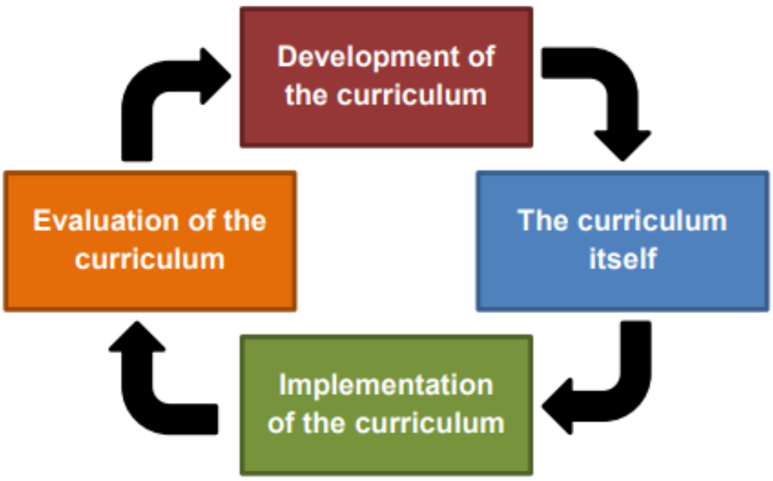

Figure 1.1 Categories of criteria for judging curriculum quality (Stabback, 2016)

The first category is the development of the curriculum. According to Stabback (2016), the development of a quality curriculum needs to be planned, inclusive, led by professionals and sustainable. This implies that the process of putting the curriculum together should not be a 'rushed activity' but rather be strategic and accountable. It should also take into considerations the peculiarities of the intended context and at the same time 'look-beyond' to learn from what others are doing outside the particular context. Stabback (2016) recommended that the plan for curriculum development should include consultation activities, timelines, and required expertise as well as anticipated costs. In order for a curriculum to be quality, it also needs to be inclusive and consultative. This means that the curriculum needs to first of all acknowledge the interests of the stakeholders and seek ways to capture their inputs in its developments. Principals, head teachers, teachers are key stakeholders that should play a critical role in the development of the curriculum, as they ultimately will be tasked with the responsibility of implementing it. Other important stakeholders are students and their families, employers, tertiary institutions, communities and governments (Stabback, 2016). While the input of all these stakeholders is vital in the development of a quality curriculum, the curriculum development process should be led and managed by professionals who have experience in the subject. Capacity development of those involved in the process of curriculum development may be necessary to ascertain that they have the requisite knowledge and skills to deliver a quality curriculum (Pepin et al, 2017; Stabback, 2016; Jackson et al, 2015).

The second category of what makes a quality curriculum is the curriculum itself. Key characteristics of a good quality curriculum are: values the equality of child, possess high quality content, and is well organised and structured (Stabback, 2016). A curriculum that values equality caters for the various interests, aspirations and preferences of each child by providing an opportunity for every child to achieve his or her full potential. This means that the curriculum should be inclusive (regardless of gender, ethnicity, ability or cultural background) and differentiated (caters for the different ways pupils learn). In addition to providing high quality subject-specific knowledge, a good curriculum develops broader competencies in communication, collaboration, problem thinking, creativity and diversity amongst other things (Harlen, 2017; Stabback, 2016; Billet, 2003; Aitken and Neer, 1992). The quality of the structure and organisation of the curriculum is very important. Stabback (2016) maintains that a good curriculum is "carefully and clearly documented". This is important for effective and efficient understanding by the stakeholders as well as implementation by the teachers. Curriculum should clearly convey the intended learning outcomes and should be user-friendly and accessible to the users.

The implementation of the curriculum is another dimension for judging its quality. Whilst clear emphasis should be placed on the development process and the content of a curriculum, these should be accompanied by good delivery and implementation. According to Stabback (2016), the implementation of the curriculum refers to "how the written curriculum is presented to students and how teaching, learning and assessment actually happen. Education systems, schools and teachers make numerous decisions as they 'translate' the requirements and advice of curriculum documents into meaningful and effective learning activities in the classroom. In quality curriculum, the responsibilities of the various stakeholders are made clear so they can sufficiently participate (Penuel et al, 2007; Samson and Charles, 2018).

Teachers play the most prominent role in curriculum implementation (Glatthorn et al, 2018; Cviko et al, 2014). The interpretation, adaptation and construction of the activities from the content of the curriculum is carried out by the teachers (Stabback, 2016). It is therefore important that teachers are equipped in these duties and be supported in the adaptation and implementation of the curriculum to deliver the intended learning outcomes and experience to the learners.

Regular and systematic evaluation is the final characteristic of a good quality curriculum. Usually, this stage of the curriculum process receives the least attention even though it is one of the most important (Barrow, 2015). According to Stabback (2016) the evaluation of the curriculum should be based on a clear purpose and scope, and carried out by experienced and qualified personnel. He further suggests that the rationale for the evaluation must be identified and be within a clear quality framework. Furthermore, professionals who have adequate understanding of the subjects, as well as evaluation strategies and processes should conduct the curriculum evaluation process. They should also be able to report their findings objectively and professionally.

The Nigerian Educational Research and Development Council (NERDC, 2018) is the curriculum agency established by the Decree 53 of 1988 (NERDC, 2018). It is tasked with various educational responsibilities (as it is a merger of four different bodies - the Nigerian Educational Research Council (NERC), the Comparative Education Study and Adaptation Centre (CESAC), the Nigerian Book Development Centre (NBDC), and the Nigerian Language Centre (NLC)). The body is chiefly responsible for formulating and publishing the overall National Policy on Education in Nigeria. However, one of its other major functions is the development of curricula at all levels of the education system in Nigeria (Igbokwe, 2015).

Several authors have researched and written about the challenges facing education in Nigeria. The problem of a poor curriculum has been reported by some of these authors. Curriculum in Nigeria has problems on all four dimensions of what makes a quality curriculum discussed earlier in this section. According to Adolphus (2011) one of the challenges to the effective teaching and learning of geometry in secondary schools in Nigeria is the poor curriculum used in the schools. Osafrehinti (1986) highlighted two key problems with the curriculum in Nigeria – one, the introduction of new curriculum in Nigeria often catches teachers unawares as they are not usually carried along in its development. Two, teachers' training (which happens at the colleges of education), curriculum development and classroom practice and delivery all happen in isolation and individually, so the teachers who use the curriculum have little or no idea on how it was developed and the teachers who are in training also do not input to its development.

More recently than Osafrehinti (1986), Asaaju (2015) also maintains that teachers are usually not represented and sometimes completely left out of vital decision-making and development of curriculum. Due to where they appear on the pyramid, the curriculum is usually a 'hand-down' to them to deliver. Figure 1.2 below shows the pyramid of educational policy/system in Nigeria (Asaaju, 2015)

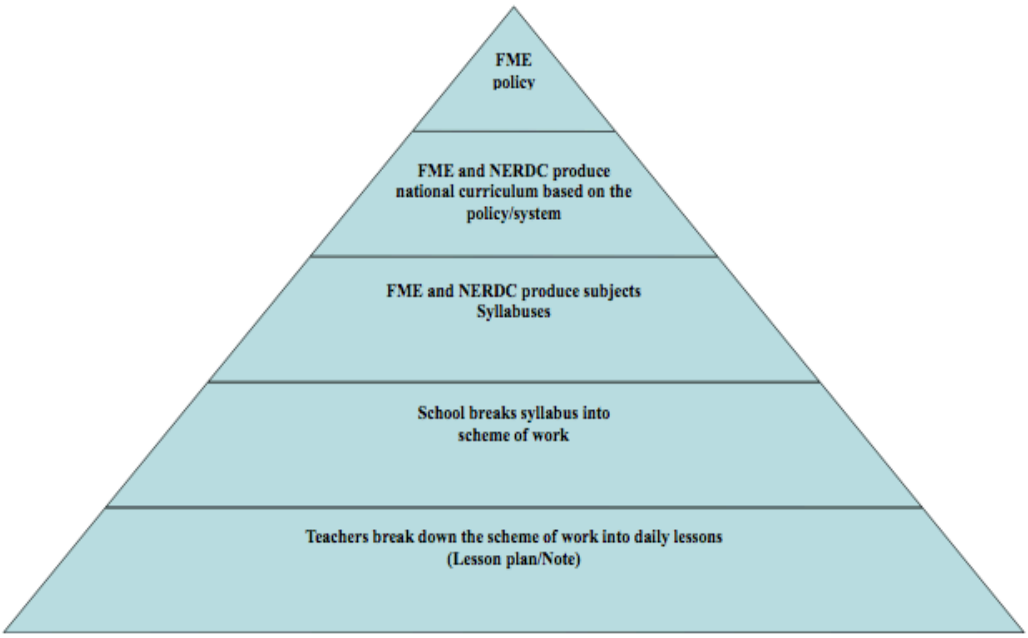

Figure 1.2 Pyramid depicting the FME- Federal Ministry of Education Curriculum as a teaching plan derived from the educational policy/system (Asaaju, 2015)

Apart from this, there is little or no research done in the development of the curriculum in Nigeria. Adolphus (2011) suggests that a common practice is for education officials to transfer curriculum from developed countries without considering the important step of relating it to the learners' environment in such a way that it can be applicable. These challenges pose a problem to the effective development of a quality curriculum.

Considering the four dimensions of what makes a quality curriculum, evidence from literature suggests that the Nigerian curriculum needs attention on the four dimensions if it would become a quality one. In Nigeria, the development process somewhat fails to provide the good foundation for a quality curriculum.

Another major challenge to the Nigerian curriculum is the curriculum itself. Educators and researchers have described it as boring, out of date and rigid. According to Njoku (2018), the curriculum needs to be updated as it is serving 'expired education' to young people. There have been calls for curriculum review as the structure and content of the curriculum makes classroom boring for learners. As mentioned earlier, the curriculum is very important to effective learner experience. However, a rigid and strict curriculum could be potentially harmful to the experience of pupils in the classroom. The rigid curriculum is a primary challenge to teachers' ability to facilitate learning by stiffening their freedom to adopt instructional methods that promote effective and engaging learning experiences (Croninger et al, 2012; Achinstein and Ogawa, 2006; Bauml, 2015). The result of this 'out-dated and irrelevant' curriculum is that private schools have been reported to replacing them with curriculum from the United Kingdom and the United States (Omeje, 2017). However, this poses the two of the problems highlighted above – teachers' ability to fully understand and deliver it, and how well the learners to a foreign curriculum.

Asaaju (2015) calls the implementation of curriculum in Nigeria "building something on nothing". This is because the operational factor employed in the development of the curriculum as well as the curriculum itself is defective. There is a challenge of incompetence and self-efficacy with respect to delivery of curriculum contents. Teachers are often not well trained or prepared to deliver the subjects they teach in the classroom (Yusuf and Balogun, 2011; Amuseghan, 2007).

Curriculum needs continuous but inclusive modifications with respect to learners' needs, society and the changes in educational policies. It needs to support the construction of 21st century competencies in preparing the learners for the world of work, however, the Nigerian curriculum only seems to allow for the primary role of the curriculum – which is to deliver learning outcomes, and even that is not at the quality it should be. The national curriculum needs a proper reviewing to ensure it accommodates modern methods of teaching, supports pupils abilities individually and collectively and leverages on modern tools and technologies. It needs to foster a change in the structure of the way lessons are delivered as well as challenge the rigid nature of the traditional classroom setup. A major challenge in many Nigerian classrooms is the number of students and the availability of teachers to cater for them. As it will be discussed in Chapter 2, overpopulation is a problem to effective learning and teaching of mathematics in the classroom. This is because the time and space is often not available to teachers to go 'over and beyond' the national curriculum in in the traditional classroom. It is therefore imperative to consider alternative options to tackle this challenge. That is why this researcher is interested in exploring the use of digital educational games in improving engagement with mathematics in the classroom.

An introduction to the methods and corresponding activities undertaken to answer the research questions above are provided in the following section.

1.6 Research Design and Activities

To investigate the research questions and carry out the objectives of this study, quantitative and qualitative data collection and analysis methods were employed at various stages of the research. This was to produce a balanced and rich picture of both depth and numbers of the concepts under study. Altogether, 226 teachers and 119 pupils were involved in this research. A diagrammatic presentation of the relationship between the research questions and the chapters of work in this thesis is available in figure 1.3. The research design is presented briefly below:

Research question 1: How can digital educational games be designed and developed to engage players?

The background research to this study adopted a mixed data collection method of a questionnaire and a structured interview to explore young people's game genre preferences, and their motivations to play games. The questionnaire used is provided in Appendix 1. 62 young people participated in the study, which took place at the 2015 Game On 2.0 exhibition in Newcastle Upon Tyne, United Kingdom. Northumbria University's research ethics committee and the Centre for Life, Newcastle approved the research.

Research question 2: What are the factors that determine the acceptance of digital educational games by teachers?

Like research question one, a mixed research method was used for this study. This study used the Technology Acceptance Model (TAM) as a basis. Using an initial in-depth interview with 12 teachers, issues around the adoption of digital educational games were explored. Using thematic analysis, the results of the interviews were analysed and used to extend the original TAM to create a model for the acceptance of games in the classroom by teachers. It was also used to create a questionnaire that was distributed to 202 teachers across 10 schools in Ado-Ekiti, Nigeria. The questionnaire was used to further investigate the findings from the interview with a wider range of teachers. The teachers were informed about the research via emails sent to the head teachers of their schools.

Research question 3: What is the effect of digital educational games on the attitude to mathematics of pupils in the classroom?

For this question, the researcher used an experimental design with mixed methods of classroom observation with the pupils, along with focus groups with the teachers involved in the study. Pupil participants were randomly assigned to one of two groups: experiment and control. The study was conducted across 3 primary schools in Ado-Ekiti, Nigeria. A total of 60 pupils and 12 teachers participated in the research. Prior to the experiment, information pamphlets were sent to the parents via their wards, and head teachers signed *loco parentis* consents for the parents.

1.7 Significance of Study

This section addresses the "why" question as to how the researcher devised the research questions and the justification for the research as a whole.

There is a problem of sustained interest and eventual choices in careers that have mathematics as a core challenge in Nigeria (Adebule et al., 2016). Anecdotal evidence has indicated that there is an on-going issue with engaging learners with mathematics in the classroom. The low numbers that choose the non-compulsory, more advanced and complex, mathematics known as 'further mathematics' also establishes this. This disinterest in choosing mathematics indirectly affects the uptake of other core subject study areas in science and engineering (Agogo and Achor, 2014). However, mathematics is an important subject to gain admission into college or any higher institution in Nigeria, so students tend to continue to study it until they do not have to, thus proving the motivation to learn mathematics while it is seen as compulsory but not beyond that.

Several studies about mathematics uptake, interest and achievement have been carried out in secondary schools (Sule, 2016; Adebule et al., 2016; Awofala, 2014), however, much less research has been done in primary schools. As evidence suggests, pupils form their interest about subject areas early in their education journey (Olgan, 2015) Research (Kislenko et al., 2007; Macnab and Payne, 2003) indicates that children can often regard mathematics as abstract, boring and unconnected to the real world. One of the mathematics teachers in this research said 'They do not like it (mathematics), many of them see it as hard and impossible, then they get disinterested in the classroom'. This led the researcher to attempt to study the issue of interest and achievement in mathematics education. A study of primary 4 and primary 5 pupils (usually aged 8 – 11 years) across three primary schools in Ado-Ekiti, Nigeria indicated that the issue with mathematics education is not one of achievement, but of attitude and identity. Over 60% of the pupils achieve higher than the average score in the standardised promotion examinations in the previous school term. However, the concern still remains that "they fear mathematics, believe it is boring and find it hard to relate with it" (Teacher, Amazing Grace Nursery and Primary School). The long-term problem this causes is the low numbers of young people who go on to study courses or work in jobs where they have to use mathematics. Discussions with teachers, as well as a look into the performance of the pupils suggest that while mathematics achievement is not an immediate challenge, the lack of sustained interest in mathematics ends up discouraging young people from pursuing careers where they perceive they have to do more mathematics. Digital educational games are one of the potential solutions identified in the literature that could be used to create and sustain interest in learning mathematics in the classroom.

However, introducing digital educational games in the classroom is a task that needs to be well thought through and planned. This is especially true in Nigeria, where the use of technology tools is not a common practise in the classroom (Hassan and Shuaibu, 2015; Anekwe and Williams, 2014). Two of the most reported barriers in the literature are infrastructure (Kamba, 2008; Osang et al., 2013) and cost (Aduwa-Ogiegbaen and Iyamu, 2005). However, the introduction of any kind of new technology into a classroom is not only a financial or technical issue, but also primarily, a pedagogical issue. In any educational system, the teachers are the ones directly responsible for the transfer of necessary and adequate knowledge to young people, and by extension a key determinant in technology adoption. Thus any new system of teaching, in this case digital educational gaming, must first be acceptable and deemed necessary by the teachers, otherwise new classroom technology will be, in many cases condemned to become a decorative dust collector, or underutilized (Hepp et al., 2004). Teachers themselves are a key factor in technology use.

1.8 Structure of Thesis

This thesis is organised into 8 chapters. This section presents an overview of each of the chapters.

Chapter 1 presents the background to this study, the research questions, the scope of the study and its significance.

Chapter 2 presents a review of relevant literature on the concepts explored in this study: mathematics education, game-based learning effectiveness, technology adoption and acceptance, learning theories as well as the context of this study.

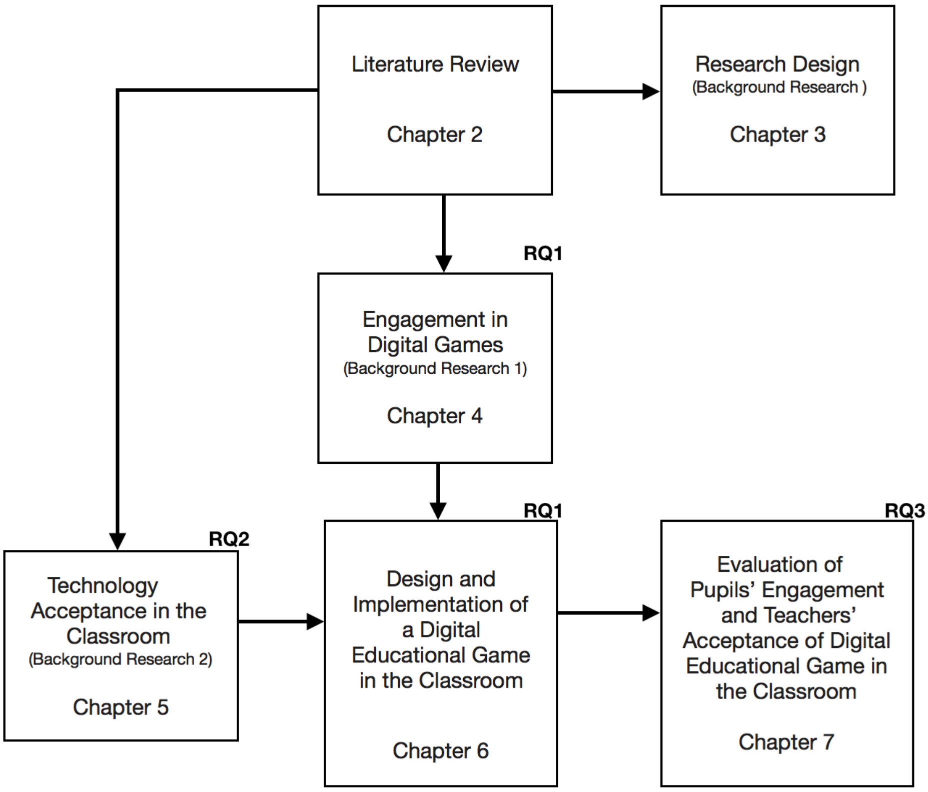

Figure 1.3 Relationship between areas of work done, research questions and chapters.

Chapter 3 describes the research design introduced here and provides more details about the research methods adopted for this study. It also details ethical considerations about the research as well as the rationale for the methodologies used.

Chapter 4 presents the research carried out with the aim of answering the first research question - *How can digital educational games be designed and developed to engage players*? Results and findings from the interview and questionnaire as well as the resulting framework are discussed. The chapter concludes with a set of design implications for digital educational games.

Chapter 5 presents the research conducted to answer the second research question - *What are the factors that determine the acceptance of digital educational games by teachers?* Working with a small group of teachers, it employs the original Technology Acceptance Model to examine the external variables that influence the intention of teachers to adopt digital educational games. The chapter discusses how the results from this were used to develop an extended TAM, which was tested with more teachers. Finally the chapter summarises the main implications for practice and recommendations for digital educational game designers and decision makers in educational settings.

Chapter 6 presents the rationale for developing a digital educational game. It brings together the findings from Chapter 4 and Chapter 5 to create guidelines for the design of a prototype game to teach mathematics in the classroom. It also presents various game genre types and suitable genres for learning games. The chapter discusses how the resulting design guidelines were used to develop the game, *SpeedyRocket* to teach mathematics in the classroom and concludes with a description of the implementation process in the classroom.

Chapter 7 presents an evaluation of the implementation carried out in Chapter 6. Each evaluation activity, its results and findings are provided. The chapter ends with a discussion about the findings presented.

Chapter 8 provides the main conclusion for the thesis. It presents the key original contributions to knowledge from this research study. It also includes a reflection from the researcher on the research process and findings, including lessons learnt, challenges encountered and limitations of the research. It also presents the key areas for future research.

2 CHAPTER TWO: Literature Review

This chapter provides an overview of the research literature related to digital educational games and mathematics in primary education. It is divided into three sections. These concepts are explored in wider contexts but also how they are particularly related to the Nigeria context. First, there is a review of mathematics education, its importance and challenges with respect to primary education. Secondly, the pedagogical benefits of technology are reviewed with a particular focus on how digital educational games could improve the educational experience in the classroom. Finally, the adoption and integration of technology in the classroom by teachers is discussed.

2.1 Mathematics in Primary Education

At different degrees, mathematics affects all aspects of human life. The social, economic, political, geographical, scientific and technological aspects of human beings are centred on numbers (Maliki et al. 2009). Davies and Hersh (2012) maintain that regardless of the profession an individual is involved in or their career path; mathematics remains an essential tool that prepares the individual for effective work. According to Umameh (2011) the knowledge of mathematics is not just for one's profession or national development, mathematics is intimately connected to our daily lives and life-long planning.

While the study of mathematics can improve the imaginative and cognitive capabilities of the mind (Etuk and Bello, 2015), its impact on national development is wider. Several studies maintain that the progress of any nation depends on their technological and scientific advancement, which largely rests on an efficient mathematics education system (Gravemeijer et al., 2017; Suratno, 2016; Tsafe and Yusha'u, 2014). Research shows that developed countries have benefited widely from well-planned mathematics curriculum and educational systems as it has proven to be the bedrock for scientific, technological and economic development.

The government of Nigeria is committed to developing its people in this respect and therefore made mathematics a compulsory subject from primary school to secondary school (Federal

Republic of Nigeria, 2004). In addition, any student who wishes to gain admission into any tertiary institution in Nigeria (colleges, polytechnics, universities) for study on any course, must pass mathematics at a credit level. The Nigerian government over the past years continues to invest millions of dollars into the teaching and learning of mathematics. The rationale being that they understand that it is a major driver in the push for development.

Despite the seemingly obvious importance of mathematics education and the efforts successive governments continue to put into improving mathematics performance across secondary institutions in Nigeria, no significant improvements have been recorded so far. Performances in the West African Senior School Certificate Examination (WASCCE) have been poor in recent years. Sa'ad and Rabiu (2014) reported that 75% of students who sat the WASCCE in 2010 did not make the minimum requirement of 5 credits including credit pass in mathematics. Although results from the past three years are an improvement on previous years, performances are still relatively poor given the awareness and resources the government seems to be putting into mathematics education. The Sun (2014), a popular news outlet in Nigeria, reported that out of about 1.6 million students who sat the WASCE in 2014, just over a third (38%) passed the minimum requirement including mathematics. Figure 2.1 shows the percentage of students who made 5 credits including mathematics and English from 2009 to 2016. Latest results show that just slightly above 50% of the total population of candidates that sat for the 2015/2016 WASCE passed both Mathematics and English (with at least 3 other subjects) with a credit pass.

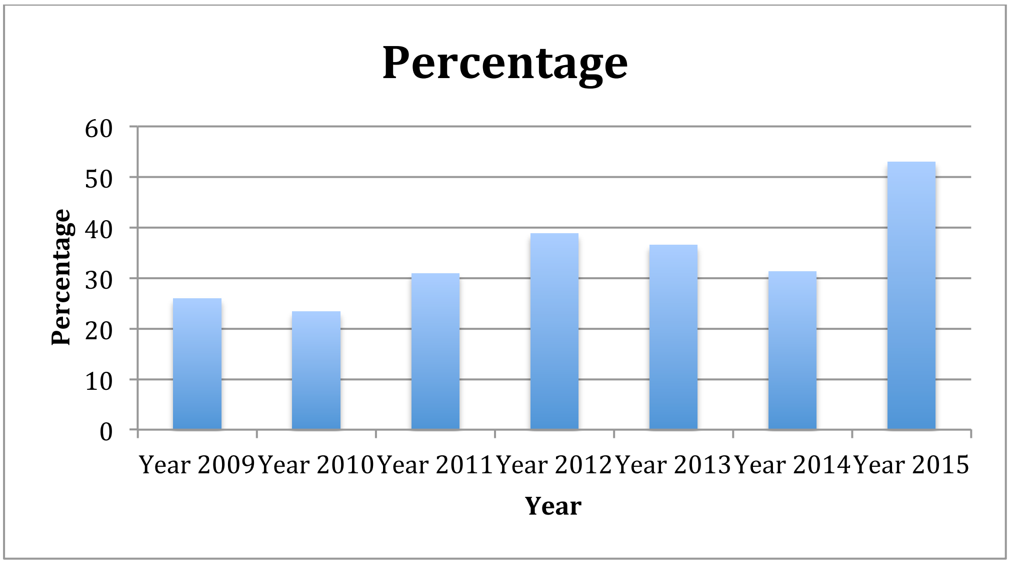

Figure 2.1: Percentage results of students in Nigeria who made five credits and above including Mathematics and English Language from 2009/2010 to 2015/2016.

While the government and academic institutions continue to find solutions to the continued poor performances, several studies that detail potential causes have been published over the past twenty years. Asikhia (2010) cited the work of Bakare (1994), which categorized the causes of poor performance in mathematics into four main areas:

i. Causations resident in the society, such as instability of educational policy; under-funding of the educational sector; mismanagement, leadership; job security and satisfaction.
ii. Causations resident in the school, such as school location and physical buildings; mathematics curriculum, teachers' training and skills.
iii. Causations resident in the family, such as cognition stimulation/basic intuition during the first two years; type of discipline at home; lack of role model and finance.
iv. Causations resident in the child, such as basic cognition skills, physical and health factors, psycho-emotional factors, lack of interest in school programme.

These categories can be further summed up in these key areas: government/wider society, family and the student, school/classroom, and they seem to sufficiently cover the individual factors identified by other studies.

i. Government and wider society factors

Several studies (Babikkoi, 2014; Adetula et al., 2017; Matthew, 2013; Bolaji, 2014) have espoused on how government policies and under-funding of the educational sector have caused poor performance in not just mathematics, but other subjects as well. In spite of the admittance of repeated governments on the importance of adequate funding for good education, allocation to the education ministry on which primary and secondary education largely depends is usually one of the least in the Nigeria budgets over the years. Central Bank of Nigeria's (CBN, 2010) data showed that allocation to the Education ministry between 2000 and 2010 did not exceed 14% of the national budget. In the 2017 budget, there was a sharp drop to 6% of the total national budget – the lowest since 2012 (Ndujihe, 2018). Compared to developed countries, and even some developing ones, this allocation of the Nigerian government to education is low with respect to the 26% recommendation by

UNESCO – of which Nigeria is a member (Nzekwe, 2008 cited in Ibe et al 2016; Matthew, 2013). The state governments in Nigeria model this poor funding as well. According to Oyedeji (2016) in 2016, 33 states of the federation allocated a combined 10.7% of their total budget to education, resulting in a nationwide strike of the Academic Staff Union of Universities calling for increased budgetary allocation to the education sector.

Apart from the problem of inadequate funding, mismanagement of allocated funds is another challenge mathematics education faces in Nigeria. According to Umar and El-yakub (2017) the lack of accountability and transparency in spending has resulted in allocated funds being diverted and embezzled by government staff and politicians. The low allocation has led to several other issues like incessant strike action by teachers requesting better pay (Ugwuona, 2016), low morale in the classroom (Wilson, 2016), inadequate instructional materials and infrastructure for effective teaching and learning in secondary schools, all of these ultimately affecting the performance of students. While on the surface, the government seem to be good at planning laudable programmes to improve mathematics education, given that the success of any intervention depends on proper funding, the commitment of the Nigerian government to this cause is doubtful if its policies and budgetary allocation are to be considered.

Increase in population has had a corresponding effect on class sizes across schools in Nigeria. Idowu (2016) suggests that overcrowded classrooms hamper effective teaching and learning of mathematics in Nigeria. In some situations, students do not have desks, and those that do have to share small desks with others, leaving little or no space to write. Overcrowded classes also mean that the government recommended student-teacher ratio of 50:1 (Asikhia, 2010) is not feasible, with some classes recording as high as 100:1 (Umameh, 2011). Alagbe (2012) as cited in Etuk and Bello (2015) reported that the issue of poor teaching quality is compounded by the inadequacy of specialised teachers in mathematics for the number of schools and classes that need them. This has resulted in many primary and secondary schools engaging the services of people who have not been trained to be teachers or to teach mathematics to fill this void. This has been a long-standing problem as Science Teachers' Association of Nigeria (STAN, 2002) listed the acute shortage of qualified mathematics teachers as one of the prominent causes of poor performance in mathematics.

Avong (2013) in a study in Kaduna, northern Nigeria found that a shortage of qualified teachers was the highest ranked factor to the poor performance of students in mathematics in the state. Yemi and Adeshina (2013) also maintain that the poor quality of teachers negatively affect students' performances in mathematics. Thus the challenge is two-faced; one is the shortage in the number of teachers while the other is the qualifications and preparedness of teachers. The teaching profession in Nigeria is not one that is attractive as research shows that there is a general opinion that the government do not treat teachers well (Akiri, 2014; Ekundayo and Kolawole, 2013).

The attitude and motivation of mathematics teachers has been shown to be another reason why students perform badly (Vudla, 2012) as cited in Tshabalala and Ncube (2014). Several of the factors identified earlier – inadequate resources, low level of training and professional development, overcrowded classrooms and poor curriculum are possible reasons for teachers' poor attitude to teaching. According to Okafor and Anaduaka (2013) when a teacher displays a lack of competence or confidence in mathematics, students may lose confidence in teacher and the subject altogether.

The mathematics curriculum itself is another challenge identified in the literature. According to Etuk and Bello (2015), the ineffective delivery of mathematics concepts to students could be linked to the curriculum contents. They suggest that some of the content of the mathematics curriculum and textbooks are foreign and so sometimes not relatable to by students. There are concepts that are abstract in mathematics and research has shown that learners find it much harder to understand the theories when the materials and methods used by teachers are not sufficiently clear. Etuk and Bello (2015) further suggest that since the introduction of 'modern mathematics', the curriculum has been a subject of controversy between teachers and mathematics practitioners in Nigeria. Teachers across primary and secondary schools are also under pressure to 'cover the syllabus,' rather than ensuring meaningful learning takes place (Adegoke, 2017).

ii. Family and student individual factors

Lack of confidence in the ability to understand mathematics by students is related to misconceptions about the subject as being 'difficult'. According to Adebule (2004) many students express "unparalleled hatred, indifference, anxiety and poor attitude towards mathematics" while some even regard it as a subject to be avoided at all cost (Tshabalala and Ncube, 2016). Results from a study of mathematics achievements of junior secondary school students in Borno State, Nigeria by Garba and Hamman-Tukur (2015) showed a negative relationship between anxiety and mathematics achievement. It further suggests that the main cause of anxiety is the fear of failure among students. Anxiety and attitudinal problems towards mathematics and education in general is partly due to the display of lack of competence and confidence by the teacher (Okafor and Anaduaka, 2013) as well as the students' personal or home challenges. A high level of student discipline and morality is usually a reflection of their experience at home. Matthew (2013) suggests that indiscipline amongst students, which is characterised by truancy, lateness to school, and other vices, is one of the reasons for poor performance in mathematics. Other home-related challenges include absenteeism as well as parents being nonchalant about their children's performances (Karue and Amukowa, 2013).

iii. The Challenge Of The Nigerian Classroom

As Bature et al (2016) maintained, the mode of teaching as well as the classroom climate impacts on the attitude of students towards a particular subject. According to Bierman (2011) classroom climate is "the classroom environment, the social, emotional, intellectual and the physical aspect of the classroom". Research has shown that students experience the classroom as not just an intellectual space, but as a social and emotional environment, one that can enhance or hinder their learning experience (Schenke et al, 2017; Scrimin et al, 2018; Barksdale, 2017). Thus, the climate of the mathematics classroom has enormous influence on a child, not just emotionally and intellectually but can also either positively or negatively impact on their mathematics attitude (Adimora et al, 2015).

The experience of mathematics in Nigerian classrooms therefore poses a challenge to young peoples' attitude to mathematics. The traditional classroom in Nigeria is passive, un-engaging and boring. According to Bature et al (2016) most classroom activities are teacher-centered with students as mere listeners and recipients of knowledge playing passive role in knowledge acquisition. This agrees with Okafor et al (2013) who maintain that most talk comes from the teachers while the pupils listen or writes what is on the chalkboard. Students also work individually to solve problems and submit their completed tasks to the teachers to be graded. These traditional teaching methods and strategies do not have a multi-sensory effect on pupils. Ajayi et al (2017) suggested that this style of teaching is one of the reasons students develop negative attitudes towards mathematics.

Classroom sizes also present a challenge to an enjoyable experience by young people and teachers in Nigeria. Due to over-population and inadequacy of teachers, many of the classes in Nigeria are overcrowded. This classroom structure often results in young peoples' loss of attention and disengagement during teaching. Ajayi et al (2017) suggests that when classroom sizes increase and become unmanageable, teachers are left with an impossible task of giving individual learners the deserved attention, leaving unmotivated learners disconnected and un-engaged. Ayeni (2017) explored the relationship between effective classroom management and the learning outcomes of students. In that study, 75% of the teachers sampled listed congested classrooms as a main constraint to effective classroom management. In a similar study, Ajayi et al (2017) examined the impact of class size on students' classroom discipline, engagement and communication. The study revealed that class size had a significant influence on engagement; it also recommended a maximum of 40:1 student-teacher ratio for effective classroom discipline, engagement and communication. This recommendation is substantially higher than UNESCO's of a standard 25:1 student-teacher ratio (UNESCO, 2016).

Several potential solutions to improve the performance of students in mathematics have been suggested in literature. Mbugua et al. (2012) believes that adequate staffing, better teaching and learning resources and materials, as well as an improved curriculum would improve students' performance in mathematics. Two strategies suggested by Ojimba (2012) include incorporating the concept of constructivism, and the use of computer-aided instructional material such as games. To address the issue of phobia for mathematics, which is one of the reasons for poor performances, Bornstein (2011) suggested that a way to improve the attention of students in the classroom is to build their confidence in the subject. According to Okafor and Anaduaka (2013) one way to build confidence is by encouraging discussion in the classroom. They challenge teachers to disrupt the typical classroom method in which they do most of the talking while the students just sit, write notes and practice whatever the teachers do. Allowing students more involvement in their learning journey engages them more and boosts their confidence in trying things out by themselves. One of the findings of Sule et al's (2016) study of mathematics phobia among students in Nigeria is that students' interest is attracted when physical and visual objects are used in teaching and learning mathematics concepts. Similarly, Etuk and Bello (2015) opined that the usual memorization method of teaching mathematics is archaic and therefore not useful in the 21st century. They suggested that to increase the prospects of mathematics education, better teaching methods that are friendly and student-centred would help 'unveil the reality of mathematical concepts to the learners'. One of the ways abstract concepts in mathematics can be brought to life for the student is through the use of game-based environments in teaching.

Okafor (2013) recommends a strategy that encourages discussion, and diversifies the learning experience. In order to create an engaging experience for students, mathematics classrooms should introduce ways to make learning exciting and adventurous. A shift from the traditional method of teaching to those that engage better by appealing to more than one sense organ (Ajayi et al, 2017) is recommended. In contrast to the passive setup of classrooms in Nigeria where it is often frowned upon to speak, Okafor et al (2013) also suggested that communication with peers and teamwork must be encouraged. Barriers to sharing and talking amongst the students and teachers should be removed. The learning experiences of students should also be varied especially as the attention span of young people can be very short (Petty, 2004) especially when dealing with complex subjects like mathematics (Tolks et al, 2016).

2.2 Benefits of Technology

Research has shown that one of the potential ways to diversify the learning experiences of young people in the classroom, and promote active learning is by using technology (Butler et al, 2014; Hwang et al, 2015; Richards, 2015). Boticki et al (2015) maintain that technology offers new ways to learn such as providing authentic learning environments that enhance the learning experiences of students. Research has also shown that learners' engagement improves when learning occurs through technology (Lu et al, 2014; Rashid and Asghar, 2016). Learning using technology enhances engagement by promoting instant access to information and proving hands-on learning

(Cheng et al, 2016). Churchill and Wang (2014) also argued that technology results in high motivational effects, serving as tools to reinforce students' learning process.

Immediate feedback is one of the particular benefits technology offers to the classroom (Shirley and Irving, 2015). This is particularly potentially beneficial to classrooms in Nigeria where it is often difficult for teachers to provide adequate feedback to pupils on their performances due to classroom population. Immediate feedback is a key ingredient for self-regulated learning as it provides information about how well one is performing on a task (Zimmerman and Labuhn, 2012). It also provides information about goals and learning process, both of which are essential to self-efficacy, motivation, and improvement in cognitive and metacognitive performance (Schunk, 2003; Saadawi et al, 2008).

Another benefit technology offers the learning experience in the classroom is the allowance it affords learners to make mistakes (Saba, 2009; Estes, 2016) without the concern of grievous repercussions. Due to the demand on the teacher in a traditional classroom and the number of students they have to attend to, the time to allow individuals try as many times as possible is often unavailable. The use of virtual reality and in particular simulated learning environments allows learners to make mistakes and learn in a non-public manner (Saba, 2009). This supports learning and re-learning as often as required by allowing the learner to make mistakes and perfect their learning.

Closely related to the allowance to make mistakes is the ownership of the learning process technology provides for students. The use of technology in the classroom promotes autonomous learning (Pombo et al, 2017). It allows students own and control their individual learning and create paths for themselves they can follow through. This also changes them from being passive participants to becoming active co-creators of their own learning process.

In like manner, technology supports collaborative learning, allowing students to share and cooperate while learning (Akpabio and Ogiriki, 2017; Jahnke and Kumar, 2014). This can be particularly useful in increasing communication between students and teachers as the technology use fosters sharing comments, feedback, doing group work and engaging in rich discussions (Boticki et al, 2015).

2.3 Learning in Game-based environments

In the past few years, digital games have come to replace most of the traditional games while at the same time establishing their impact on how leisure time is spent. This is largely due to the availability of new consoles, platforms and technologies for the delivery of games (Connolly et al, 2012). The increase in the number of games and the amount of time children (and adults) spend playing them has made researchers more interested in conducting various studies on gaming.

Digital games are one of the many technologies educators are using in the classrooms. While there are claims from some studies that digital educational games have improved learning and knowledge acquisition (Garneli et al, 2017; Hamari et al, 2016; Riemer and Schrader, 2015), results of digital games use on learning should be treated with caution (Southgate et al, 2017). This is because of the lack of published randomised control trials and rigorously designed empirical studies that investigated learning outcomes and digital educational games (Boyle et al, 2016; Girard et al, 2013). However, digital educational games are still useful in the classroom, especially in enhancing the interest of learners. Research shows that the main reason teachers use digital games is to improve students' motivation to learn (Khan et al, 2017; Ma et al, 2017; Plump and LaRosa, 2017).

Digital educational games also accommodate various learning styles and pace, which can result in increased motivation for students. Given the way many digital games are designed with several short-term goals and a long-term goal, players can make progress and have a sense of progression by achieving the short-term goals (De-Marcos et al, 2014). As Su and Cheng (2015) argued, the feeling of competence derived from achieving the short-term goals may give the learner, continued motivation in the learning journey.

One of the ways digital educational games is being used to enhance experience and motivate learners is by providing context and live examples of curriculum content in the classroom, what is otherwise referred to as situated learning (Hsu, 2017). Preston et al, (2015) argues that this feature of situated learning promotes experiential learning and assists learners in understanding the application of the concepts they are learning. Hsu (2017) also affirms that it improves on the traditional one-way teaching by getting students to actively engage in the learning environment themselves while changing the role of the teacher from instructor to facilitator. This agrees with the values of constructivism. Constructivists believe that for learning to occur, context is very important. They stress that effective learning happens when the task and context are real and tangible to the learner (Anderson, 2017). Digital educational games present a learning environment that engenders related context. Through the active engagement of the learner in the process, they are offered the opportunity to learn by going beyond already established formulas or solutions to developing their own solutions that work in different contexts and scenarios.

Digital educational games also provide a collaborative learning experience that promotes more cooperation and engagement in the classroom. Cecez-Kecmanovic and Webb (2000) suggest that more effective learning occurs during interpersonal interactions in a co-operative environment rather than a competitive one. Advocates of collaborative learning have further argued that it improves communication and dialogue between participants in the group, thereby making them more critical learners (Lane, 2016). Working with others also exposes learners to a wider range of other learners' learning styles and perspectives causing them to appreciate more variety (Palloff and Prat, 2003).

Most collaborative platforms in education provide environments where small groups of students are presented with the opportunity to work together in order to solve problems for the purpose of learning (Cheung and Vogel, 2013). Some game-based learning platforms are examples of these environments that are built on the characteristics of collaborative learning theory. Research has shown that gamers now interact in sophisticated environments that gives them the self-directed freedom to explore to test out new ideas and develop innovative skills during play (Twining, 2010).

2.4 Examples of Game-based environments

Games are usually mentioned along with virtual worlds and educational simulations, and although the three are similar, they are not synonymous. Despite the amount of research conducted recently on each of them individually, very little literature has concentrated on exploring their differences and relationship. However, Aldrich (2009) maintains that despite the fact that the three can look similar in operation, they each have their own individual peculiarities.

According to figure 2.2, Aldritch (2009) describes them as points along a continuum and all being highly interactive virtual environments (HIVEs) with their individual and different affordances and purposes. All three (serious games, educational simulations and virtual worlds) can be set in 3D worlds and 3D avatars. However, a virtual world cannot be used in the place of an educational simulation simply because it provides context and no content and even though an educational simulation can occur in a virtual world, it still has to be rigorously designed and implemented. In the same vein, virtual worlds are different from serious games (Aldritch, 2009).

Derryberry (2007) maintains that Second Life (one of the most popular virtual worlds) has striking differences to a game as it lacks the components in a game definition – modes of play, levels of play, rules, chance and distinct outcomes.

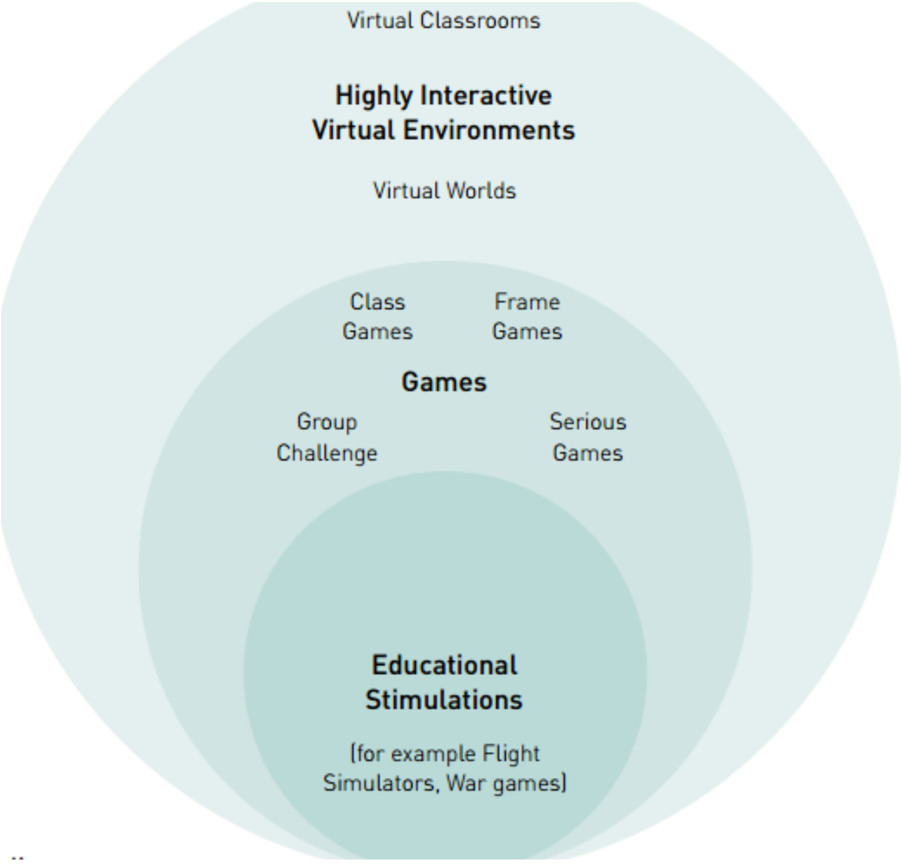

Figure 2.2 The HIVE continuum (Aldrich, 2009)

A. Virtual worlds

The past few years have witnessed a growing interest in the use of 3-dimensional virtual worlds for different purposes ranging from entertainment to training and education. Virtual worlds such as Second Life, jibe and lately *Minecraft* have gained popularity among people of all ages and contexts at different times. This recent increase in interest and popularity can be attributed to the enormous advancements in computing technology as well as network infrastructure. Records provided by Linden lab, the maker and creator of Second Life – one of the most popular virtual worlds – suggest that as of 2010, the number of unique users stands at over 750,000 and these users collectively spend over 105 million hours (in the third quarter of 2010 alone) in the virtual online world (Linden Lab, 2010).

According to Mennecke et al (2007), a virtual world is 'a computer-generated boundary-less, immersive 'game-like' environment often equipped with three-dimensional graphics that resembles the real world'. Liao et al (2014) considers a virtual world to be an electronic environment, which visually mimics complex physical spaces wherein people are represented by avatars and interact with each other via virtual objects. These definitions suggest that one of the unique features of virtual world is their ability to imitate realistic worlds, while enabling users to participate and engage with each other as well as with the virtual objects that are created and maintained exclusively within the virtual environment (Menneck et al, 2007). Furthermore, users are capable of creating virtual characters (avatars) to represent themselves and partake in activities on their behalf. Using the avatars, users can also interact with each other using body language, voice, text messages and other media (Michael et al, 2013). Despite the fact that many virtual worlds target the entertainment market, the unique and special features they offer open them up for use in learning and training. This is because they can provide students with 'real-world like experiential learning' (Michael et al, 2013).

Kemp and Livingstone (2006) opined that one of the prevailing reasons virtual worlds are being explored for educational purposes is their ability to provide synchronous communication and collaboration. This has led universities and several other educational institutions to adopt virtual worlds for teaching and learning. The Harvard Law School for example has offered virtual courses in Second Life (Brown and Adler, 2006) with interactions taking place between instructors and students within the virtual world environment.

Generally, there have been positive reviews and comments from users using virtual worlds for learning. Students who played 'Nutrition Game', a video game created in Second Life, were asked to provide their opinions on how effective the game is. Cooper (2007) found that most of the students gave positive reviews about the game as they found it 'engaging and informative'. Likewise, a study of the users of the virtual courses in Harvard Law School virtual world shows that the overall responses were positive (Brown and Adler, 2008).

However, using virtual worlds in education and learning also presents some challenges and disadvantages. Some research work has highlighted some problems with virtual worlds, especially Second Life. One major challenge identified by Jarmon et al. (2008) and Vogel et al. (2008) is that it is difficult for some students to see the value it provides, while according to FitzGibbon et al. (2008) some just did not take it seriously. A survey carried out by Warbuton and Perez-Garcia (2009) on several literatures and online sources revealed several downsides and challenges reported about Second life. These they grouped under eight broad categories: Technical, Identity, Collaboration, Standards, Economic, Scaffolding Persistence and social discovery, Standards and Time. However, only five of these have direct impact on learning within Second Life: Technical, Identity, Time, and Economic.

i. Technical

From high consumption of bandwidth and machine power (Franklin et al, 2007; Chow et al, 2008) to issues of server downtime and management of client interface, the technical challenges Second Life presents are capable of causing users to have experiences inconsistent with the real world scenario.

ii. Identity

In Second Life, identities are not fixed and so it is possible to find it hard to know who did what. This poses a serious challenge to building social relationships, as consistency of personality cannot be assumed. Similarly, it becomes a problem to ensure accountability for actions taken.

iii. Time

In Second Life, the simplest things can consume a lot of time. The process of creating, designing and ensuring teaching contents conform to Intellectual Property laws can be rigorous and time consuming. Furthermore, to effectively carry out these functions, educators often need to develop extra skills.

iv. Economic

The financial implications of implementing learning content on Second Life might be weighty on educational institutions. Although a basic account is free, anything beyond that – creating teaching spaces, uploading teaching materials and buying in-world tools – costs money. Virtual worlds like Second Life offer considerable potential for teachers, learners and other stakeholders working to use this technological environment to improve educational delivery. However, just like other educational tools, research suggests the potential should be considered carefully and the challenges in managing it weighed equally in the process of making a decision to adopt or not to adopt it.

B. Educational simulations

Teaching and training students in engineering and science is getting increasingly challenging (Yoon et. al., 2017; Ødegaard et al., 2014). One of the reasons for this is the abstract nature of science and engineering concepts, and the ability of students to understand the logic, and relationships involved in scientific processes (Nikolic et al., 2010). The use of educational simulations has been found to be one of the approaches to handling this challenge. This is because an educational simulation is built on a model of a real-world phenomenon in which some components have been made simpler or even totally omitted for the main purpose of facilitating learning in an effective way (Lunce, 2006). Perhaps, the most important use of educational simulation is the provision of real world scenario-like experience. Jones et al (2014) opines that while it might be difficult or even impossible to construct a building with various configurations, apply various loads and manipulate it in the real world, simulations make this achievable.

Simulation has also been found to be a capable strategy to stir the interest of middle school students in health careers (Sweigart et al, 2014). Flanagan, Nestel and Joseph (2004) defined simulation as 'the artificial representation of a real-world process to achieve educational goals via experiential learning,' while Aldrich (2009) stated that educational simulations are designed to use vigorously structured scenarios with highly defined sets of rules, challenges and strategies which are constructed to develop particular competencies, skills or knowledge that can be directly transferred to the real world.

The use of simulation as a new and innovative teaching and training strategy in combination with other traditional teaching methods has been well documented in existing literature (Parker and Myrick, 2009; Weaver, 2011). Particularly, educational simulations have been widely used especially in medical and nursing education to provide more experiential learning in a safe environment for students (Sweigart et al, 2014). In recent pasts, human patient simulators like iStan (CAE Healthcare, Saint-Laurent, Canada), which are technologically enhanced manikins that interact with students like real patients, are being used in combination with traditional clinical training methods. The use of educational simulations as an adjunct to other traditional teaching and training methods has been found to be effective in some quarters. Using an experimental design to analyse knowledge gain predictors among nursing students who used simulation as part of their training methodologies, Shinnick et al (2012) discovered that regardless of the age or preferred learning styles of the students, using the human patient simulators proved to be an effective teaching strategy. This might be due to the fact that educational simulations offer some advantages over some other instructional methodologies or media.

According to Alessi and Trollip (2001), students generally find active participation in simulations to be more interesting and motivating as they appear to be closer to real-world experiences in comparison to other learning methodologies. The degrees of control the student and teacher has over a simulation process is also a positive thing as it will be easier for the variables to be manipulated frequently with little or no risk (Hung and Chen, 2002). Perhaps the major advantage of educational simulation is the allowance it gives students to experience and practice processes and activities that could be dangerous, costly or sometimes impossible in the real world (Alessi and Trollip, 2001).

However, educational simulations have their own drawbacks. One of the major ones is that the design and development of educational simulations involves extensive planning and can consume a large investment in time and financial resources (Lunce, 2006). Furthermore, Leemkuil et al.(2003) argues that even with the potential educational benefits simulations offer, without proper orientation and reflection students can end up interacting with simulations merely as a game, thereby not gaining much educational value.

C. Serious games

Following recent invasion of the entertainment industry with different kinds of digital games, there has been an increase in the interest of researchers in exploring the potential games offer for learning. According to Meluso et al (2012) some research work argues that serious games can make a positive impact on learning by providing an 'intrinsically motivating and engaging learning environment' for learners across several fields in ways and manner that traditional school methods cannot. In literature serious games have also been referred to as 'educational games' (Dumitrache & Almăşan, 2014), 'computer games' (Amory, 2001), 'video games' (Gee, 2003), 'game-based learning' (Meluso et al, 2012) and 'instructional games' (Sitzmann, 2011).

Although the concept of serious games still lacks a simple definition (Bourbia et al, 2014), according to De Freitas (2006) they are 'applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specific learning goals, outcomes and experiences,' while Barbosa & Silva (2011) refer to '*all games that engage the user and simultaneously contribute to the achievement of a certain objective other than just entertainment, whether the user is aware of the fact or not*.'

Julian (2007) suggests that a serious game is any computer application whose objective is to combine teaching and learning amongst other educational aims with the elements of entertainment from normal games. Desmet et al (2014) share this view as they consider serious games to be both educational and fun. The main distinction between serious games and traditional digital or video games is in their aim. Serious games are aimed at educating or facilitating the transfer of skills or knowledge (Kato, 2010). From literature (Annetta, 2010; Kapp, 2012; Boyle et al., 2012), the learning effects of serious games are derived from three usual sources:

i. Through the creation of immersion, which leads to the player becoming absorbed and engaged in the game thereby, creating experiences and connections with the character.
ii. By satisfying a player's urge for challenge, autonomy, diversion, fantasy or mastery.
iii. By establishing a flow through which the individual experiences a balance between knowledge acquisition and challenge.

Serious gaming has been explored in several areas from medicine and life sciences to sports and language education. De Paolis (2012) put forward a serious game for training on suturing in laparoscopic surgery. It is built around pre-defined sets of parameters that are used to assess the level of skills developed by trainees. In the same vein, a team made up of researchers from the Serious Games Institute in Coventry University and the Studies in Adolescent Sexual Health (SASH) research group created a serious game to support relationship and sex education within a classroom setting (Arnab et al, 2013). In language learning, Johnson et al (2005) examined the Tactical Language Training System, a serious game that provides rapid acquisition of foreign language and cultural skills.

Over time, there has been considerable use of serious games in vocational areas than in formal education (JISC, 2007). According to Sara de Freitas (2006), this might be connected to the fact that vocational areas of learning are more experiential and they model more problem-based learning approaches. Furthermore, the vocational areas involve 'learning how' rather than 'understanding how,' which is the usual and common way in formal education. Nevertheless, regardless of the domain in question, serious games have been found to have the capability to integrate with existing and ready-made educational tools to provide a unique learning experience for students (JISC, 2007).

2.5 Learning effectiveness and player engagement in serious games

Proponents of game-based learning maintain that games can support learning through increased motivation, better problem-solving skills, increased engagement and the provision of real-life applicability of concepts (Yang, 2012; Ypsilanti et al, 2014; de Freitas and Oliver, 2006). However, despite the general conception from literature that serious games have the capability to aid students in achieving learning objectives using a fun-based approach, there are still some concerns and questions in research concerning the educational benefits serious games can actually provide (Mouhaheb et al, 2012). Other concerns include finding the optimal balance between entertainment and education (Cowley et al, 2013), what game features promote learning, the extent to which games can assist students in learning (Butler, 2014) and how serious games help in engaging learners as well as ensuring learning effectiveness. However, it appears that the most common question in the debate about whether to use or not to use games for learning remains: Is learning *possible* with serious games?

Given how popular the subject of games for learning is at the moment, it is no surprise that several reviews and studies that examine the evidence of learning in games are being carried out. Due to the increase in the number of these studies, it is difficult to conduct a review that covers the whole subject area (Tobias et al. 2011), as the review would have to use diverse criteria for selection of studies and also focus on different topics (Backlund and Hendrix, 2013). Boyle et al (2016) carried out a systematic review of literature that presented empirical evidence of the outcomes and impacts of computer games and serious games from 2009 to 2014.

One hundred and forty three high quality papers were found which provided positive outcomes of games. There are majorly two categories for these studies - those comparing a game-playing group with a control group with respect to a specified learning outcome, and those examining how the characteristics of game players influence the outcomes. Their review found evidence for diverse outcomes: knowledge acquisition, behaviour change, soft and social skills. One of the most common ways the educational effectiveness of serious games has been studied is by the evaluation of predefined learning outcomes and knowledge acquisition (Calderon and Ruiz, 2015; Petri and Von Wangernheim, 2016; Castellar et al, 2015).

Arnab et al (2013) provided evidence that their serious game designed to support relationship and sex education within a classroom setting improved the understanding and the psychological preparedness to deal with sexual coercion amongst students. They found that the serious game was more effective than the control condition with respect to knowledge acquisition. In their study, Nishikawa and Jaeger (2011) proposed that computer-based games could be used to implement active learning goals. They conducted an experiment in which participants were assigned to either a class using a computer game or a traditional lecture. Their results provided evidence that games are as effective as traditional classroom lectures and even create better retention of the learning concepts on a long run.

More recently on knowledge acquisition, Castellar et al (2015) explored the differences between training with Monkey Tales (a commercial game used for training arithmetic skills in children) and paper exercises. In their study, children in grade two (in the United States) were randomly grouped into two classes – one to play an adapted version of Monkey Tales for three weeks and the other to complete maths drill exercises over the same course of three weeks. Using pre- and post-tests, they reported that pupils who played the game increased their accuracy in mental calculation more than the pupils who completed drill exercises. A critical step in developing serious games that will be effective and engaging is identifying the game features that promote learning (Butler, 2014).

Some researchers have studied various game designs features that make an effective serious game. Tao et al. (2009) carried out research on 185 Taiwanese higher education students who have used a business simulation game in previous classes. It was discovered that perceived playfulness is positively associated with students' satisfaction as well as a desire to keep using the game. Other characteristics include well-defined goals (Kiili, 2005), feedback (Sweetser and Wyeth, 2004; Burgers et al, 2015) teamwork and cooperation (Billieux et al., 2013) and self-efficacy (Klimmt and Hartmann, 2006).

However, there still seem to be a shortage of evidence-based studies done in this regard. Garris et al. (2002) and Butler et al. (2014) both suggest inconsistency in the results of most of the studies carried out within the educational context to identify these game features, with Garris et al. (2002) maintaining that 'there is little consensus on game features that support learning, the process by which games engage learners or the types of learning outcomes that can be achieved through game play'. Essentially then, game designers and developers end up making serious games to be 'fun' and 'effective' based on personal intuitions and experiences rather than research-proven elements that have been found to make the games such. Therefore while the value of digital games in engaging young people may be obvious, there still need to be more empirical tests to confirm what the features that support learning effectiveness are in games, as well as the learning outcomes that can be derived from serious game play using rigorous methodological approach.

2.6 Technology acceptance in the classroom

The design and introduction of games in the classroom can support a more active learning experience (Grimley et al., 2011; Panoutsopoulos and Sampson, 2012) by offering students more control over how they learn (Conde et al, 2012), in line with the constructivist theory. However, like any other technology, it is important to take the users' wants and peculiarities into account during the design, development and final introduction of the technology. This is particularly important when introducing informal tools like games into formal environments like the classroom, as research has shown that such attempts often have no continuity, and mostly do not produce expected results (Sanchez-Prieto et al, 2016).

Pupils and teachers are regarded as the main users of technology in formal settings like the classroom, and while pupils are keen to embrace technology, often the barrier to acceptance is the teachers (Nair and Das, 2012). Research also suggests that most of the studies on acceptance of technologies is focused on students with little or no attention being paid to the teachers (Sanchez-Prieto et al, 2017). Chen et al. (2009) maintain that one of the major determinants of a successful integration of new technologies in the learning process is its acceptance by teachers. This is in addition to educational research findings which suggest that teachers will only use a technology in the classroom if they believe it will aid their professional duties either administratively or in teaching (Schifter, 2008). Therefore, to ensure the adoption and effectiveness of game-based learning, we need to understand the perception, beliefs and reservations of classroom teachers (Kriek and Stols, 2010; Bourgonjon et al., 2013).

2.7 Adoption And Integration of Technology In The Classroom

As established from literature, technology can improve the efficiency of both instructional and non-instructional classroom activities. However, while the development of Information and Communications Technologies (ICTs) tools to enhance classroom experience continue to increase, adoption, integration and use of these tools have not witnessed the same progress (Mirzajani et al, 2016; Aziz and Rahman, 2017) particularly in developing countries like Nigeria (Isiyaku et al, 2018). In like manner, Lawrence and Tar (2018) argue that despite the huge spending of governments and various organisations in developed countries on ICTs for education, the return on investments have not been apparent due to little evidence of ICT adoption and use.

Most of the research around technology adoption and integration in the classroom has been done with teachers (Dougherty, 2015; Pareja et al., 2018; Scherer et al., 2018). "In a classroom, the teacher perceives and defines a teaching situation, makes judgements and decisions and then takes related actions" (Chen, 2008). The role of the teacher is therefore central to the adoption and effective integration of technology in the classroom and this explains how much focus it has received. Research also suggests that understanding teachers' pedagogical beliefs is the only way to fully understand technology adoption and integration (Sang et al, 2010; Liu, 2011; Burke et al., 2017; Bano et al, 2018)

Several studies have examined the slow pace at which technology is adopted and integrated in education by teachers (Hu and Yelland, 2017; Salinas et al, 2017; Lawrence and Tar, 2018). Many of these studies have been done in developed countries, where digital inclusion is wide and government is committed leveraging ICTs for educational transformation. In the United Kingdom for example, in 1998, the National Council for Educational Technology was expanded and formed into the British Educational Communications and Technology Agency (BECTA) in 1998 and tasked with promoting and integrating ICTs in education (Lee and Caldwell, 2010). Bodies like BECTA tried to improve ICT adoption and integration by producing evidence for the impact of ICTs like interactive whiteboards, broadband and PCs on learning gains (Hammond, 2014).

The barriers to technology adoption and integration have been discussed and categorised severally in literature (Porter et al, 2016; Reid, 2014; Burke et al, 2017). However, most studies adopt two main areas of classification (Bingimlas, 2009; Makki et al, 2008). These are external barriers – barriers related to resources and institutions, internal barrier – those related to teachers and their attitudes. Ertmer (1999) describes these two classifications as first-order (extrinsic to teacher) and second-order (intrinsic to teachers) barriers. Table 2.1 shows some of these barriers as explored by Ertmer (1999)

First-order barriers	Second-order barriers
Extrinsic to the teacher	Intrinsic to teacher (and possibly subconscious or 'private theories')
Lack of access to technology	Beliefs about teaching (and learning)
Insufficient time to plan for integration	Beliefs about computers and technology
Lack of training	Beliefs about classroom practices and routines
Inadequate technical and administrative support	Unwillingness to embrace change

Table 2.1: First and second-order barriers to technology integration (Ertmer, 1999)

Recently, Tsai and Chai (2012) added a classification – third-order barriers, which relate to teachers' ability to set learning experiences considering learners' context and needs. They questioned if removing first and second order barriers would automatically cause technology adoption and integration to happen. They further argued that due to the dynamic nature of the classroom, a teacher's ability to create learning materials and adapt the instructional needs of the learner for different contexts is equally as important as their access to sufficient facility, resources, positive attitudes and beliefs.

There is a lack of research on the adoption and integration of technology in education in Nigeria. However, the challenges of availability of devices, and access to technology, as well as training of teachers have been reported (Oluwatunbi and Olubunmi, 2017; Asubiojo and Ajayi, 2017), which are all first order barrier. There is also some evidence of the presence of second-order barriers. Kwache (2007) highlighted teachers' attitude as one of the barriers to effective adoption of technology in education in Nigeria. Research suggests that teachers' motivation to incorporate technology in their classroom practice may help address first-order barriers (Ward and Parr, 2010; Makki et al, 2018). This suggests putting more priority and focus on understanding and addressing second-order barriers.

The challenges of first and second order barriers are more common in low-income populations like Nigeria. Purcell et al (2013) suggest that in places like that (low-income economies) teachers are twice likely to cite lack of access to digital technologies as a “major challenge” in their schools. This lack also potentially affects their self-efficacy, preparedness, attitude and willingness to adopt technology in the classroom. As mentioned earlier, there is shortage of which of the orders present the most challenge in Nigeria. However, the attitude of teachers and the commitment of government to teacher training and continual professional development indicates the presence of the first, second and third order barriers. These barriers are interconnected and research will benefit from more work to understand the stance of teachers in Nigeria towards technology adoption.

Likewise, research has called for a deeper understanding of the potential connections between intention and behaviour at individual and institution levels with respect to particular contexts (Harrison et al, 2014).

In research about information technology or information systems’ adoption, the most commonly used theory is the Technology Acceptance Model (TAM) (Park et. Al. 2012). This is due to its simplicity, robustness and comprehensibility (King and He, 2006). Section 2.8 introduces the TAM and considers its usefulness in explaining and predicting the acceptance of Game-based learning by classroom teachers.

2.8 Technology Acceptance Model

Originally derived from the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975; 2011), the TAM has been widely modified and extended to cater for several studies and fields. The TRA (Figure 2.3) seeks to predict an individual’s behaviour through their behavioural intention, which is a function of their attitude and the subjective norm – which is the perception of the expectation of other influencers. These influences may be societal or organisational towards the performance of a particular behavior (Ajzen, 1991; Wu and Chen, 2005). In the TRA, attitude is defined by the belief that performing a particular behaviour yields a certain result, and the desirability of that result is the determinant of the attitude of the individual (Teo and van Schaik, 2012).

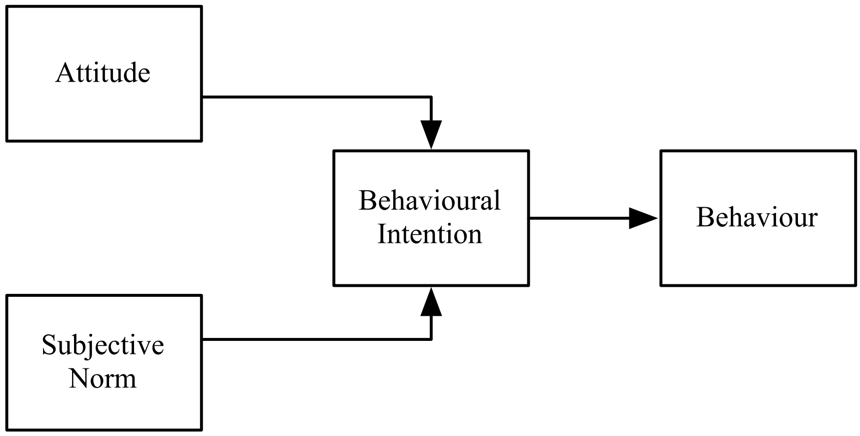

Figure 2.3 Theory of Reasoned Action (Fishbein and Ajzen, 1975)

On its own, the TRA has been used in various research fields – IT, health as well as business – to study and predict the behaviours of individuals. Mishra et al (2014) investigated the behavioural intention for the adoption of green information technology among IT practitioners. Their findings indicated that behavioural intention has a positive influence on the actual behaviours as workers with positive intentions towards Green Information Technology are actually practicing it in their professional capacities. Similarly, Fisher et al (2013) applied the TRA alongside the Theory of Planned Behaviour to evaluate the intentions of women and men to receive the Human Papillomavirus Virus (HPV) vaccine. According to the authors, the TRA posits that the intention to be vaccinated is influenced by the attitude toward HPV vaccination and the perceptions of the social support for HPV vaccination. Their findings confirm the propositions of the TRA.

Despite the usefulness of the TRA, its use in other fields of study exposed some of its limitations, one of the main shortcomings being its inadequacy with individuals who have little control (or feel they have little control) over their attitudes and behaviours (Marangunić and Granić, 2015). In an attempt to cater for individuals' feelings of different levels of control of their attitudes and behaviours, Ajzen (1985) added an extra concept – *perceived behavioural control* – to the original TRA, which resulted in the Theory of Planned Behaviour (TBP). The TBP sufficed for the limitations of the TRA with respect to predicting the influences that motivate the behaviour of individuals who are not under their own voluntary control.

However, the TRA and the TPB came under criticism for not considering some factors that affect behaviours and actions. Some of these include personality, demographic variables, unconscious motives (Marangunić and Granić, 2015) and so on. In addition, most of the studies carried out with TRA and TBP did not yield reliable results that could predict or help researchers understand the acceptance or otherwise of new technologies.

Davis (1986) first modified the main theory of the TRA to analyse the adoption process of an information system to produce the original TAM –Figure 2.4. While adapting the TRA, he maintained 'behavioural intention' as the determinant of a person's actual behaviour (which was, in that case, the actual use of the information system), but removed the subjective norm as a determinant of actual behaviour. Instead, he considered only the person's attitude, which he said would be determined by the perceived ease of use and perceived usefulness of the information system by the individual (Davis, 1986).

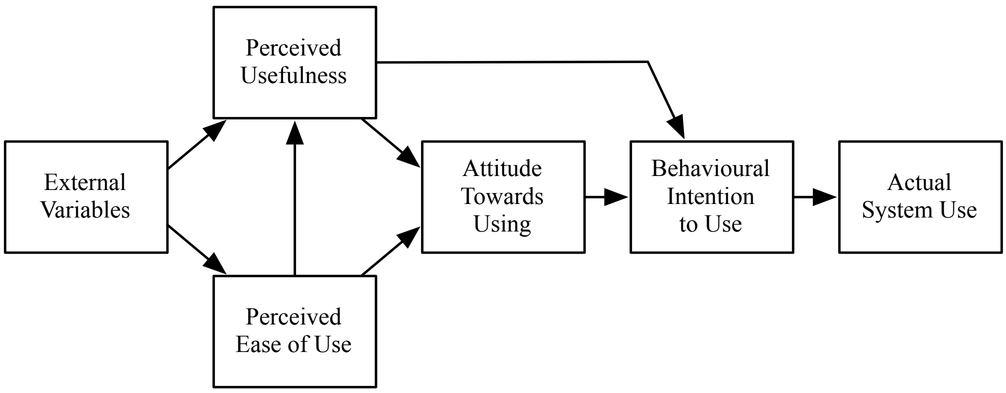

Figure 2.4 Technology Acceptance Model (Davis, 1986)

2.9 Application of TAM in Education

Advancements in technology as well as the drive to ensure that deliverers of formal education keep up with happenings in the 'outside world' make the study of technology acceptance a major element in the integration of technology in education (Marangunić and Granić, 2015). TAM application in education broadly consists of studies aimed at measuring either the intention to use or the actual use or acceptance of technologies in school. Tarhini et al (2014) extended the TAM to include social, institutional and individual factors in order to empirically measure if students were willing to adopt and use e-learning systems. The factors include quality of work life, computer self-efficacy and facilitating conditions. They found out that in addition to perceived usefulness and perceived ease of use, all the factors had a significant positive influence on the adoption and use of electronic blackboard systems. Sawang et al (2017) extended the TAM to include external variables aimed at understanding the relationship between the intention to use and the actual use of keypads. Their model was tested with 131 first year undergraduate students in a university in Australia. They found that attitude towards the keypad system; social pressure to use the new technology facilitating conditions to use the keypad system and students' personalities would all significantly affect the intent to use, which would subsequently affect the actual use of the keypad. In a bid to understand in-service teachers' intention to use technology, Teo (2011) used five variables (perceived usefulness, perceived ease of use, subjective norm, facilitating conditions, and attitudes towards use) to develop a modified TAM and formulate nine hypotheses. Data gathered from 592 teachers from schools in Singapore were used to test the model and hypotheses. Results and analyses suggested that the model was a good fit with eight out of the nine hypotheses supported. An interesting finding from that sample and study was that 'subjective norm' was not a significant determinant of teachers' intention to use technology, unlike in other research (Choi and Chung, 2013; Abdullah and Ward, 2016; Chang et al., 2017). This brings to bear the challenge with TAM research: the inconsistent results of the factors that influence the intention to use or actual use of technologies.

King and He (2006) suggest that despite the fact that the TAM has been widely used studying adoption and acceptance of technologies in education, studies continue to show mixed results about the effect and influence of the different constructs that make up the TAM. Bourgonjon et al (2013) suggest that existing literature provides two possible explanations to the discrepancies in TAM findings: Firstly, in some of the tested models, the effect sizes of the paths vary depending on the types of technology and the type of user under study; this is more common in TAM research in education. Studies have found inconsistencies between the adoption factors between teachers and students, and also between educational technologies used to enhance teaching and more office or class management tools (Sumak et al, 2011). Secondly, the original TAM is inadequate in accounting for peculiar individual, organisational and contextual characteristics that may affect adoption or acceptance. These shortcomings have prompted researchers to call for more contextual studies of the adoption and acceptance factors (Ali et al., 2013) as well as more focus on the study of the influence of moderating factors such as age, gender and experience especially in educational settings (Tarhini et al, 2014)

Conclusion

This chapter presented an overview of the research literature around mathematics education in Nigeria and its challenges, the benefits of technology-enhanced learning and issues around technology integration and adoption. This literature review presented some useful insights – one, technology, in particular digital educational games could be potentially useful in addressing at least one of the challenges mathematics education faces in Nigeria- the classroom climate. However, the gap in the understanding of technology adoption and integration in the Nigerian context and the challenges teachers face in the process calls for more research to be done in this regard. Furthermore, through the review of literature, this researcher did not find any empirical work carried out in Nigeria with respect to the use of digital technologies like game to improve classroom experience. The body of research will benefit from more work to fill this gap and provide insights to the use of digital games in these kinds of contexts. The next chapter will discuss the methodology and details of the research questions that guided this study.

3 CHAPTER THREE: METHODS

3.1 Introduction

This chapter presents the methods and techniques used in this research. First, a general rationale for the research is presented; this is followed by more in-depth consideration of each research question and the specific techniques used in answering it. Each research question is then discussed in terms of participants, instruments used, procedure and analysis. The chapter then ends with the consideration of ethical issues related to the research.

3.2 Research questions

i. How can digital educational games be designed and developed to engage players?

ii. What are the factors that determine the acceptance of digital educational games by teachers?
iii. What is the effect of digital educational games on the engagement with mathematics of pupils in the classroom?

These questions and the techniques employed to answer them are presented in the next section

3.3 Research techniques

This section discusses the techniques and methods used to address each research question in more detail, and a rationale for the techniques used. This study used both qualitative and quantitative research techniques. These are presented in the following sub-sections.

A. *Engagement in gameplay: How can digital educational games be designed and developed to engage players?*

This research focuses on the issue of engagement and enjoyment. Although digital educational games developers and educators try to build games on established educational theories, most of the resulting games appear to fail to engage the learner, or even to bore them (Tang and Hanneghan, 2014). This is not surprising, as many game players are used to playing engaging and interesting entertainment games. However, most of the educational games unfortunately do not offer an entertainment experience comparable or even recognisable as relatives of the entertainment games. It therefore becomes important to determine the factors that make entertainment games engaging in order to provide better insight into how serious games can be designed and developed to foster an engaging experience while still providing an effective learning experience. By answering this question, the researcher wanted to find out what the game factors that support players' engagement in gameplay are.

The researcher used a literature review as a basis to answer this research question, followed by the collection of empirical data to confirm findings. Quite a number of works have been done regarding engagement with games – with many using the popular work of Csikszentmihalyi (1990) on flow as a basis. This highly referenced work is however more of a psychological research than about design and engagement in games, especially recent games.

Moreover, since the gaming industry is fast-moving as a result of increasing computer capabilities and technologies, it is imperative to keep the research updated and relevant to present realities. The researcher was also interested in adding to the literature and backing up or challenging previous findings with empirical data – especially specific to the age group under study.

However, to provide a basis to the concept of engagement in digital educational games, an initial literature review was carried out. The concept of flow by Csikszentmihalyi (1990) as the central basis of engagement with/in an activity or process is an established one in research. This researcher therefore used it as a starting point to explore engagement with games. Csikszentmihalyi (1990) suggested that for people to experience flow, eight major components are involved:

i. Sense of control over task
ii. Balance between challenge and skills
iii. Clarity of goal
iv. Immediate feedback
v. No concern for self
vi. Deep but effortless involvement that removes from the frustrations and worries of everyday life
vii. Alteration of the concept of time
viii. Intrinsically rewarding

However, given that flow is usually reflective of a state of complete and total absorption with no allowance for distractions or external stimuli (Hamari et al, 2016), and it is possible to be engaged without being in the state of flow, the author drew upon other work on engagement. Malone (1980) suggests that activities around subjects or concepts that are intrinsically interesting to an individual play a major role in engaging them. Furthermore, Hakulinen et al (2015) and Hamari (2013) both maintained that a precursor to engagement in an activity is the interest on the individual towards the activity. This also agrees with the more recent work of Nakamura and Csikszentmihalyi (2014) around the concept of flow. Finally, the work of Prensky (2001, 2007) on social interaction was drawn upon.

The six factors that the researcher hypothesised to make up engagement are therefore: Challenge, feedback, clarity of goal, immersion (Csikszentmihalyi, 1990), interest (Malone, 1980), and social interaction (Prensky, 2001; 2007). These factors form a theoretical understanding of the concept of engagement for the researcher. To confirm or extend this theoretical framework, the researcher planned a background study with young gamers. The population for this study was drawn from the participants of the GAME ON 2.0 exhibition at the centre for life in Newcastle Upon Tyne, United Kingdom (Michael, 2015 http://www.chroniclelive.co.uk/news/north-east-news/game-20-exhibition-arrives-newcastles-9311102). The researcher set up a "meet the scientist" stand alongside the exhibition. Visitors who came to the stand were informed about the research and invited for either the questionnaire or interview or both. In total, 62 individuals were involved in the background study – 51 completed the questionnaire while 11 granted a short-structured interview. Parents of participants were asked to sign a consent form on behalf of the children. The age range of participants was 7-16 years; in all there were 20 girls and 42 boys – the gender gap not surprising as there is still evidence of gender difference amongst regular gamers (Lemmens and Hendriks, 2016). This sample was appropriate for the background study as they would tend to have knowledge of various games and would have spent a considerable amount of time playing and engaging with games and is therefore capable of answering the questions.

For this research question, two tools were used: a questionnaire (Appendix 1) and a short, structured interview. The questionnaire was used to collect quantitative data on game preferences, motivations and habits. Other questions include game platforms used and the frequency of play, and then an open question on why respondents like their favourite game. Given the busy environment and the short time available, the interview was intentionally designed to be short and structured. It was used to provide further insights into the reasons they choose to play certain games and what the engagement triggers are. Three main questions were asked: 'What are the features that attract you to a game? 'What are the characteristics of a game that make you continue to play?' and 'What makes you come back to a game?'

Descriptive statistical analysis was carried out on the questionnaire. The questionnaire also had one open-ended question, which asked why each respondent plays the game they played the most. The responses from this were combined with the qualitative data gathered from the interviews. This set of data was cleansed by removing null responses and those that were too generic e.g. 'I like everything about the game'. The interview was analysed using thematic content analysis. Chapter 4 contains more details about the procedure, data analysis and the results.

B. Digital educational games acceptance in the classroom: What are the factors that determine the acceptance of digital educational games by teachers?

Acceptance is a major issue in the deployment of a new technology in an environment. This is especially important in a place where individuals there are not familiar with the technology or with anything similar. Ado-Ekiti, where the population for this research is based, is a town in the wider region of southern Nigeria. Although mobile phones and computers are getting more popular and either or both can be found in most homes, to the best of the researcher's knowledge this research is one of the first studies into the use of technology in the classroom in the region. It was therefore important to consider the acceptance of a digital game in the classroom.

Taiwo and Downe (2013) maintain that interaction between humans and technology is influenced by a number of social and psychological factors and characteristics; a proper understanding of these factors should precede the introduction of a new technology into a setting. In particular, research suggests that many initiatives to integrate technology in teaching and learning practices in the classroom end up not being successful (McKnight et al. 2016). This may not be unconnected to how isolated the introductions may be, little or no plan for continuity and support which mostly ends up in lack of expected results (Sanchez et al, 2014). The factors that contribute to the acceptance or rejection of a technology are usually mediated through the beliefs and attitude of the users.

The researcher has identified the pupils and teachers as the main users of digital educational games introduced into the classroom. The current element of this study is however focused on the teachers' acceptance, and worked on the assumption that the pupils would accept the games. This assumption was based on two beliefs: teachers are seen as the ultimate decision makers in a school setting, and pupils and parents would normally buy in to whatever the teachers say, particularly in Nigeria. Teo (2008) called the teachers the 'true change agents of the school'. Chen, Loo and Chen (2009) maintain that a major determinant of the success or otherwise of technology integration in the classroom is acceptance by the teachers that will be using it.

There is a large body of research on the acceptance of technology in the classroom by teachers (Ertmer et al., 2014; Aldunate and Nussbaum, 2013; Ifenthaler and Schweinbenz, 2013). However, the peculiarities of the study population and the general focus of the present research on digital games calls for a particular approach. The researcher chose the Technology Acceptance Model in this case to model the acceptance of digital education games by teachers. This was for two major reasons; it is the most-used model and so has been widely validated and proven, and it has the greatest flexibility in terms of extension and modification (Azza and John, 2015; Indu and Mukunda, 2012). Both aspects are vital to the current study.

The target population was mathematics teachers in Ado-Ekiti. A total number of 220 teachers drawn from 20 schools in Ado-Ekiti, Nigeria were involved in this research. The teachers are mathematics teachers in secondary and primary schools across the town. The teachers in this sample had varying levels of mathematics teaching experience (1 – 30 years) and age (21 – 60). Most of the teachers were familiar with the use of technology devices like phones, tablets and computers, but none had previously done any form of technology-enhanced teaching. Details about the sample profile, choice of teachers and characteristics are presented in chapter 5.

The first stage of the data collection exercise was an initial semi-structured phone interview with 10 of the teachers (Female: 6, Male: 4). The interview design and rationale is explained in the next section. The second stage was the administration of the questionnaire to the whole sample. In April 2015, just before the mid-term breaks, the questionnaire was sent to the schools.

The comprehensive review of the literature on TAMs and their extensions highlighted the key elements of the model when used to look at technology acceptance in a generic context. The basis of the model is a combination of TRA (Fishbein and Ajzen, 2011) with Davis' original

TAM proposal (Davis, 1989). Following the recommendation of Hu et al., (2003) the 'attitude towards use' construct was removed as they opined it has a limited mediated effect on the dependent variable. As this model was designed to predict the acceptance of educational games by teachers who had yet to use this specific technology, the 'actual use' construct was also removed. This decision aligns with previous studies exploring the use and acceptance of technology among teachers.

Consequently, a modified version of the original TAM and the theory of use was developed as a framework for the new extended TAM with the following constructs: perceived usefulness, perceived ease of use, subjective norm, behavioural intention to use and external variables. In order to extend the model, it was necessary to identify those external variables peculiar to the context of study: teachers new to using educational games in the classroom.

I. Interview

The purpose of the interview is to identify and understand the factors that teachers say affect their intention to use digital educational games in the classroom. The five structured interview questions were drawn from the constructs mentioned earlier (perceived usefulness, perceived ease of use, behavioural intention, subjective norm and the external variables), with scope for follow-up questions depending on the nature of their responses. A semi-structured interview was conducted over the phone with 10 of the teachers from the wider sample.

II. Questionnaire

The extended TAM questionnaire (Appendix 2) was used to gather quantitative information from the teachers. It has three parts- variables of the extended TAM, questions about teachers' career and personal experience with technology and demographic information. The variables were adapted from previous literature and the results of the interview: perceived usefulness (Davis, 1989), perceived ease of use (Davis, 1989), self adequacy (Bandura, 1977; Cheung and Vogel, 2013), syllabus connectedness (Baek, 2008), enabling environment Venkatesh et al (2003), experience with technology and technology-enhanced teaching (Thompson et al., 1991), subjective norm (Fishbein and Ajzen, 2011). Bourgonjon et al., (2013) argued that job performance defines perceived usefulness in the original TAM instead of the process of teaching. It was therefore important to include a variable that examines if teachers perceive digital educational games as potentially useful in terms of educational values and increased classroom engagement, so the researcher added engagement and learning opportunities. Adapting the variables and backing them up with data from the interview helped the researcher bring the variables into the context of digital educational games and also use the language of the teachers. This was one of the recommendations of Venkatesh et al (2003).

Data from the questionnaire was recoded and entered into SPSS. The scale responses were coded from '1 = strongly disagree' to 5 = 'strongly agree'. Negative items were reversely coded for the purpose of analysis. The following analyses were carried out on the data:

Correlation: Pearson product-movement analysis was carried out to check the nature of the relationship; positive or negative between the different constructs.
Fitness of model: the goodness of fit indices was calculated and compared to the recommended value a good fit. This allowed the researcher to measure how well the developed model fits the empirical data gathered.
Regression analysis: This was conducted to measure how significantly the independent variables affect the dependent variable. Behavioural intention to use as the dependent variable and each other variable as independent variables one after the other.
More details on the analyses, results and findings are presented in chapter 5.

C. *Evaluating the effect of digital educational games in the classroom: What is the effect of digital educational games on engagement of pupils with mathematics in the classroom?*

A prototype mobile game- *SpeedyRocket,* was developed in Chapter 6 of this thesis, based on findings about the engagement factors, technology acceptance model and concepts drawn from the curriculum of the target class. The game was used over a period of two weeks in the mathematics classroom with the pupils and teachers. While this last research question particular looks at evaluating the attitude to mathematics of the pupils, the researcher also evaluated the acceptance and attitude of the teachers to the use of *SpeedyRocket* in the classroom.

Target Population, Sample and Procedure

The target populations were mathematics teachers and pupils in the upper primary classes (Primaries 4 and 5; Ages 8-11 years) of the three partner schools for this study. This presented a pool of 106 pupils and 13 teachers. In order to get an equal mix of gender, the researcher randomly selected the same number of gender into the sample for the study. A total number of 60 pupils (20 from each of the three schools) were further randomly divided into two groups – 30 pupils in the experimental and 30 pupils in the control group.

The quasi-experiment lasted for two weeks. All but one of the thirty pupils (he was absent on one of the days) in the experiment group played *SpeedyRocket* for 160 minutes over two weeks- an average of 15 minutes per session. The control group had traditional mathematics lessons for 30 minutes everyday while the experimental group had 15 minutes for traditional mathematics lessons and thereafter played the games for 15 minutes everyday for the two weeks. Teachers also alternated the traditional mathematics lessons and the gameplay sessions amongst themselves over the course of the two weeks.

Two weeks before the experiment, the mathematics attitude questionnaire (Appendix 3) was distributed to the sixty pupils to gather the baseline data. Using the same questionnaire, follow up data was collected from the pupils on the last day of the study. Focus groups were carried out with the nine teachers (three teachers per school) that participated in the experiment. The following tools were used for this study:

***SpeedyRocket**:* This was the digital educational game used for the experiment. The design and development process are extensively discussed in Chapter 6.

***Attitude to mathematics questionnaire**:* Attitude to mathematics is a well-researched topic and therefore there are various tools researchers have used over time to measure it. One of the most popular tools used is the Trends in International Mathematics and Science Studies (TIMSS) Survey (Mullis et al, 1999), short Attitudes Toward Mathematics Inventory (short ATMI) (Lim and Chapman, 2013); Academic Motivation Toward Mathematics Scale (AMTMS) also by Lim and Chapman (2013). It has been widely used to measure trends in students' mathematics and science achievements. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) and administered on 9-10 year olds and 13-14 year olds every four years in participating countries (Pose, 2014). Although the TIMSS has been well validated, it was not used in for this study. This is because the TIMSS includes some constructs that were central to it and yet not relevant to this current study, for example, the researcher was interested in Attitude and not achievement and in mathematics and not science. Another popular instrument that has been used to measure attitude towards mathematics is the Fennema-Sherman Mathematics Attitude Scales (FSMAS). Originally designed to examine gender-related differences in the attitude of high school students towards mathematics (Fennema and Sherman, 1976). It consists of nine scales, each of which pertains to domain-specific attitudes the authors considered to be associated with the learning of mathematics. The nine scales are - Attitude toward the success in mathematics, mathematics as a male domain, Mother (perception of mother's attitudes toward one as a learner of mathematics), Father (perception of father's attitudes toward one as a learner of mathematics), Teacher (perception of teacher's attitudes toward one as a learner of mathematics), confidence in learning mathematics, Mathematics anxiety, Effectance motivation in Mathematics, and Mathematics usefulness. Each of the nine scales has 12 items measured on a 5-point likert scale (from "strongly disagree" to "strongly agree"). While these nine scales can be used together or separately – (individual scales or combination of two or more), researchers have often used it flexibly to examine different dimensions of attitude to mathematics (Ren et al, 2016). Another flexible way in which the FSMAS has been used is in shortened versions that were developed for particular studies, which necessarily did not require all the nine scales. Sachs and Leung (2007) adapted a short form of the attitude tool using the teacher-relevant scale to examine the use of FSMAS in programme evaluation. Likewise, Lim and Chapman (2013) used a revised version of the anxiety subscale in their study instead of the nine scales. The researcher therefore decided to create a mathematics attitude questionnaire from the Fennema-Sherman Mathematics Attitude Scales (FSMAS) specifically for this study. In addition to being a common practice in literature to modify existing evaluation tools, the researcher considered the language of the original Fennema-Sherman Mathematics Attitude Scales (FSMAS) and its clarity to the intended respondents. The researcher was keen to ensure that it fits with the context of the research as well as the age group under study. Given the particular construct under study – attitude to mathematics, the researcher thought it wise to draw items from the different nine scales that relates to attitude to mathematics. Finally, the length of the original FSMAS was a reason to modify it. Following the recommendation of Kirby (2004) research tools like questionnaires for young people should not be too long as they young people could become bored over time filling them.

The questionnaire was adapted and modified with Keller's ARCS model of motivation (Keller, 1987; Keller, 2009). The ARCS model has been widely used in designing and evaluating motivational learning techniques. It measures four variables: *Attention*, which is defined by the interest gained and sustained during educational activities *Relevance,* this is defined by the students' perception of the activity as a personal need. *Confidence,* is concerned with the students' expectation to succeed in the activity and *Satisfaction* refers to the rewards the student expects to get from the activity.

In order to use relevant items to the variables in the ARCS model, the researcher adapted the FSMAS scale items. Given that the researcher focused on just attitude, only items relating to attitude to mathematics were selected from the FSMAS, with special focus on interest, motivation, confidence and enjoyment of mathematics.

The questionnaire thus consists of ten attitudinal questions and two demographic questions. This was kept intentionally short so as to limit the demand on the classroom time and ensure the pupils did not lose concentration while completing the questionnaires. University experts with experience in developing questionnaire tools confirmed the content validity of the questionnaire instrument in education. A team of primary school teachers from the schools in Nigeria checked for appropriateness of language for the target age group. The reliability of the scale was also estimated using the cronbach's alpha measure. The score is higher than the recommended 0.7.

The classroom observation and focus group with teachers are both discussed in chapter 7

3.4 Critique of Sampling and Research Methods

One potential issue with the work presented in this study is the concern on the development of the engagement framework from work carried our with UK young people. Given that the engagement factors were developed from the work with UK young people for a game to be developed for young people in Nigeria. The researcher focused on getting an optimum result more than producing a generally valid framework. The framework developed acted as a blueprint and a guide in informing the design choices to be made in the game. Following Krueger and Casey, 2000), it was the intention of the researcher to gather responses from a sample who have not only experienced playing digital games, but who would also be able to give informed responses about their gaming choices. This is referred to as purposive sampling, a form of non-probability technique.

In non-probabilistic sampling, samples are gathered in a process that does not afford every unit/individual in the population an equal chance to be included (Etikan et al, 2016). In this form of sampling, the focus is on particular characteristics features of the population that are of interest, which will be useful in answering the research questions. The sample employed here for the development of the engagement framework is not representative of the population and this was an informed judgement of the researcher on the value of the potential responses from the sample.

In particular, the type of purposive sampling used here is called expert sampling. It is the type of purposive sampling in which content is gleaned from a relatively small sample (<1%) of the user population, called expert users (Ghosh et al, 2013). It is particularly useful when responses are needed from participants that have a particular expertise to open door to the new users (Laerd, 2018).

In the case of this research, and considering the kind of question the researcher was interested in answering, it was important for the researcher to get responses from gamers who had a greater than average interest and experience playing digital games. Bernard (2002) emphasised the importance of availability, willingness to participate and the ability to communicate experiences in a clear manner. Also, following the recommendations of Patton (2002), another rationale in this regard was the limited time resources and ethical peculiarities of the current research. These formed the criteria for inclusion for the participants:

i. Young people < 18 years old at the time of the event
ii. Play digital games more than 1hour per week
iii. Willing to participate
iv. Able to communicate their experience and opinion in an articulate manner.

It was assumed that the group of young people would have substantial interest and experience playing digital games and would be able to provide useful insights into what makes digital games interesting and engaging.

According to Palinkas et al (2015), a major strength of purposive sampling is the possibility it afforded the researcher to examine concepts in a population while reducing the complexity of analysis. In addition, as it relies on participants 'being at the right place at the right time', it presented a less expensive sampling method as there was no need to list all the population elements. However, this sampling method presented its own disadvantages. Apart from the assumption of who an expert gamer is in this case, the sampling was susceptible to variability and bias by the researcher. The researcher dealt with this challenge by adopting clear and concise criteria for inclusion. The other challenge posed by purposive sampling is the concern about the appropriateness of the sample in making logical generalisation. However, as stated earlier, it was not the intention of the researcher to generalise the findings from the game engagement framework but to use it to provide a guideline and a blueprint for the development of engaging digital educational games.

3.5 Ethical Considerations

Considering the fact that this research focuses on and engage children, the ethical issues that will be addressed are similar to those stated in other social and medical research guidelines; however Tisdall et al (2009) suggests that the way the ethical issues are handled might be different in practice, this research will therefore consider the following guidelines drawn from similar research and the Northumbria University Research Ethics and Governance Handbook. It also adopts the UN Convention on the Rights of a Child (2008), which defines 'children and young people' as all persons under the age of 18 years. The following accesses the ethical considerations for this research:

i. Consent
ii. Disclosure and Barring Service (DBS) Clearance for the Primary Researcher

Consent

In contrast to obtaining consent for older people and other populations, getting consent for a child for research is much more complex. Technically, in the context of research, it makes sense to view children as independent individuals capable of making their own decisions and giving their responses. However (Greig et al, 2007; Tisdall et al, 2009) suggests that since their views and opinions are widely influenced by parents and other gatekeepers such as teachers and social workers, children are considered legally incompetent to provide consent for participation in research, more so, as an important part of research is making sure that respondents and participants are fully informed and aware of the nature, purpose and outcomes of the research (Tisdall et al, 2009). It is therefore imperative that this research seeks consent from both the children and their respective gatekeepers. In lieu of this, this research will initially seek to first obtain

consent from the following

i. Head teachers of Schools involved in the research (in loco parentis) and assent from
ii. The children themselves

Considering the fact that this research poses only a negligible ethical issues to the respondents, teachers were be expected to opt the children into research. The parents would be informed and still held the ultimate decision to withdraw their children from the research if they want to. The consent outlines the following:

i. The purpose of the research
ii. What the involvement of the child will be
iii. The outcome of the research

After consent has been obtained from the school, this research will then seek to obtain assent from the children. This is the child providing a signal that they are willing to participate in the research. According to (SRCD, 2009) this does not have to be signed or written assent, simply a signal that they are willing to take part. It is important that the children have a good understanding of the research and the objectives are presented in a way they can understand. This research seeks to pilot the consent phase with a sample of the children to ensure that the research information presented is clear and easily understandable. In addition to the document containing the consent information, a verbal discussion of the research and what it entails was carried out with school management and teachers.

4 Chapter 4: Engagement in Digital Games

4.1 Chapter Introduction

So far, this thesis has examined the literature on game-based learning and presented the findings of the study into attitude to mathematics. One of the other key objectives of this study is to identify the factors that contribute to engagement during gameplay. Knowing what makes a game engaging can inform the design of educational games to ensure they are attractive and appealing. Educational games face the challenge of providing a similar enjoyable experience to players who are used to engaging and showing interest in games. Thus, it is important to find out what the motivations are for playing games and what the preferences are of the players in terms of the kind of games they play and enjoy the games. This chapter presents two closely related but separate studies: the first is a questionnaire to capture data about general play and preferences; the second is a structured interview designed to gather information about what are the main influences on their game choices and the engagement triggers in those games are. The chapter ends with a presentation of the three levels of engagement and a discussion on how the factors fit together in an engagement framework and a discussion of how the different factors fit together.

4.2 Methods

One of the primary goals of a digital games developer is to create enjoyable games (Sweetser and Wyett, 2004) and that the games possess characteristics that would draw a player's initial attraction to it, maintain the engagement and make them want to return to play it. This is as important for digital educational games as it is for entertainment games. Young people have quite a wide range of games to choose from and play, and they would not choose games that do not interest them. As technology advances and designers get to build more engaging games, educators and educational digital games designers need to understand how these advances influence engagement and the choice of games young people make. Engagement is a complex construct and as such should be explored by considering the responses of players to the gaming experience (Squire and Barab, 2004), in this case, young people. That is what prompted this researcher to undertake this background study.

Digital educational games often need to be context-specific and adapt to particular environments including culture, language and most importantly the curriculum. These can differ from place to place. However, as discussed in Chapter 3, a purposive expert sampling was considered appropriate with respect to determining the engagement factors in everyday entertainment games. To the best of the knowledge of the researcher, there is no record of any digital educational mathematics (or any other subject) developed for use in Nigeria classrooms.

Most of the commonly used maths games are developed for the developed and western world where schools mostly have the resources to purchase licenses. An example is *Mathletics* is a subscription-based mathematics online game. In the development of engaging educational games for mathematics in the Nigerian classroom, this engagement framework offers guidelines with respect to where resources should be focused. This is particularly important because schools in Nigeria often do not have access to large funds to acquire licenses to large and widely used educational games and at such most of the games they use would be developed by independent game makers, teachers or other educators.

The focus is on examining the factors that young people find engaging from amongst a population of regular gamers. This would have been difficult to do in Nigeria as young people do not have the same access to technology and digital games, hence the researcher worked with young people attending the Game On exhibition at Life. Two data collection techniques - questionnaires and interviews were used for the primary data collection process. The questionnaire was used to explore what kinds of games young people are playing and why they play them. This was followed up with a short structured interview to provide further insights into the reasons they choose to play certain games and what the engagement triggers are.

4.3 Game Preference and Motivation Questionnaire

The first part of this study involved the use of a simple questionnaire to gather data about game preferences and motivations from young people. The population used for this study was visitors to the *GameOn* exhibition that took place in Newcastle upon Tyne from May 2014 to January 2016 at the life science centre. *GameOn 2.0* is the biggest collection of playable computer games in the world (BT, 2015). The exhibition provided a collection of games from the past 60 years to be played on their original historic equipment. This population and context was considered appropriate for three reasons – the first was accessibility of the location to the researcher as it was sited in Newcastle and the researcher's university had links with the Centre; and being visitors to a gaming exhibition suggested that participants would be willing to spare some a few minutes completing a questionnaire about games. Secondly, it was assumed that many of the young people would visit with their parents/guardians and so consent would potentially be easy to get. Finally, the researcher expected that most of the visitors to the exhibition love games and spend considerable amounts of time playing games and therefore the results would be valid for regular gamers. However, that also meant that findings could not be generalised to others who are not regular gamers. This was a necessary compromise because the second part of this study examined what were the engagement factors in gameplay.

A questionnaire (Appendix 1) was designed to examine the motivation to play games, game preferences, a ranking of the five most played games, type of devices played on, and some demographic information. In order to ensure clarity and reduce ambiguity of terms and the items on the questionnaire, a pilot of the questionnaire was carried out initially with a small number of young people; before being reviewed and revised for the main sample.

The researcher had a stand at the exhibition for three days in September 2015. There was a screen showing videos of live play of a number of game playing sessions and a paper poster that stated the title of the research. There were also information leaflets that provided more information on the research, contacts at the researcher's university and how the obtained data will be used. At the back of the pamphlet, a consent form (Appendix 2) was made available for the parent/guardian to read and sign before the paper questionnaire was handed over to the child.

i. Overview of results

In total, 37 males (73%) and 14 females (27%) completed the questionnaire. Respondents were aged between 7 and 16 years of age with the average age being 12 years old. The responses confirmed that the majority of respondents were regular gamers with 47% spending at least 4 hours a week playing games with some up to 20 hours. The highest percentage of respondents (86%) played games on tablets, followed by the Xbox (60%) while the PlayStation was the least used device (24%). In terms of the ranking of the five most played games by each respondent, 64 different games were named. *Minecraft* topped the ranking score with 1964, followed by *Candy Crush* (814) and *Terraria* (712). *Lego Lord of the Rings* (60) was the least ranked game.

ii. Game genre preferences (question7, 8 and 10)

Respondents play a wide range of games – 64 in all. Adventure games are the most played (80%), followed by multiplayer games (60%) and shooter games (47%). The least type of game is flight fighting (10%) and arcade (14%). Tassi (2016) reports *minecraft* to be the second highest best selling game of all time just behind *tetris* and ahead of classics like *super Mario* and *GTA*. Originally created independently by a game developer named Mojang, Microsoft bought it for a $2.4 billion in 2014 (Ovide and Rusli, 2014). Its popularity has since increased, surpassing over 100 million sale milestone as at June 2016 (Warren, 2016).

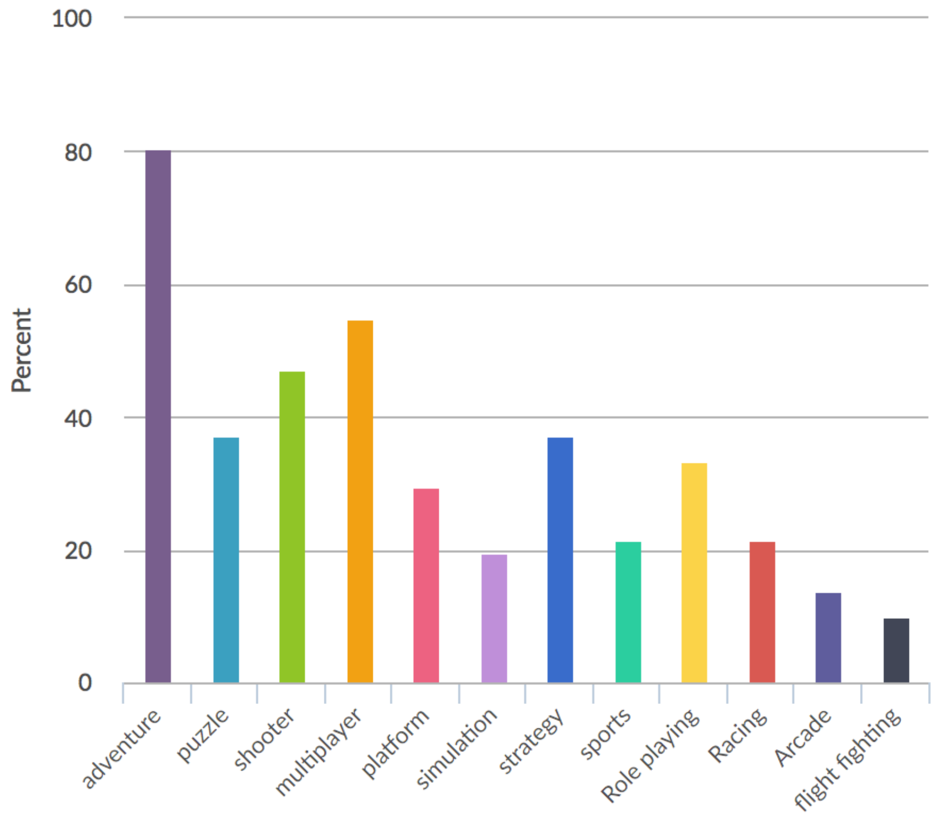

Figure 4.1: **Preferred game types**

The choice of *minecraft* and adventure as the most played game and most preferred genre respectively might not be unconnected to the desire and interest of young people in creativity, control and misery. Research suggests that the success of games like *minecraft* could be partly explained by the absence of specific goals or aims and the freedom it affords players to explore and immerse themselves as much as they want in the environments (Riordan and Scarf, 2016). The open-ended nature of *minecraft* encourages players to maximise their creative power to build and put together resources to do anything they can imagine. This is in contrast to the real world where they often face one limitation or the other. *Minecraft* also has a multiplayer mode that makes it possible for multiple players to collaborate in a single world and build, fight and create together. *Multiplayer* – the second most played genre underscores the importance of community and interaction with other players to the gamer.

iii. Motivation to play video game (question 9 and 10b)

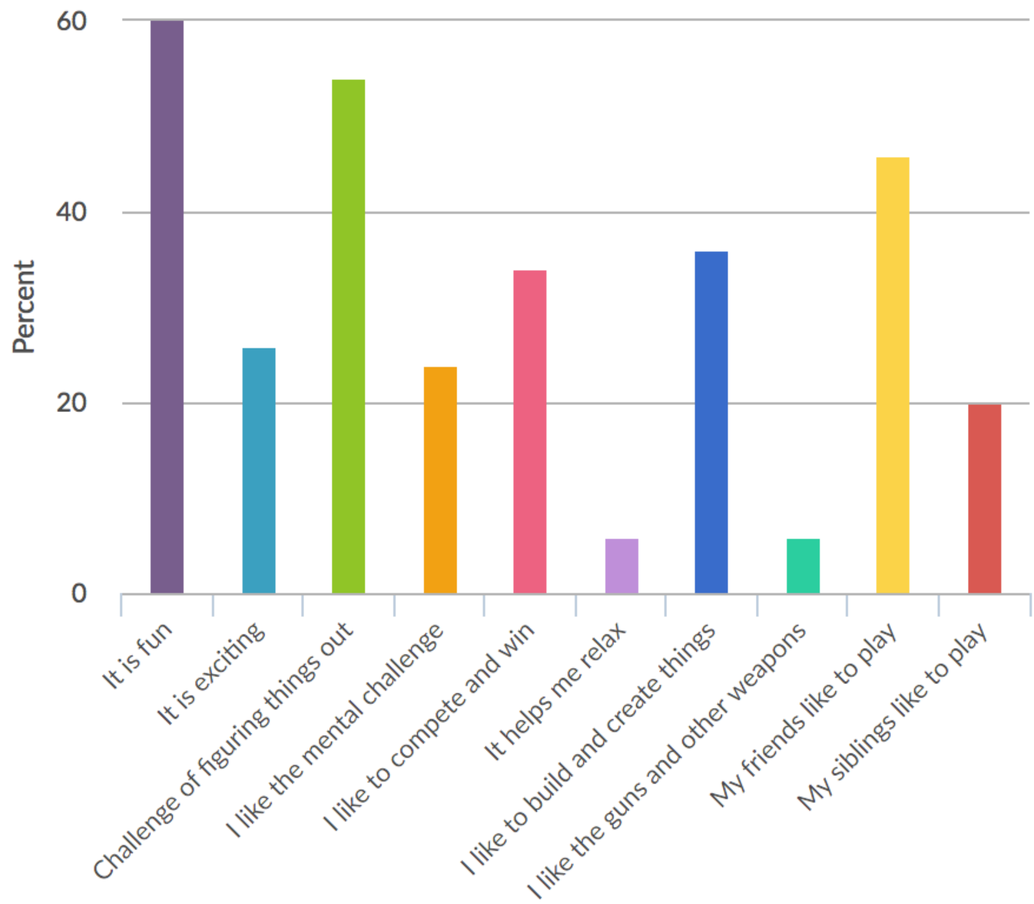

Figure 4.2: **Motivations for playing games**

Most of the young people surveyed considered fun as the main motivation for playing video games. The challenge of figuring things out and the social aspect of gaming – playing with friends, are also strong motivational factors. However, the researcher could argue that fun is the main motivation, and different young people define fun in different ways- to some it is competing and winning, to others, it is playing in a community, or it may come from the challenge the game offers to their intellect.

iv. Digital educational games

In terms of experience with educational games, 67% of the respondents have played at least one digital educational game before and 33% had not. In all, 10 different games were reported with *MyMaths* (41%) being the most played game and *xtables, once upon a monster lexia* and *parking panic* the least played at 3% each. It is worthy of note that the two most played educational games (*MyMaths* and *Mathletics*) are about mathematics. This underlines the amount of attention the subject gets in schools. It is interesting to note that respondents regarded *Minecraft* as an educational game. The researcher did not consider the responses to the questions with respect to gender, as the respondents were not evenly split in terms of gender.

4.4 Interviews and Analysis

Emerging from previous studies, some theoretical factors that support engagement in games have been identified. Some of these factors have been studied extensively in the literature and tested widely. However, since the field of video games and entertainment is a fast-growing and evolving space and several innovations and technological advancements have changed the type of games played in the last few years, it is important to update theories to reflect new discoveries and creations.

Thus, the researcher sought to ask the 'gamers' of the day what triggers their engagement when they play games. One of the questions in the questionnaire was open ended to allow respondents state why they play their most popular game. In addition to that, an interview was carried out to provide further insights into the reasons players choose to play certain types of games. The interview employed structured but open-ended questions in order to avoid leading the respondents to biased answers and opinions. Three main questions were asked: "what are the features that attract you to a game?", 'what characteristics of a game make you continue to play?'; and 'what makes you come back to a game?'

The responses from the interview were combined with the qualitative results from the questionnaire to produce further 30 answers. The data was then cleansed by removing null or ambiguous answers e.g. '*I like everything about the game'*. The resulting set of data was separated into 118 statements.

The short answers collected from the interview were analysed using an inductive coding process as part of the thematic content analysis (Vaismoradi et al, 2013; Braun and Clarke, 2006). Basit (2003) defined codes as tags that are used to give meanings to sentences or words. The coding process of the data was performed manually on paper and was focused on the meaning of the statements. As the aim was to deduce what the engagement factors were for the participants, open coding was used to highlight and examine the data for emerging factors. The researcher read the data repeatedly to identify themes and categories that were relevant to the research question. The factors that reoccurred across the whole data were then grouped according to themes. The themes are presented in the following section.

4.5 Findings and discussions

This section presents the discussion around the themes found out from the data analysis in the previous section. The engagement themes are: *Challenge, thematic and visual appeal, social interaction, feedback and rewards, clarity of goal, Immersion and creativity.* The discussion will draw on evidence from the questionnaire and the interview as well as the literature around engagement generally.

a) Challenge

Challenge is one of the features respondents reported they like in games they play the most. Results of the questionnaire show that the *challenge of figuring things out* is one of the most popular motivations for playing games. Challenge also comes out strongly in the interview responses. For example one of the responses said:

> *'If things get harder and makes me involved in the play',*

Early work in engagement and flow theories by Czikszentmihalyi (1990) show that the more complex and challenging a task is, the more deeply students engage with it. Wang and Chen (2010) suggest that getting the challenge style of a game right is a way to maintain motivation, facilitate knowledge construction using trial and error and also enhance the consolidation of knowledge by providing progressively more difficult challenges. A game is challenging if it provides a number of different levels of difficulty and allows players to use a range of mechanisms and approaches to solve problems or achieve certain objectives. As one respondent said:

> *' I come back to play a game I enjoyed the first time I played it and there are new challenges and levels to overcome'.*

These suggest that building a certain amount of challenge into a game is key to engaging players in the play. It is imperative to get the mix of difficulty and ease right and ensure that the level of challenge presented to the player corresponds closely to their level of skill.

Bryant and Fondren (2009) maintain, "*Moderate levels of complexity create intermediate levels of cortical arousal which is both optimally pleasing and efficient*". Fullagar et al. (2013) opined that getting the right balance of the challenge-skill dynamics enhanced engagement and motivation while also increasing the capacities of the player to do more difficult tasks. Responses such as including

'*a right balance of easy and hard especially with the tips and instruction*'

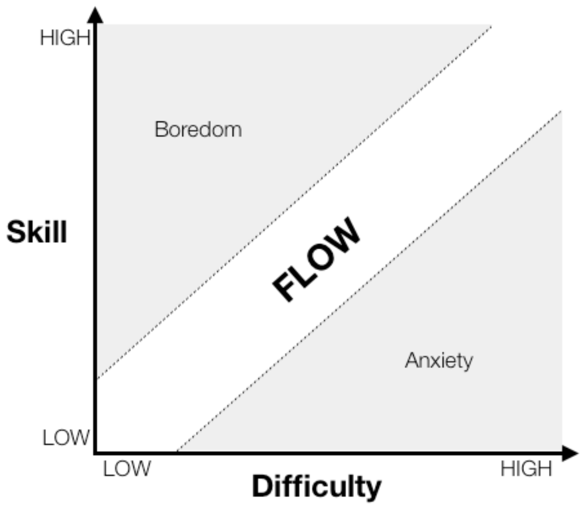

Figure 4.3 *Flow Channel: The challenge matches the skills* (Csikszentmihalyi, 1990)

suggest the importance of getting the level of challenge right. Csikszentmihalyi (1990) in figure 4.3 describes a stage where challenge or difficulty is too high and anxiety sets in or when challenge is too low and boredom occurs. He went on further to maintain that the desired level of flow in a task is achieved when the individual employs a high level of skill to meet a major challenge. This means the particular task is not too easy for their skills, neither is it too hard or impossible for them to do. 'Strategy' and 'thinking' are further terms used by the respondents. One respondent said

'*I like how you have to figure the words out with your brain and it really helps you with spelling, writing and reading*';

another one reported that she would continue playing a game if

‘*It makes me think’*.

These responses suggest that challenge can be a function of the amount of strategic thinking a game requires. Progressive challenges encourage the player to think about ways to navigate and deal with difficulties in the game. Learning and mastery go hand-in-hand in challenging games as players are able to think, learn and improve their skills as difficulty increases (Denisova et al., 2017).

Players want to stay mentally engaged during game play. The desire for challenge may not be unconnected with the perceived sense of achievement and rewards that often come with passing the challenge. These sort of rewards may be in the form of progress through the game, greater challenge or even just a sense of increase in self-efficacy. The sense of mastery and accomplishment is a major drive for game players to push themselves mentally to meet the challenges. However, making a game too difficult can lead to frustrations just as making it too easy may lead to boredom and apathy. Game players get more engaged in gameplay when design ensures a match between the challenge and their expertise (Klarkowski et al, 2016).

Adam (2014) maintains that there are two main types of challenges – defined by the demand they place on the gamer: mental or physical. In order to make digital games more challenging to the player, designers push challenges in two main different ways: either by increasing the cognitive or physical limits of player (Cox, 2012). While physical challenges targets a player’s ability with respect to the speed and accuracy with which they undertake task, cognitive challenges push a player’s memory, observation and problem solving capacities (Denisova et al., 2017).

b) ***Thematic and Visual Appeal***

Thematic and visual appeal cover elements of engagement that have to do with interest in the story/theme of the game and in its graphical interface. This could include the characters’ appearance in addition to the game itself. Thematic appeal is illustrated through the respondents’ comments that the reason why they play certain games is that they match their interests in the real world. Research has shown that male gamers tend to prefer sports, racing, shooter and role playing games while females prefer arcade and puzzle/word games (Homer et al, 2012; Scharkow et al, 2014). For example, one respondent said ‘*the reason why I play the game is because I love to play football’*

and another respondent with an interest in trains and railways, said that he played the game because

‘I can operate a railway’.

It is therefore important to note that engagement is sometimes not entirely a function about the way a game is made but also dependent on the general interests, career interests, and real life hobbies of the players. This implies that certain players engage with games because of their interest in the subject of the game and these thematic preferences influence how engaged a gamer is in the gameplay. It is important to take this into consideration especially with games targeted at particular sets of people. The gaming world is a make-believe one, in which players can be what they want to be, and do what they want to do even if it is impossible in real life. This explains some connections that players have with particular game genres and stories. The content and characters are particularly important in the game for players, as there appears to be a relationship between playing some games and the observed behavioural and social outcomes amongst gamers. This explains the assumption that males have been reported to prefer physical game genres and females are attracted to games that have a social interaction aspect as well as cooperation elements to it (Scharkow et al, 2014), Furthermore, females generally dislike games that depict highly sexualized female characters or have violent themes and contents (Hartmann and Klimmt, 2006).

Some studies (including this research) have reported that males appear to be more interested in games than females; evident by the amount of time they spend playing games. Generally males spend more time playing games than females do (Lemmens and Hendriks, 2016). The literature highlights some particularly wide gaps. Rehbein et al (2014) reported that in a German adolescent game player sample of about 11,000 students, males played 162 minutes a day compared to 27 minutes a day for females. Although Rehbein et al (2016) claims that the explanation for longer engagements in males are still not well formed and understood, the comments from respondents in this research suggest that the wide difference could be explained by the availability of game themes that traditionally interest boys more than those that interest girls.

Other responses suggest that the graphical nature of the interface and characters are triggers of engagement for them. Considering latest advancements in technology that have resulted in the capability of designers to use computers in creating graphics that are real and attractive, it is not surprising that this plays a major role in attracting and maintaining the interests of players in the game play. For example, a respondent said that he likes games with

'*clear graphics that show the characters as real as possible*'

while another mentioned that

'*the art and style*' is what attracts them to a game

One major result of better graphics technology in games in recent times is the creation of avatars. The ability to create avatars is a common feature in many of the video games today. It is through an avatar that a player gets to experience the game world and gameplay (Soutter and Hitchens, 2016); this has positive implications for the player with respect to engagement and enjoyment (Trepte and Reinecke, 2010).

Excellent graphics in a game can be an attractive feature to a player. Newman (2013) maintains that it is "*clearly important for many if not all games and gamers, and that the (audio)-visual composition of the game world has an enormous impact on players, non-players and purchasers of games alike*." However it is important to note that there are several games that have engaged players in the past and are successful in the gaming world that do not have attractive graphics. Examples are games like the paddle tennis games and the early football manager games, while some like Dragon's lair and Myst have presented highly technical and aesthetically sound visuals and have failed as video games. Although these games had great visuals, they failed to provide corresponding opportunities for interaction, which is equally if not more of a greater importance to engagement. This indicates that while excellent graphics and visuals are good, they are not enough on their own as they need good game play to sustain interest.

c) Social interaction

This component of the engagement framework captures the game characteristic that allows a player to share the experience of playing with another person. Some respondents that play multiplayer games against/with friends reported that they were engaged in those games because the games provided a platform for communicating and cooperating with others, interacting with the community and building friendship. Advances in network technology now means that different types of social interaction can be possible during gameplay depending on the design of the game. Some of the responses suggest that there is a link between competition and social interaction. For example one respondent stated that their reason for continuing to play a game is so

'I can beat the high scores of myself and my friends'

while another says

' I love the competition as I can tell my friends I will beat you later'.

Competing with friends and other players has now become a major aspect of a video game. One of the respondents said the reason why he loves the game he plays is because he can

'start campaigns and compete against my friends',

Humans like to win, and it is no different with digital games. It is a good feeling when a player competes with the computer or the game and wins, but it is a better feeling playing and beating another human being. Game designer Gregory Trefry (2010) puts it this way:

"winning a single-player game feels like an accomplishment; beating your friends feels like a triumph"

While competition is a form of social interaction, cooperation is another form. Skills and expertise and playing as partners can be another reason why a player is engaged in gameplay. According to Greitemeyer et al. (2012) the structure of cooperation in games is that in which the goals are positively linked so much so that individuals are successful in attaining their own goals when their partners attain theirs. One respondent stated they liked the game because:

'I can be friends with other people'.

However, it is worthy of note that socialising in games is not restricted to communicating or competing with friends in the game. Some of the responses suggest that socialissing occur as a function of feeling as a member of a community:

'play with the community' and also *'communicate with the teams'*.

This community need not be restricted to 'in the game" as sometimes the conversations had during gameplay can be carried on outside the gaming experience. Engaging game plays have the capacity to create new relationships, and foster interesting conversations about the game subject and other related things outside the game.

d) Feedback and rewards

Respondents reported feedback as one of the features that they like in a game. Through feedback, a player can self-access their progress and competence. A good feedback mechanism in a game can help engage the player. Players like to receive feedback and/or information in order to know if they are making progress, and if their actions are correct or not. This helps players plan and make decisions about their future actions and gameplay. As one respondent stated:

'I like to receive updates about my performance and scores'.

There are different types of feedback: visual, auditory or sensory (Lyons, 2015) and they can either be positive or negative. The different kinds of feedback are useful under different circumstances. While positive feedback is a mark of competence and increased expertise, and has been shown to be particularly useful in maintaining long-term motivation and play, negative feedback reduces the feeling of competence but can increase immediate game play (Burgers et al., 2014). Some responses also suggest that players view reward as a form of feedback. For example, one respondent said:

'*I need to know what to do to get high scores and get the necessary points'*.

Rewards such as extra lives, points, money, ability to unlock special skills and tools, promotion to a new higher level, all help keep a player engaged in game play and are illustrated through comments such as

'earning new points', *'achieving new things'* and *'being able to play better'*.

All these statements confirm the belief that rewards can provide access to new experiences in the game, which helps motivation and engagement. Having a variety of rewards, feedback mechanisms and progression routes can all support a more engaging experience for the player.

e) Clarity of goal

This element has to do with how clear the objectives of the game are and additionally whether there are clear instructions and rules of play. In order to initially draw a player to a game environment, the player needs to understand what the objectives of the game are, or at least the initial objectives for the game play. This element is associated with both motivation and achievement as knowing the objectives helps maintain motivation and completing objectives helps with the player's sense of achievement and further contributes to their motivation to continue playing. This desire for clarity of goal is evident from the statements:

'I want to know what the game is about and what I should be doing'

and

'I will continue playing a game if I understand what the game is about'.

Clear goals provide a sense of purpose that can be easily understood by the player and are essential for motivation and engagement.

f) Immersion

This element of engagement describes the desire of the player to experience the story and be part of the gameplay. This could be considered to occur as a result of engagement. The point where players 'loses themselves' and becomes part of the game can be considered the ultimate point of engagement. At this point, players consider themselves to be 'in the game' (Jennett et al., 2008; Wirth et al., 2007). Some respondents reported this as the reason why they would keep playing a game. The interaction with the characters of the game as well as conceptualising themselves as part of the virtual world is appealing to some players. One of the respondents said

‘I like being involved in the play and experiencing the environment’.

The state of being involved in the gameplay sometimes results in unintentionally placing all the focus on the game and somewhat losing sense of the real actual environment the player is in. One respondent said:

‘I love the world of the game as I get carried away while playing it’

while another said

‘because I can see myself in the story, it makes me attached to the game’.

This feeling of immersion leads to engagement with the game and a feeling of attachment.

g) Creativity

Providing the opportunity for players to be creative and use their imagination was highlighted as an important factor to maintain a player’s interest in a game. This is a key finding from this study. In a study by Kankaanranta et al., (2017) “*children became emotionally attuned to the games that offer possibilities to utilize one’s own creativity”*. The popularity of games like Minecraft and FIFA may explain this. Players feel engaged and involved in the game play if they are able to create and control content and other elements of game play. For example in FIFA16, players can create teams, and manage players, as they want. Two of the respondents reported that the reason they come back to play a game is because

‘it allows me to build anything I want to build using my imagination’

and

‘I can build my own teams and control them’.

This feeling of control and creativity is essential to engaging players in the game play. It is also related to achievement and mastery. As one respondent remarked:

'the reason I like to come back to play is because it gets my attention as I am trying to be creative in order to survive'.

4.6 Game engagement framework

It has already been established from the literature that one of the reasons why digital educational games are not as successful as entertainment games is their inability to offer a comparable level of enjoyment found in the entertainment games. Research has also shown that engagement is positively related to learning (Lee and Hannafin, 2016; Barkley, 2018). Successful digital games have been able to engage players and sustain their interests for long periods of time. However, since the goal of a digital educational game is to teach, it is understandable that designers and developers prioritise that over creating a fun and engaging experience for the players. Nevertheless, the purpose of an educational game will not be achieved if it is also not attractive, engaging and fun as learning in and through the game requires sustained and continued interest in the game play. That is why this research draws on the experience of young people playing entertainment games and what they view as 'engaging' and 'fun' about these games. The framework built from responses from young people who play entertainment games is fundamental to the development of engaging digital educational games. The structure of the interview enabled the researcher to map the factors of engagement into those that initially attract players, those that sustain the engagement and those that keep the players coming back. These factors have been grouped into three main categories: initial engagement, on-going engagement and engagement outcome. The importance of this framework is not just in highlighting factors that are needed for engagement in digital educational games, but also in assisting the designer and developer to think about the context of use. Majority of The current commercial mathematics games are not readily accessible in Nigeria, therefore designing a 'freely accessible' one seemed appropriate. Furthermore, some of the current commercial games would not be linked to the Nigerian context particularly the curriculum so the framework helps the designer/developer look at these issues in relation to the different factors that young people find engaging/fun in a game.

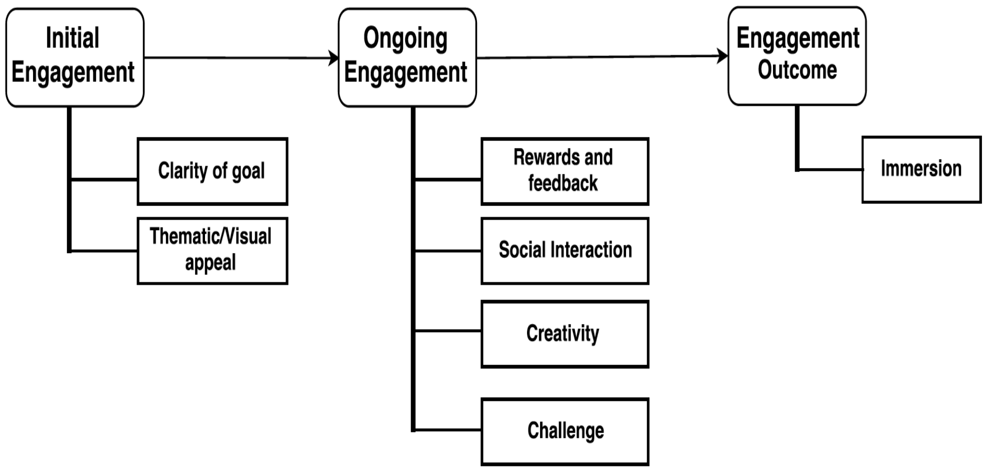

Figure 4.4 Game Engagement Framework

Initial engagement factors are those that appear to be antecedents to engagement, they precede and tend to trigger engagement. Motivation is the basis for initial engagement. This motivation can either be powered by thematic/visual appeal as well as interest in the subject of the game (extrinsic) or clarity of goals, objectives and aims of the game. With digital games, the personal interests of a player in a game genre, story, graphical presentation or layout determine some of these initial engagement factors. However, after this initial attraction, a player would need more than nice graphics and colourful layouts to stay engaged.

For the initial engagement factors, the clarity of goal is very important even though in the case of digital educational games for use in Nigeria classroom, the initial choice of the game does not lie with the pupils.

Clarity of goal in this context is how defined the aims and objectives of the games are. This provides the player with an understanding of what success is for the game and what they need to do to achieve that. Usually, this will be appropriate and useful to outline at the start of the game as gives an idea of what is required for the player to do. In digital educational games, it is also useful to explain briefly what the learning outcomes of the game are. Not only does this help the pupils, it also assists the teacher to properly understand how the game supports their teaching. Pupils can easily be frustrated and disengaged even before they start playing if it is an uphill task to know where to start from. Goals can be presented in text, or video format to give an overview of what the game is about and what is required of them as a player. Goals can be as comprehensive as a video play-through of the worlds in an imaginary planet and how to get from one to another or as concise as a statement that defines what the game is about. Whichever way a goal is expressed, it should endeavour to speak the language of the player; it is only by understanding the goal that the player can assess their own success or failure with respect to achieving the goals. It is important the game's goal and relationship to the maths topic being treated is clear. Just as learning objectives are important in traditional teaching methods, clarity of goal is equally as important in digital educational games. The thematic and visual appeal is also essential, although tricky as responses suggest that it is based on individual preferences. Research has shown the importance of good graphics in the design of instructional tools (Annetta et al., 2009). However, in the design and development of digital educational games, smaller budgets are a common challenge and therefore costs can be prohibitive in terms of using high-end graphics in digital educational games. The most basic form, the characters in the game, as well as the design elements should tell a compelling story. This is particularly useful in maintaining the engagement of the player in digital educational games.

As noted earlier, the thematic and visual appeal in the game is not just about the graphics. It is also about how well players can relate to the look and feel of the game and the story-line. In developing educational mathematics games, while it impossible to satisfy all the individual preferences and desires of the whole class, it is still important to capture them as much as possible. Parameters such as game story, settings, look and feel should be well thought-out and researched to satisfy a wide range of audience. An example of how contexts affects this is the development of games and around stories and characters that the intended audience can relate to.

The on-going engagement factor; hypothesised as the ones that keep players interested in the game are the most important factors of the engagement framework in developing digital educational games in the classroom. During gameplay, these are the factors that help sustain the engagement of the players. By providing rewards and feedback, a reasonable level of challenge, a way for players to be socially active during gameplay and ways for them to be creative, players can potentially be expected to experience more than the initial engagement, and actually start ‘getting into the game’. This is like the substance of the game; it is what many of the average games are missing. It is not an easy task blending game story, rewards, and the right amount of challenge in a digital game, and these appear to be the core of the experience a game player wants to have.

Creativity was one of the factors respondents said would make them continue to play a game. As Gee (2003) rightly noted about good games “they allow players to be producers and not just consumers”. Digital educational games should allow players to be co-creators of the game environment, and develop their own knowledge acquisition. Although games are often set in a make-belief world, players still want to be able to mentally experience the world and relate to it as much as possible, and part of experiencing it is being involved in creating it. Lin and Wang (2014) suggest that this creative capability is key to engagement in video games, and designers should allow players develop realistic avatars. Players are more likely to create characters that they can relate to and that represent characteristics similar to their own.

Challenge is another factor that is key to on-going engagement. The right level of challenge has already been established as a key factor in engaging players in gameplay (Lomas et al., 2013; Sherry, 2013). Early work around flow and engagement has shown that to ensure that players do not get bored or frustrated, the right level of challenge has to be built into the games. In educational games, this is even more important, as researchers have shown that challenge is a major source of motivation in learning activities (Leper and Henderlong, 2000). However, integrating challenge require some though. Gee (2003) recommends that the gaming experience should be “*pleasantly frustrating but not insurmountable*” in terms of the challenge it offers. Digital educational games that engage players should at the very least provide the opportunity for players to choose difficulty levels based on the self-assessment of their own skills. Great games could go a step further to learn and adapt difficulty levels to the performance of the player using machine learning or similar technologies. This would mimic the traditional teaching method of giving more challenging tasks to pupils that need them and allowing pupils that need more time on simpler tasks to do so.

Rewards and feedback is also very important in engaging players in the game-playing process. It is much more important in educational games as studies have shown that feedback in educational games can “reduce redundant cognitive processes” and at the same time provide a blueprint for learners to correct their errors (Clark and Mayer, 2008). Feedback in educational games can be in the form of notifications and tips on how to make progress in the game, whether game activities have been completed correctly or not. It can also be in the form of rewards like special abilities, access to new levels and new equipment. Using a scoring system is one of the most common and basic ways to provide feedback in terms of rewards to a player (McKerna et al., 2015). However, Kelle et al., (2013) suggests that rewards in form of the scores are only useful in game-based learning if they are combined with a time limit. It is also important that rewards and feedback should not interfere too much with the flow of the game play.

In designing a maths game for pupils in Nigeria, it is also important to embed these factors to provide an equally engaging experience to the players. In contrast to the traditional teaching/learning styles in Nigeria where feedback is usually non-existence or at best generic, digital educational games should present regular (but not intrusive) feedback to players. In addition to this, rewards should be added to give players an incentive to continue to play the games and keep them motivated.

Finally, ***Social Interaction*** is another factor that is reported to support on-going engagement. Social interaction in digital educational games is also an on-going engagement factor. This is one of the factors that are more pronounced recently due to the pervasiveness of more connected devices. In many current digital games, social interaction includes scoreboards, competing while playing together over the internet. Even though network capabilities and device connectivity has improved, embedding social interaction within digital educational games is still challenging. In a study involving *Mathletics*, Nansen et al, (2012) maintain that "direct communication with other players within the application is not possible, so interaction is limited to more indirect forms of displaying and viewing profiles or competing against other *Mathletes* in games of live *Mathletics*.

The kind of social interaction available in *Mathletics*- viewing profile may not even be feasible for digital educational games created for use in Nigeria, as internet access is a rare commodity. However, as this factor is essential for on-going engagement, developers and educators need to find a way to implement it in games – directly or indirectly. Social interaction features should help keep players engaged and active with the game. This should be done in such a way that it does not completely disrupt the orderliness in the classroom.

Good games engender engagement on different fronts, but adding a community factor to the game can increase motivation to play and continue playing. This is in line with research carried out at Cornell University (Culbertson et al., 2016) that found that games are more fun when they are played with others, and more importantly, educational games are much more effective when players can interact with others. As mentioned earlier, this element of engagement can either be setup for players to cooperate or compete, or do both. Not only will players and pupils be able to compare scores and share knowledge, they get to learn collaborative and team work skills. It is important to note that most collaborative features that have to happen in the game need interconnectivity between devices. This sometimes proves challenging especially in schools or areas where network access cannot be guaranteed. However, as mentioned earlier, social interaction is not limited to in-game features, and face-to-face interactions can prove even more useful that online interactions, especially in the classroom. In digital educational games designed for classroom use, it is useful to think about how activities in the game can be set up in a way to encourage pupils to work together.

The engagement outcome – ***immersion*** is a state that is not likely a game player gets to within the allocated time for the activity in the classroom. However, if pupils enjoy playing a certain game in the classroom, the possibility of playing the game outside the classroom increases. If/when this happens, they may be able to experience immersion.

4.7 Conclusion

This chapter has focused on exploring why young people find some games more engaging than others. It stems from a strong indication from the literature that a more engaging experience can support more effective learning in a gaming environment yet often digital educational games have lost their 'engagement/fun' factors because of their focus on education. The results from this study indicate that engagement is complex. The factors are inter-related, but also have their distinct characteristics and implications for engagement. The diversity of the responses and resulting engagement factors suggest that young people engage with particular games for a variety of reasons. This aligns with research that indicates students have different learning styles. Thus the design of a digital educational game should cater for this variety and incorporate a broad range of engagement factors to provide the flexibility for players to find their own individual learning route through the game. The resulting framework from this chapter is used in conjunction with the results from the extended technology acceptance model in the next chapter to inform the design requirements for a digital educational game for use in supporting mathematics education in the classroom.

5 Chapter 5: Technology Acceptance In The Classroom

5.1 Chapter introduction

As researchers continue to study the barriers and challenges that affect the integration and adoption of digital learning technologies in the classroom, more focus is being placed on the role of teachers in the adoption process. A number of studies have attempted to identify the challenges teachers face and understand their adoption process. In these studies, it is important to understand the local environment and context that the teachers operate in. For example each developing country has its own specific level of education, culture, practices and economic situation and within this there will also be regional differences. Thus it is important to recognise these and examine the process of acceptance of technology by teachers in the classroom in each particular context. This is especially important in countries where little or no previous research has been done. Using the Technology Acceptance Model as a basis, this chapter presents the study that was carried out with teachers in the Ekiti State of Nigeria to understand the factors that are central to their acceptance, adoption and integration of digital educational games in the classroom. The study employed a mixed methods approach and combined the outcomes from previous research studies with data gathered from interviews with teachers to develop a modified TAM. Independent evaluation by a group of experts gave further confidence in the model. Following this, the model was tested with a wider range of teachers from Ekiti State, Nigeria. The chapter concludes with a set of implications for practice to guide the introduction of digital educational games into the classroom.

5.2 Research Approach

As established in Chapter 2, a key element for ensuring the success of the introduction of new technologies is that the users are prepared and ready to accept the technology. This research combined the original Technology Acceptance Model (TAM) – Figure 2.4, and interviews with teacher to explore the preparedness and intention of teachers to use digital educational games in the classroom. There are two main rationales for using TAM for this study -the first is that TAMs have been widely used and validated as a model for understanding users' intention to adopt a particular technology and/or the actual adoption while highlighting their main concerns and issues (Dong et al., 2017) particularly in the field of education (Huang et al., 2016; Chintalapati et al., 2017). TAMs have also been found to work well across cross-sectional boundaries (McCoy et al., 2005), which is a vital consideration in this study.

However, previous studies have argued that the primary constructs of the original TAM (perceived usefulness and perceived ease of use) are usually not sufficient to explain user's acceptance of new technologies (Wang et al., 2003) and so it is important to carry out research to understand the factors that influence perceived usefulness and perceived ease of use. This approach of combining the results from previous studies together with interviews from the targeted group enabled the key variables/constructs to be identified.

a) Interview purpose and design

The main purpose of the interviews was to identify the external variables for the TAM similar to the approach taken by Ng et al., (2013) and Wong (2015). However, the research team also included questions to explore the variables adopted from the original TAM, namely: *perceived usefulness, perceived ease of use, subjective norm and behavioural intention.* This was to provide contextual evidence for these variables and ensure that they hold for the particular population of this study. Prior to each interview, the teacher was given a brief introduction and definition of a digital educational game to ensure that their responses were focused on these and they did not confuse them with other digital games and/or board and card games. The questions that the researcher asked the teachers are listed below:

i. Do you play digital games?
ii. Perceived usefulness: do you think digital educational games can be useful in the classroom for teaching mathematics? If yes, what for?
iii. Perceived ease of use: how easy do you think digital educational games would be for you to use in the classroom?
iv. Behavioural intention: would you use digital educational games in your classroom? If not, why not?
v. External Variables: are there other factors that could influence your decision to use or not to use digital games to teach mathematics in your classroom?

The five structured interview questions were drawn from the constructs mentioned earlier: perceived usefulness, perceived ease of use, behavioural intention, subjective norm and the external variables with scope for follow up questions depending on the nature of their responses. If teachers asked for further clarification on any of the questions, further explanation was always provided.

b) Participants and data collection

The semi-structured interviews were carried out with primary school teachers across four of the ten schools that signed up as partners for this research in Ado-Ekiti, Southwest Nigeria (n = 10; Female = 6; Male = 4). The teachers were selected to have varying levels of experience of teaching mathematics across a number of different age ranges and are representative of the wider population of teachers across the ten schools. Many of the teachers were familiar with the daily use of technology devices such as phones, tablets and desktop computers. They also all knew what a digital game was, but none of them had ever used such technology to aid teaching at any point in their career.

5.3 Results and analysis

The data from the teacher interviews were analyzed to identify the key elements from the teachers' perspectives. These were then combined with the results from the literature review to produce the following variables/constructs:

Perceived usefulness: the degree to which the teacher believes that using digital games for teaching and learning will enhance their job performance. This construct and description was adapted from the original TAM, which found that perceived usefulness has a direct positive effect on behavioural intention to use. This aligns with the views from the teachers who are positively disposed to the idea of using digital educational games in the classroom. Teacher J said:

"*I think educational games can create interest in learning mathematics as they like games already. It can also help them learn difficult things"*

Teacher I noted:

"*digital educational games can be very useful in increasing motivation as the motivation to play the game is already there and you wouldn't need to create it again unlike with traditional teaching that you have to make them enjoy. Since they can enjoy the game, they can easily enjoy the mathematics*".

The hypothesis for this variable is as follows:

H1. Perceived usefulness will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

Perceived ease of use: this is the degree to which the teacher believes that using digital games for teaching and learning will be free from effort. This variable and description is adapted from the original TAM and confirmed by the results from the teachers' interviews. These results suggest that teachers who are negatively disposed to the use of digital games in the classroom have a pre-determined opinion about 'how easy technology is to use'. One of the teachers stated that

"using something I was not familiar with before would be difficult for me, spending that precious time learning to use it can be a waste of precious teaching time, it may end up being too difficult to use".

The sense of novelty and lack of experience with 'new technologies' also appears to affect the perception of usefulness. Teachers who feel digital games will be easy to use appear more likely to be positive in identifying its usefulness and vice versa (Teo and Ursavas, 2012). One teacher commented,

"*because of lack of experience, if the tool is too hard to use, it may be difficult to identify the usefulness and use it appropriately."*

Hence perceived ease of use has a direct association with perceived usefulness. This is also consistent with previous research results that suggest that greater experience with technology is a strong predictor of intention to use more technology, and creates a more positive disposition towards trying new technologies out (Tondeur et al. 2008; Potosky and Bobko, 2001)

The hypotheses for this variable are:

H2 Perceived ease of use will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

H3 Perceived ease of use will be positively associated with perceived usefulness of digital educational games to teach mathematics in the classroom.

Self-Adequacy/Efficacy: Bandura (1977) defines this as the teacher's belief in their ability to use digital games for learning and teaching. This is a self-reported assessment of the teacher's competency and efficacy in using digital educational games in the classroom. This variable has appeared in several studies that looked at the 'intention to use information technology' (Cheung and Vogel, 2013; Mun and Hwang, 2003). It was also reinforced by several of the responses from the interviews. Consider the cases of Teachers A and B who both acknowledge they are not familiar with the use of technology. Teacher A maintains that

"*I will be willing to try it out as I believe with training and practice, I can get used to using games to teach"*

while Teacher B maintains that

"*I do not think it is something I can use, I use less technology as much as I can, I just don't get it"*.

These contrasting responses suggest that self-concept and belief in one's ability is a major determinant of the intention to use digital educational games in the classroom. This aligns with Cheung and Vogel's findings that "*self-efficacy is not concerned with the skill one has, but with the judgment of what one can do with whatever skills one possesses"* (Cheung and Vogel, 2013)

The hypotheses for this variable are as follows:

H4 Teachers' self-efficacy will be positively associated with their behavioral intention to use educational games in the classroom.

H5 Teachers' self-efficacy will be positively associated with their perceived ease of use.

Syllabus-connectedness: this is the connection between the game and the syllabus and how the game can help a teacher meet their curriculum goals. It describes the suitability of digital educational games to delivering syllabus-related content. In formal education settings especially, where there is predefined content teachers are supposed to teach, teachers want to ensure that there is educational value in whatever tools or methods they are using to teach (Wong, 2015; Ketelhut and Schifter, 2011). This variable arose from a combination of the interview analyses and evidence from the literature that the adoption of games is also determined by the potential to embed learning materials in the game (Bael, 2008; Becker, 2007). Teacher D while responding to the question about the perceived usefulness of digital educational games in the classroom said

"*the play method has been used before, and has been largely successful; games can enhance the learning experience and make the classroom interesting, but in terms of learning real syllabus content, I am not sure how that would work'*.

Becker (2007) observes that because digital games are not traditionally designed to fit the 'content-and time-related' boundaries that learning content typically has, teachers can find the adoption complicated. On the other hand, if a teacher considers digital games to have the potential to teach the kind of things they want to teach, the perceived usefulness increases. This provides a direct relationship between syllabus-connectedness and perceived usefulness. The hypotheses for this variable are as follows:

H6 Syllabus-connectedness will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

H7 Syllabus-connectedness will be positively associated with perceived usefulness of digital educational games to teach mathematics in the classroom.

Enabling environment: this variable measures the teachers' perceptions of the environmental factors and conditions that make using digital games to teach in the classroom an easy act to accomplish. This includes the infrastructure that is available such as the power, internet access, hardware devices, time and human and technical support. It has its origins from the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). This variable has been widely used and appeared in various literatures as facilitating conditions (Sanchez-Prieto et al. 2016; Becker, 2007)**.** In this study, '*environment'* appeared more often than '*conditions'* so the variable was modified to become '*enabling environment'*. For example, in response to the question about other determinants to use or not to use digital games in teaching in the classroom, Teacher B mentioned

"*the general environment including power (electricity) and cost, devices and internet access"* going further to state that "*these things are lacking in our communities"*.

Teacher G also maintained that

"*introducing games to teachers without the right amount of preparation and awareness can be counterproductive, and in this environment we are in, it can be hard to find support to help one train*".

These responses suggest that teachers' perception of the peculiarities and realities of their work environment impacts on their intention to use digital games to teach, as well as the perceived ease of use. Teachers feel that without adequate training and continued support, it will be difficult to successfully use digital games to teach in the classroom. This is consistent with other findings. Teo (2012) found that facilitating conditions has a significant effect on perceived ease of use. The following hypotheses are proposed to examine the effect of enabling environment:

H8 Enabling environment will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

H9 Enabling environment will be positively associated with perceived ease of use of digital educational games to teach mathematics in the classroom.

Experience with technology and technology-enhanced teaching: the teacher's experience of using technology to support teaching and learning as well as using technology generally in the wider sense. There are conflicting views from the literature on whether experience or familiarity with a particular technology is a major determinant of the intention to use that technology. Thompson et al. (1991) found that prior experience can influence in three main ways: directly, indirectly through attitude and beliefs, and thirdly through moderating the effect between other variables in the model and the intention to use the technology (Thompson et al. 1991). The results from this study supports claims that lack of specific experience can be potentially problematic and can create a divide between teachers and students. Teacher H who did not play digital games expressed the view that

"*games are not what I want to use in my classroom'*.

Other teachers who were also not familiar with digital games backed this up:

"*I do not think it is something I can use*".

Thompson et al. found this variable directly affects the behavioral intention to use digital games in the classroom directly and indirectly by affecting self-efficacy, and also perceived ease of use (Thompson, 1991). The following hypotheses are proposed to examine these effects:

H10 Experience with technology and technology-enhanced teaching will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

H11 Experience with technology and technology-enhanced teaching will be positively associated with perceived ease of use of digital educational games to teach mathematics in the classroom.

H12 Experience with technology and technology-enhanced teaching will be positively associated with self-efficacy.

Subjective norm: This describes the external and social pressures a teacher is under to behave in a particular way or carry out a task. It describes what the key individuals (e.g. colleagues, government, parents) think about using educational games in the classroom where those key individuals are those whose opinions matter to the teacher. This variable originated from the TRA. Although it was not incorporated from the TRA into the original TAM, it has been used and proved useful in various research studies particularly in education to examine the pressure teachers are under to adopt technologies in their teaching practice(Wong, 2015; Sanchez-Prieto et al. 2016, Calisir et al. 2014). Hu et al. (2003) maintain that it is highly likely for teachers to turn to their colleagues for advice and suggestions when presented with new technologies. The data here shows that a key area where teachers feel pressure is from their senior management. According to Teacher B

"*if the management wants it, or maybe it is used in another school and a member of the PTA(Parents' Teachers' Association) committee sees it, they may ask the school management to get something like that*".

Sun and Zhang (2006) suggest that subjective norm can affect the behavioural intention in two ways: directly by teachers wanting to comply with the demands placed on them by others; or indirectly by its influence on their beliefs. The indirect effect is from teachers believing that it must be useful if others are using it. This construct however has shown varying results in research with some attesting to its impact (Teo and Ursavas, 2012) while others are yet to prove that it influences behavioural intention (Kennedy-Clark, 2011)
The hypotheses for this subjective norm are as follows:

H13 Subjective norm will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

H14 Subjective norm will be positively associated with perceived usefulness of digital educational games to teach mathematics in the classroom.

Engagement and Learning opportunities: The origin and widest use of the technology acceptance model is in business and commercial research where objectives are largely different from education objectives (Hu et al, 2003; Teo et al., 2008). This suggests that there is a possibility that the original TAM variables (perceived usefulness and perceived ease of use) amongst others may not necessarily portray the same definitions in the context of education. Bourgonjon et al. (2013) argued that job performance defines perceived usefulness in the original TAM instead of the process of teaching. It was therefore important to include a variable that examines if teachers perceive digital educational games as potentially useful in terms of educational values and increased classroom engagement. The variable draws from what the teachers under study mentioned to be some of the perceived usefulness of digital educational games.

Therefore two hypotheses were proposed for this variable:

H15 Engagement and learning opportunities will be positively associated with teachers' behavioral intention to use digital educational games to teach mathematics in the classroom.

H16 Engagement and learning opportunities will be positively associated with perceived usefulness of digital educational games to teach mathematics in the classroom.

The variables and the resulting questionnaire were subject to face validity by a team of independent teachers in the United Kingdom. The experts are former teachers who have all used technology-enhanced teaching in their classrooms. The rationale for this kind of validation was to confirm if the variables were well constructed to prevent ambiguity and ensure that the items under each variable provide sufficient measurement for it. The experts commented that the number of items under each variable should be reduced as some of them were examining the same things. They also re-worded the questionnaires to improve clarity and relevance.

The modified TAM constructs are presented in the modified TAM is given in Figure 5.1. This modified TAM has been deployed to provide guidelines toward the introduction of digital games to support the teaching of mathematics in a group of schools in Nigeria. The results have provided a strong indication of the key issues and barriers that needed to be addressed to support teachers and ensure they are ready to embrace the introduction of digital games in the classroom.

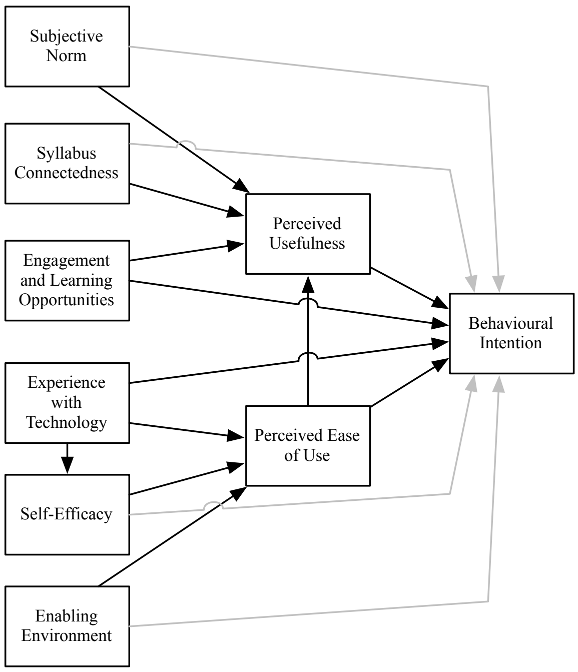

Figure 5.1 Extended (Modified) TAM

5.4 Instruments, Participants and Data collection

Following the development of the modified TAM from the identified constructs, a questionnaire was developed to test out the TAM on a wider audience. The first part of the questionnaire contains measures for the constructs in the model. The second part examined constructs related to the career of the teachers under study and the third part collects demographic information about the teachers. For the extended TAM, just as in similar studies, the researcher adapted and modified scales from previous research just to exploit well-validated psychometric measures (Straub, 1989). Items that measured teacher-related constructs e.g. teaching experience were modified and included from Bourngonjon et al. (2010). The scale items were measured on a five-point Likert scale (1 strongly disagree – 5 strongly agree).

A pilot study tested the instrument with twenty teachers in three of the partner schools. In addition to this, suggestions and recommendations were taken from four teachers and 5 university academics in order to remove any ambiguity in the questionnaire. Minor changes to the language of the items on the questionnaire were made based on the comments of the experts and the test sample. In order to ensure the validity of this study and considering the exploratory nature of this research, the researcher used a convenient sample of teachers who currently teach across schools in Ado-Ekiti, Nigeria. A range of school types were used – public and private funded, primary and secondary. Initial contact was made with the headteacher of each school to explain the purpose of the study and how teachers would be required to participate. Pamphlets detailing information about the research were given to the teachers one week before the data collection exercise and questionnaires were only given to teachers who showed willingness to participate in the research. Paper samples as well as link to the online version of the questionnaire were provided to the teachers. Of the 220 teachers contacted, only 212 returned the completed questionnaire. 17 of these were discarded, as they were not completely filled thus presenting an 87% response rate. This left the researcher with 195 valid questionnaires. Table 5.1 contains the breakdown of the sample for this study.

Characteristics	N	%	significant difference (agree)
Gender			
Male *Female*	*101* *94*	*52* *48*	*Chi-square = 9.553; p = 0.004* *Male= 58%; Female = 42%*
Age (years)			
21-30 *31-40* *41-50* *51-60* *Over 60*	*23* *72* *89* *11* *0*	*12* *37* *45* *6* *0*	*Chi-square = 28.49; p = 0.001* *21-30 = 83%; 31-40 = 58%* *41-50 = 39%, 51-60 = 18%*
Teaching experience (years)			
1-10 *11-20* *21-30* *Over 30*	*99* *83* *13* *0*	*51* *42* *7* *0*	*Chi-square = 19.158; p = 0.005* *1-10 = 63%; 11-20 = 40%* *21-30 = 23%*
***Technology proficiency**			
High *Medium* *Low*	*70* *50* *75*	*36* *26* *38*	*Chi-square = 138.727;p=0.001* *Low = 7%; Medium = 34%* *High = 95%*

Table 5.1 Breakdown of Sample
(Very good, good = High; Moderate = Medium; Poor, No ability = Low)

5.5 Analysis and Results

SPSS version 24 was used for the analysis of this data. The data was coded for easy analysis and inputted into the statistical package for analysis. Results of the analysis starting with reliability tests on the entire dataset are presented below.

a) Instrument Reliability: Cronbach's Alpha

To begin the analysis the researcher assessed the reliability of the nine scales used in the survey. Cronbach's alpha is an index of reliability, commonly used to evaluate if an instrument will produce consistent and reliable data each time it is used, even in cases when the items on it are replaced with similar items. To ensure the validity of the research instrument, the researcher used a combination of exploratory factor analysis and reliability analysis using Cronbach's alpha. For the exploratory factor analysis, the researcher checked that all assumptions needed to carry out the analysis were met: the study sample size is adequate (at least 150 for results to be valid), the multiple constructs are ordinal in nature, there is a linear relationship between all variables (checked by scatterplots of the variables), and there are no outliers in the data (checked by the standard deviation scores). The Kaiser-Mayer-Olkin (KMO) measure of sphericity supposes the recommended threshold of 0.60 (KMO = 0.953) while the Bartlett's test of sphericity is significant at $p < 0.001$. A one-factor solution explains 67% of the variance amongst the items on the scale.

For the reliability, alpha coefficient ranges from 0 to 1, the closer the number is to 1, the more reliable the scale is. The internal consistency is the strength with which each of the questions in the questionnaire is related to one another and it should be at least 0.70 to be considered acceptable (Streiner and Norman, 2008) The Cronbach's alpha coefficients demonstrated a high level of internal consistency among the scale items with values well higher than the acceptable value as shown in table 5.2:

Construct	***Cronbach's alpha (α)***
Perceived usefulness	0.923
Perceived ease of use	0.924
Syllabus connectedness	0.922
Enabling environment	0.930
Experience with technology	0.930
Self-Adequacy	0.930
Engagement and learning opportunities	0.926
Subjective norm	0.936
Behavioral intention	0.919

Table 5.2 Cronbachs alpha for Extended TAM Constructs

The researcher concluded based on these findings that the instrument is reliable and was able to be used to measure the intended constructs of the extended TAM.

b) Descriptive Statistics

Descriptive statistics and frequency distributions were calculated for each of the construct items in the questionnaire. The results are presented in table 5.3 below:

Construct	Mean	Std. Deviation
Perceived usefulness	3.21	1.415
Perceived ease of use	2.75	1.026
Syllabus connectedness	2.86	1.008
Enabling environment	2.44	1.055
Experience with technology	2.64	0.949
Self-Adequacy	2.82	0.910
Engagement and learning opportunities	3.47	1.194
Subjective norm	2.91	0.744
Behavioral intention	3.05	1.399

Table 5.3 Descriptive statistics for Extended TAM Constructs

c) Correlation Analysis

Correlation analysis was carried out between pairs of variables to see if they co-vary thereby testing the validity of the hypotheses. This method is a widely used method for evaluating the correlation between pairs of variables. It is worthy of note that the bivariate analysis using Pearson's r does not present anything more than a confirmation of a relationship between two variables, for example variable A and variable B. The knowledge of the understanding suggests that if the value of A increases, then the value of B increases and vice versa (Bryman and Bell, 2015). The results of the correlation analysis are presented in Table 5.4 below:

In order to understand the relationship further, the researcher carried out regression analysis by establishing if there is a causal effect of the independent variable on the dependent variable.

d) ***Regression Analysis***

To understand the interrelationship between the different variables and explain the variance in behavioural intention to use digital games in the classroom, regression statistical analysis was carried out on the extended TAM. As stated earlier, in order to ascertain a relationship between a dependent variable and an independent variable, an equation called a regression equation can be used. According to Bryman and Bell (2015), regression means that the average value of the dependent variable can be explained as a function of the independent variable. There are two types of regression analysis: simple and multiple.

		PU	PEOU	SC	EE	ET	SA	EL	SN	BI
PU	Perceived usefulness	1								
PEOU	Perceived ease of use	0.714**	1							
SC	Syllabus connectedness	0.732**	0.729**	1						
EE	Enabling environment	0.576*	0.629*	0.653*	1					
ET	Experience with technology	0.621*	0.618*	0.594*	0.540*	1				
SA	Self-adequacy	0.710**	0.642*	0.731*	0.566*	0.569*	1			
EL	Engagement and learning opportunity	0.680**	0.654*	0.688**	0.548*	0.535*	0.666*	1		
SN	Subjective norm	0.507*	0.451*	0.492*	0.456*	0.386•	0.471*	0.493*	1	
BI	Behavioural intention to use	0.810**	0.735**	0.773**	0.645*	0.651**	0.724**	0.739**	0.529*	1

Table 5.4 Pearson Product-Moment Correlations. (*Key: *Moderate, **Strong*)

Simple linear regression is focused on examining the impact one independent variable on a dependent variable. Multiple linear regression examines how much multiple variables affect the dependent variable. Given that this study examines the relationship between nine variables, multiple linear regression is appropriate. Looking at the model, the researcher carried out multiple linear regressions on the hypothesised paths (H1 – H16) in the conceptual model.

Results of the multiple linear regression are presented in table 5.5. The F-ratio in the **ANOVA** table (table 5.6) tests whether the overall regression model is a good fit for the data. The table shows that the independent variables statistically significantly predict the dependent variable, $F(8, 186) = 33.694$, $p < .0005$ (i.e., the regression model is a good fit of the data).

Hypothesis	Independent Variable	Dependent Variable	β	t-value	p	R^2	Hypothesis Supported?
H1	PU	BI	0.81	19.177	0.001	0.656	YES
H2	PEOU	BI	0.735	15.037	0.001	0.540	YES
H3	PEOU	PU	0.714	14.171	0.001	0.510	YES
H4	SA	BI	0.724	14.58	0.001	0.524	YES
H5	SA	PEOU	0.642	11.647	0.001	0.413	YES
H6	SC	BI	0.773	16.906	0.001	0.597	YES
H7	SC	PU	0.732	14.937	0.001	0.536	YES
H8	EE	BI	0.645	11.714	0.001	0.416	YES
H9	EE	PEOU	0.629	11.248	0.001	0.396	YES
H10	ET	BI	0.651	11.901	0.001	0.423	YES
H11	ET	PEOU	0.618	10.919	0.001	0.382	YES
H12	ET	SA	0.569	9.619	0.001	0.324	YES
H13	SN	BI	0.529	8.662	0.065	0.280	NO
H14	SN	PU	0.507	8.168	0.096	0.257	NO
H15	ELO	BI	0.739	15.23	0.001	0.546	YES
H16	ELO	PU	0.68	12.886	0.001	0.462	YES

Table 5.5 multiple regression analysis table

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	269.553	8	33.694	69.306	.000[b]
	Residual	90.426	186	.486		
	Total	359.979	194			

a. Dependent Variable: BI

b. Predictors: (Constant), SN, PEU, SA, ET, EE, EL, PU, SC

***Table 5.6* Anova Table for the overall regression model**

The paths of the model were examined by checking the hypotheses formulated earlier in the chapter. 14 out of the 16 hypotheses were confirmed, with different levels of strength and variances as depicted by the values of R^2. However, as the researcher was keen to understand the factors of the model that have the biggest effects on the behavioural intention of the teachers directly or indirectly under study to accept digital educational games, the focus was on the higher values for R^2 – called the co-efficient of determination. This co-efficient depicts the proportion of variance in the dependent variable that can be explained by the independent variable.

Unsurprisingly, perceived usefulness (β = 0.810, R^2 = 0.656) comes out as the biggest predictor of teachers' behavioural intention to use digital games to teach in the classroom supporting H1. It also explains 66% of the variance in behavioural intention to use digital educational games. Syllabus connectedness, perceived ease of use and engagement and learning opportunities are all positively associated with perceived usefulness supporting hypotheses H3, H7, and H16. However, syllabus connectedness (β = 0.732, R^2 = 0.536) is the strongest predictor of perceived usefulness, and it explains 54% of the variance in perceived usefulness. Results show that subjective norm is not positively related to perceived usefulness (β = 0.507, R^2 = 0.257) and the variance explained shows that it explains only 25% of the variance in perceived usefulness. In the same vein, subjective norm is not positively related to behavioural intention to use (β = 0.529, R^2 = 0.280) and as a result only 28% of the variance in behavioural intention can be explained by subjective norm. These results about subjective norm therefore made the researcher reject hypotheses H13 and H14. Perceived ease of use (β = 0.735, R^2 = 0.540) too is a strong predictor of behavioural intention to use, thus supporting H2. Furthermore, it explains 54% of the variance found in behavioural intention to use. Constructs self-adequacy, enabling environment and experience with technology are all positively related to perceived ease of use confirming hypotheses H5, H9 and H11. Results however show that self-adequacy is the strongest predictor (β = 0.642, R2 = 0.413) of perceived ease of use. Self-adequacy explains 41% of the variance found in perceived ease of use. In all, results shows perceived usefulness as the main predictor of behavioural intention to use and subjective norm as the only construct that does not predict behavioural intention to use. Table 5.5 shows all the t, p and R^2 values as well as the hypotheses supported or not supported.

5.6 Discussions

Table 5.3 and Table 5.1 shows more details about the descriptive statistics and breakdown of the population used for this research. The descriptive statistics show that teachers in the population are fairly mixed in their technology proficiency (m=3.07, sd = 1.043). 36% consider themselves highly proficient in the use of technology while 38% consider themselves very low. The technology proficiency significantly affects the intention to use digital games in the classroom. Results show that 95% of teachers who consider themselves highly proficient in the use of technology is positively disposed to use digital games in the classroom.

This is similar to earlier findings about self-efficacy and confidence (Koehle et al., 2007; Lee and Lee, 2014; Hamari and Nousianen, 2015). It is interesting to note that only 34% of teachers that consider themselves moderately proficient in technology are positively disposed to using digital games in the classroom. This indicates that teachers need to be confident in their ability to properly use technology before they would consider using digital games to teach in the classroom.

Teachers' age group also significantly affects teachers' intention to use digital games in the classroom. Results show that older teachers are less likely to want to use educational games in the classroom. While 83% of teachers between 21 and 30 years old are positively disposed to using games to teach, only 18% of teachers aged over 50 responded positively. This agrees with studies that suggest that younger and older teachers may have different attitudes towards and confident levels of technology use (Venkatesh et al, 2003). This may also be further explained by the little exposure older teachers may have had to computer training and use. It is strongly possible that many of the teachers aged 40 and above have little or no experience with technology.

These findings are consistent with the influence of teaching experience has on intention to use digital games in the classroom. 63% of teachers with 1-10 years of experience are positive about using digital education games in the classroom. On the other hand, only 23% of the teachers with over 20 years of teaching experience agree that they would use digital games in the classroom. A possible explanation is that in Nigeria, phone, computers and other digital technology tools became popular just close to two decades ago and at such many teachers trained before then would not have been trained to use or work with these devices. It is therefore a possibility that these results mirror the peculiarities of the study population.

However, the findings of this research is in contrast to the findings of Blackwell et al (2014) that suggest that teaching experience has a negative direct effect on technology use. Although they originally hypothesised teaching experience to have a negative effect on intention to use technology, they found out that it had a positive effect. They explained that while teachers with more experience were likely trained in more traditional ways and at such shouldn't be very familiar with technology, the teaching experience may be beneficial to them in that they have some fundamental knowledge of education and how technology can be incorporated into it.

Findings also show that gender is a factor that significantly differentiates the population in this study. Male teachers are 16% more likely to use digital games in the classroom than female teachers. This agrees with Venkatesh (2003) submission that intention to use technology is moderated by gender. The differences in inclination can be explained by the confidence in the use of technology. While male teachers may not necessarily be more experienced or skilled in the use of technology in the classroom, it is likely that they are more confident in their ability to learn and get familiar with it than females are. As several studies suggest (Dhindsa and Shahrizal-Emran, 2011; Li and Kirkup, 2007; Yau and Cheng, 2012) the opinion that females think technology is generally more for me and the gender stereotypical views can also make females doubt their ability to use digital games to teach.

In terms of constructs, results are generally neutral with most of the means around 3 (on a scale of 1 to 5). This is with the exception of 'enabling environment' (m = 2.44) and "experience with technology" (m = 2.64) that had mainly negative responses. Other constructs with negative means are self-adequacy (2.82), subjective norm (2.91), perceived ease of use (2.75) and syllabus-connectedness (2.86). Results are somewhat complex in terms of perceived usefulness and ease of use. On one hand, the teachers in the sample tend to believe that digital games would be useful in the classroom (m= 3.21, sd = 1.415) but disagree that it would be easy to use (m= 2.75, sd = 1.026). This agrees with the results of another construct – engagement and learning opportunities (m= 3.47, sd = 1.194), which is the most positive of all the constructs. This suggests that teachers somewhat agree that using digital games in the classroom will be beneficial especially in engaging pupils but doubt if they have the skills to use it in teaching syllabus contents (m= 2.86, sd = 1.008). Thus us similar to previous findings that suggest that usefulness in providing learning opportunities is not a major concern for the teachers (Kennedy-Clark, 2011) but are also not convinced that it can improve their own job performance e.g. in teaching syllabus contents (Bourgonjon et al, 2013).

The Pearson Product-Moment Correlation test was carried out to measure the strength of the linear association between each construct and the others on the extended TAM. This draws a line of best fit through the respondents' data of the pairwise constructs being tested. The

Pearson correlation coefficient denoted by r(-1, negative association to +1, positive association with 0 denoting no association) then shows how far away the data points are from the line of best fit. This test treats all constructs as the same and does not take into any consideration independent or dependent variable. It is important to note that the association presented by the correlation coefficient r does not equate to a cause-and-effect relationship between the constructs but only describes the strength and direction of the relationship. According to Prion and Haerling (2014) the 'rule of thumb' for interpreting the coefficient r results are: 0 to ±0.20 is negligible, ±0.21 to ±0.35 is weak, ±0.36 to ±0.67 is moderate, ±0.68 to 0.90 is strong, and ±0.91 to ±1.00 is considered very strong. The very strong values are considered very rare in social science research (Shavelson, 1988).

Table 5.4 shows the result of the pairwise correlations. Expectedly, each of the constructs correlated perfectly with themselves at r = 1. Other coefficient values ranged from 0.810 (highest) to 0.386 (lowest). There is no negative association amongst all the constructs, and all the associations were significant at the $p < 0.05$ level. Following Prion and Haerling's (2014) rule of thumb, the strengths of the relationships are either moderate or strong. There is a strong relationship between perceived ease of use and perceived usefulness. This is consistent to findings in previous similar studies (Elkaseh et al, 2016; Calisir et al, 2014; Teo et al, 2016).

Expectedly, syllabus connectedness also has a strong positive relationship with perceived usefulness. Interesting, all the constructs except subjective norm, enabling environment and experience with technology have positive strong relationships with behavioural intention to use. Results also show that only the three constructs (subjective norm, enabling environment and experience with technology) do not have a single strong relationship with other constructs with subjective norm visibly holding the weakest relationships with the others.

5.7 Implications for practice

The results and findings presents recommendations for policy makers, school leaders as well as developers of digital educational games. These practical insights are also very useful in guiding deployment activities especially in places where such technological interventions have not been used before. It is interesting to note that ease of use is not as important to the behavioural intention to use digital games as much as perceived usefulness. This is in contrast to many similar studies (Huage, 2016; Wwang et al, 2017). The explanation in the literature that perceived ease of use has a greater influence on users' intention to use a technology when they had little experience of it, and that perceived usefulness has more when the population had more experience (Lin, 2011) is challenged here as the population of teachers studied here has had no experience with using technology in the classroom.

This finding suggests that a greater awareness about the usefulness of digital educational game is of more importance to teachers. Teachers need to be conscious of how games can be used to improve their professional duties as it does not matter how complex or easy it is if it does not make their work more effective and efficient. However, it is also important to evaluate and understand how easily these teachers are able to integrate digital games in their teaching practices (Manches and Plowman, 2017). For the population of teachers studied who are new to technologies in the classroom, the advantages and possibilities digital games offer may not be immediately obvious.

This means that any attempt to introduce digital games in the classroom should be preceded with more than a briefing session for the teachers. It will be necessary to expose them to workshops and trainings focused on raising their awareness of the uses of games in the classroom. Examples of successful implementation of game-based learning and its impact on teachers' productivity and pupil's performance could go a long way in making them aware of the usefulness and ultimately preparing them to adopt it in their own classrooms.

However, findings about technology proficiency, self-efficacy and experience with technology also suggest that training should not just be focused on the use of digital games in education. Teachers want to be confident in their own ability to use whatever tool they are bringing into the classroom. Findings suggest that they are more comfortable with using technology in everyday life and those that consider themselves highly technologically proficient are more positively disposed to using digital games to teach in the classroom.

This is consistent with recommendations from Baturay et al (2017) and Hsia et al (2014). Training should therefore be holistic, starting from computer appreciation, and general tools like Microsoft Office Suite applications like Microsoft excel to improve classroom administration and then gradual introduction of more complex tools such as games. Improving teachers' self-efficacy and experience with technology can significantly increase their readiness to accept and use digital games in the classroom.

Another factor that strongly predicts perceived usefulness is syllabus connectedness. This suggests that in order for teachers to see digital games as useful, they should be able to see how the syllabus content can be taught with it. It is not enough for the teachers to know games could improve engagement and create more fun in the classroom. They believe that completing their syllabus is their primary duty and so if they are adopting games, the games must be useful in delivering their lessons and getting pedagogical outcomes. One way of achieving this is by involving teachers in developing game stories. Game development processes could easily be isolated and by thus out of important considerations that teachers my have. Bourgonjon et al, (2013) maintain that just promoting digital games as a new popular teaching method would not be as effective as allowing teachers to take an active role in the process. Teachers can specifically suggest what parts of the curriculum developers should focus on when designing digital games. Being part of that process in itself can potentially improve their intention to use digital games in the classroom.

Interestingly, the findings of this research downplay the importance of social pressure on the teachers' intention to use digital games in the classroom. The study suggests that teachers' intention to use digital games in the classroom would be greatly influenced by their own opinions rather than that of others. This is in contrast to the findings of Bourgonjon et al, (2013) and Barab et al (2009). This suggests that in the decision making process of the teachers, they do not significantly consider what other teachers, parents and pupils think about the subject matter. This may be due to the fact that teachers consider themselves experts in this matter and that the parents/guardians of their pupils are not well informed about teaching methods or classroom activities as much as they are and so are not in a position to put them under any form of pressure. This is more noticeable in Nigeria as a result of the literacy levels of many parents and guardians. Further findings suggest that subjective norm is mediated by technology proficiency. Subjective norm exerted more influence on the intention of teachers' towards using digital games in the classroom when they have low technology proficiency.

Our findings also suggest that teachers' demographics and characteristics mediate their intention to use digital games in the classroom. Interestingly, younger teachers are more likely to readily accept to use games in teaching than older teachers. Earlier the researcher suggested that is most likely due to the increased exposure the younger generation have to technology compared to older teachers. Again, this is a confidence issue that can be handled by strategic training and support. Before the introduction of games for teaching to the teachers, it is important to assess them with respect to their technology proficiency. This need not be specifically about games as it is noted earlier that general technology proficiency strongly predicts intention to use digital games. It is therefore necessary to provide varying levels of support and training as address the specific needs of the teachers.

Gender mediates perceived ease of use, technology proficiency, as well as self-efficacy, as males are generally more positive than females. As suggested earlier and from the literature, this is not mainly due to actual skills gap between the genders but due to a difference in identity and a belief that males are generally better with technology that females. Given that self-efficacy and perceived ease of use significantly impacts on behavioural intention to use technology in the classroom, it is important to address this during any practical deployment of digital educational games in the classroom. One way this may be done is to project images of females using games in the classroom or generally working with technology in day-to-day work. Training materials like slides, pictures and narratives should be gender-balanced. In addition and as much as possible, training personnel should be balanced as well.

Finally, the introduction of digital games in the classroom needs to take a holistic approach that incorporates awareness and exposition on the advantages and possibilities it offers to teachers, training as well as continuous technical and usage support.

5.8 Conclusions

This chapter presented the second background study of this research project. This study was conducted with teachers who have had no experience with using digital educational games in their teaching practice. The aim was to gain an insight into their needs and requirements as well as to provide an understanding of where the focus for supporting the implementation of digital educational games in their classrooms should be.

The study further strengthened the belief that strong relationships exist between the original TAM constructs. Building on previous work, the researcher extended the original TAM with TRA, and other variables like syllabus-connected, experience with technology, self-efficacy and enabling environment. While previous studies have ascertained the value and impact of the subjective norm on people's behavioural intention and use of technologies, this study found out that subject norms do not affect teachers' in Nigeria behavioural intention to use digital educational games in the classroom. It also presents varying levels of effect of the factors in the extended TAM on the behavioural intention to use digital educational games in the classroom.

The insight generated from this background study will be used in guiding the design, development and implementation of digital educational games in classrooms in Nigeria.

6 Chapter Six: Design and Implementation *SpeedyRocket*

6.1 Introduction

One of the aims of this research is to create a prototype digital educational game to support the teaching of mathematics among young children. This chapter presents the development process of the game: *SpeedyRocket*. The game is built on the findings from the literature about the motivations and preferences for digital games, mathematics curriculum in Nigeria, the engagement framework described in Chapter 4, and the findings from the extended TAM study carried out with teachers and presented in Chapter 5. Firstly the rationale behind developing a game rather than using a ready made one is discussed. This is followed by a discussion around game genres and their suitability for learning. The next section presents the choice of game, the design requirements for it and the subsequent development process. The chapter ends by outlining the implementation procedure and associated processes for using *SpeedyRocket* in the classroom environment.

6.2 Rationale for Developing the Digital Educational Game

One of the key arguments of this research study is the need to ensure that digital educational games are designed and developed to have the same engagement factors as digital entertainment games. Also as the game was going to be used in Nigeria where there was limited Internet access, the game needed to be able to be played as a stand-alone programme on a tablet, and be low cost or preferably free of charge. Having investigated the current range of 'free' or 'low cost' games, the researcher concluded that none met the main engagement factors and thus the researcher decided to build an educational game from scratch rather than use an existing one. This also had the advantage that the researcher had control over the number and quality of engagement factors that could be designed into the game from the outset. The researcher could also ensure that the game would be freely available and would work on a stand-alone tablet.

A further justification for this approach is based on the findings from the background work with the teachers using the Technology Acceptance Model in Chapter 5. This highlighted a number of additional constraints on using games in the classroom. The researcher was keen to ensure that the educational game considered the concerns of the teachers about time constraints, technology efficacy and the availability of resources. The teachers have previously mentioned that given the *mathematics period* (*period* is the allocated time on the class day time-table for a particular subject) is thirty minutes, a game should be playable in around ten minutes to ensure it could be fitted into this period and still allow time for other mathematical activities.

Also it was important to consider the expertise of teachers and the learning curve required of them by the game. It was clear that specific and simple instructions would be required to use the game in the classroom. All these factors may not have been considered in the design and development of an on-shelf digital educational game.

Having decided to build a game, the researcher had to consider the design constraints in terms of development time and expertise. It was decided that a fully developed game would take too much time to develop and a working prototype could be designed and developed that could still be used to test out the main theories from this research and would be an effective tool for use in the classroom. The next section considers the game genres that can be appropriate for learning and their corresponding educational values.

Game Genres and Learning

Unlike regular digital entertainment games that have entertainment as their ultimate aim, effective digital educational games must be primarily based on learning theories. As discussed earlier in chapter 2, there are a number of different learning theories that support game-based learning, each with their own advantages and challenges. Some Therefore the game genre should be selected carefully for a digital educational game to ensure it supports the learners and improves their educational experience.

In the literature, the concept of game genre has not fully evolved and is not well defined (Clearwater, 2011) with many different types of categorisation, often insufficient to cover the range of games available today. This is because there are some games that do not fit into any of the major genres and some that can fall into more than one genre (Khenissi et al, 2016). Several studies have previously examined game genres, with classifications ranging from high level ones such as action, strategy and role-playing genres (Wiklund, 2006) to more detailed categories such as adventure, action, fighting, puzzle, role-playing, simulation, sports and strategy (Kirriemuir and McFarlane, 2004) and very elaborate classification such as the 40 categories presented in the work of Wolf (2001).

This research has adopted Kirriemuir and McFarlane (2004) categorisation of video games: action, adventure, fighting, puzzle, role-playing, simulation, sports and strategy genres and the definitions of the genres by Gros (2007). For the purpose of this study, the researcher extracted relevant game genres from these categories that could potentially be useful for game-based learning with a particular focus on three factors: the targeted age group, the aim of using the game in the classroom, and the choice of mathematics as the subject of the game. Using these factors, the following genres were excluded: fighting, sports, puzzle, strategy and action as these genres have characteristics that present the least value in an educational setting (Whitton, 2007) and/or are considered inappropriate for young people or require deep thinking (Khenissi et al., 2016).

From the studies on game-based learning, quizzes, simulations and adventures were reported the most (Connoly et al, 2012). Quizzes are regarded as one of the simplest form of games for learning (Granic et al, 2014). They are usually presented as tests or questions that the players have to answer in competition with the game or other gamers. Simulation games are presented as representations of real world scenarios where the gamer is allowed to experiment on actual events or actions that are either too expensive, dangerous or challenging to do in real life. These are mostly used in health and military training scenarios.

Adventure games are usually set in virtual worlds that a player can explore and navigate and gain skills and expertise while playing. Research has shown that adventure games in particular have characteristics that support constructivist-learning environment (Whitton, 2007) and enhance creativity (Loiseau et al, 2017; Malegiannaki and Daradoumis, 2017). Also, adventure genre elements have been found to be components of other video game genres like role-playing, simulation, platform and action (Scharkow et al., 2015)

	Genre	Definition
1	Action games	They are reaction-based games. They are also referred to as platform games.
2	Adventure games	The player solves a number of tests in order to progress through a virtual world.
3	Fighting games	These games involve fighting against computer-controlled characters or those controlled by other players.
4	Role-playing games	Human players assume the characteristics of some person or creature.
5	Simulation games	The player has to succeed within some simplified recreation of a place or situation to achieve a particular goal.
6	Sports games	These games are based on sports.
7	Strategy games	These are games that recreate a historical or fictional situation to allow a player to devise an appropriate strategy to achieve a goal.

Table 6.1 *Game Genres and Definitions: Adapted from Gros (2007)*

Adventure games, sometimes referred to as narrative games (because of their story-like nature) are built around a story and set of objectives for the player to achieve. Examples of adventure games include the popular and most referenced first text adventure *Colossal Cave Adventure* (Crowther, 1976), and other early ones like *Grim Fandago* (Schafer et al., 1996)*,* *Broken sword* (Broken Sword, 1996), and *Monkey Island* (Games, 1990), and more recent examples like *Technobabylon* (Mundy, 2017) and *Life is strange* (Jones, 2017)

Generally, in an adventure game, the player usually takes the role of a protagonist in the game's narrative (Adams, 2013) who explores the world, solves puzzles, and makes progress in the virtual world by interacting with the objects in the story. These games are usually set in some sort of virtual world that the player has to navigate and manipulate objects in. Many adventure games involve a kind of treasure hunt while travelling in a virtual world, overcoming obstacles and challenges, and searching for information (Garris et al, 2002). The fun and mystery of the treasure hunt motivates the player to explore the world, especially if the narrative is compelling and engaging.

However, not all adventure games have narratives. Some are closely related to the experimentation model simulation games possess. An example of a game like this is the *Bamiyan valley* game (Spaniol et al., 2008), which was aimed at creating awareness about cultural heritage in Afghanistan and the vocational training of people in the use of specialised tools such as Global Positioning System GPS cameras. These types of adventure games particularly engender the 'learning by doing' model. The combination of exploring a virtual world set in the form of a story and to 'learn by doing' offers great potential for providing an effective learning experience through an educational adventure game. The former provides engagement and fun through the mystery in the virtual world while the latter offers a sort of real hands-on, problem-solving skills to the player. An example of a game that combines this approach into an adventure game is the *Janus project* (Mathieu et al, 2013). In the game, players carry out different activities in order to create a virtual notice for an archaeological site. The learning by doing approach encourages the development of problem solving skills as well as knowledge construction.

The combination of the narrative characteristics as well as the quests provides a good incentive or learning. This is because educational content can be embedded in the story and quests and the players can pace themselves as they want due to the absence of any specific time limits (Mehm et al., 2013). One other reason why the adventure genre is suitable for educational settings is the cost implication of developing a game. The cost of developing a game is usually high given the number of skill sets and people needed for the development cycle. Unlike commercial and entertainment games, educational games do not usually have a big budget allocation for design and development. Research has shown that unlike other genres, the development costs for adventure games are lower than simulation or first person shooter games, and thus favour the small budget usually available to develop educational games (Torrente et al., 2010). The story-like nature of adventure games also means that the design could be created around a narrative that in itself contain some of the learning outcomes intended for the audience. Taking all of these factors into account, the researcher decided to create a simple adventure game for this study.

The next section presents the composition of the design requirements for the game.

6.3 Game Engagement Factors and *SpeedyRocket's* Design

This section presents the design requirements for the game based on the findings from the engagement framework presented in Chapter 4. For each of the engagement factors, a short description is provided, and then followed by how it translates into a design requirement for *SpeedyRocket.*

Challenge: As highlighted earlier, digital educational games must present levels of difficulty either by allowing users to choose the level they are most comfortable to play on, or by providing a form of progressive difficulty that intuitively changes the level of difficulty presented to the player based on their progress or performance

SpeedyRocket was designed to present seven levels of difficulty to the players. Following the recommendations of Denisova et al., (2017) the challenges were designed to particularly push the problem solving capacities of the players. These were embedded in the seven different planets players have to travel to. First, each new level/planet in *SpeedyRocket* presented more challenging arithmetic calculations for the player. Secondly, more obstacles were presented for their rockets to avoid as they journey to the destination.

Figure 6.1 *SpeedyRocket's* Campaign Menu

Some allowances for error was provided for the players with respect to calculations in the game and a player's rocket would still travel even if the calculations were wrong. However, not providing enough fuel would mean the rocket would not make it to its destination, and over-fuelling it would reduce the speed of the rocket which would also prevent it from getting to its destination. In order to create a good balance for the skills and challenge in *SpeedyRocket*, a player would first be presented with very minor obstacles at low speed, to get them used to dodging the obstacles quite easily and understanding the game environment, as they progress, more obstacles are presented at higher speeds to ensure the player does not get bored of too easy game play.

Thematic and Visual Appeal: This factor falls under the initial engagement section of the framework and as discussed earlier, it is not an absolute necessity for digital educational games designed for use in the classroom. However, there are two elements of this factor that should be thought about and built into digital educational games- the general look (visual appeal) and feel of the game and the game's story (thematic appeal). These are both needed to provide an initial attraction to the player.

The first step the researcher took was to think about a story for about *SpeedyRocket* was the story. As indicated in Chapter 4, engagement in games is sometimes due to players' interests and personal preferences. This was a challenging one, as the game could not have been built to accommodate every player's preferences but needed to be designed to be broadly appealing to this age range of children. Firstly, the researcher eliminated violent themes, and story lines that depicted sexualised female characters. Then, a balanced theme drawn on the back of a *travelling story* was created with the intention of appealing to both genders.

The researcher also spent some time thinking and reviewing the colours used in creating elements in the game. Research has shown that young people prefer bright and lively colours like yellow, blue and red as these are more interesting and stimulating (Rachel, 2017). The game was therefore themed blue and yellow. Although the researcher wanted to incorporate avatars into the game, the time constraints as well as the limitations of the design platform did not allow this to be actually implemented. However, the "*art and style"* of the game was modelled in a way to mimic actual space, using dark skies, asteroids and stars. Sound effects that mirrored rocket travelling as well as collision sounds were added to provide the player with an experience that was as real as possible given the available tools.

Social Interaction: This engagement factor is one of the means for sustaining initial engagement in digital games. Digital educational games that would be engaging should offer the possibility for players to interact in a community, share ideas and compete with one another.

This factor was a challenging one for the researcher. From the onset, the peculiarities of the research context posted some significant limitations of the features that could be built into *SpeedyRocket*. One of those is the lack of Internet access. Social interaction is one feature that is commonly built on network communications and the capability of the game to be played online – which would be very unlikely in Nigeria. However, given the discussions around social interactions in chapter 4, and how interactions do not have to be online to be effective, the researcher decided to implement social interaction in how the game will be rolled out in the classroom using an open classroom combined with paper exercises/physical interaction between the children in the classroom

Rewards and Feedback: This is also another factor that is key to on-going engagement in digital games. As stated earlier, it is important that game players are aware of their progress or otherwise while playing. Notifications and tips as well as rewards are all essential parts of a feedback system.

In *SpeedyRocket,* as a player progresses in the game world, they earn coins on their way, while also avoiding obstacles. A scoring system for this reward was implemented, and the more coins the player earns, the more their score increases figure 6.2 giving them a sense of accomplishment. This shows the amount of coins a player has earned, and what is left of it after making purchases of fuel or other rockets. Tips and information about formulas, and parameters were also embedded on the play area.

Also, feedback on the progress of the player as they played is provided. This includes when the rocket is about to run out of fuel, or when the destination is being approached. There is also a map on the screen that gives an indication of how far the rocket is from the destination. All these were built in carefully to avoid disrupting the play.

Clarity of goal: This involves a description of what the game is about and what the player needs to do to achieve success. With digital educational games in particular, it should provide some information about the learning outcomes related to the work being done in the traditional classroom. Clear instructions are also important to maintaining overall clarity. They should not be cumbersome, confusing or contain other unnecessary information.

Figure 6.2 *SpeedyRocket's* feedback

With *SpeedyRocket,* an instruction tab was provided on the home screen. The goal of the game was made short and precise: *Navigate your rocket through space to reach its destination using the arrow keys!* It then goes further to provide more information on the input to the rocket. This simple goal was used to ensure that players know it is a game and not a 'serious classroom activity'. However, more information was provided later that linked the gameplay to the educational value the game offers. The teachers were consulted to go over the instructions and comment on the choice of words and clarity to the pupils.

Creativity: This factor enables game players to be co-creators of the world they play in. In the adventure genre of games, avatars are mostly used to engender creativity. However, it is not only limited to that. Creativity can be presented in the form of allowing players to change the look of game assets and/or characters to depict their own preferences such as colour, look and feel, or names. In advanced games, it may include the provision for the player to extend functionalities or capabilities of the game.

Although this is another key on-going engagement factor, design constraints meant that the researcher was limited about how much creativity could be incorporated into the game. However, functionalities that enable players to customise the rocket by changing some elements of it including its shape, colour and name were included into the game design.

Immersion: Immersion is the ultimate experience of engagement. On the engagement framework, it describes expressions like "being lost in the game", or "seeing one' self in the game". Given the way young people describe the way they feel, immersion unlike the other factors come from not playing the game a few times (Cheng et al., 2017). In addition to this, going by the description of Jennett et al. (2008) there are three distinctive components of immersion: "lack of awareness of time, loss of awareness of the real world and involvement and a sense of being in the task environment".
Due to the time constraints in the classroom, the researcher did not consider immersion a useful factor in the development of the game.

This section has presented the engagement factors and how they were fed into the design of *SpeedyRocket.* The next section considers the findings from chapter 5 and how they impacted on the design requirements of *SpeedyRocket*.

6.4 Technology Acceptance Model and Game Requirements

The analysis of the extended TAM produced some implications for the development of *SpeedyRocket.* These are discussed below:

Usefulness: Following the work from the teachers, one of the findings was that they have not had much contact with technology and its application in teaching. This meant it was difficult for them to see how useful digital games could be in the classroom. This construct is the strongest predictor on the extended TAM used to predict the intention of teachers to use digital educational games in the classroom accounting for up to 66% of the variance.

Although teachers realised that their pupils would like the games and hence they could be interesting to use in the classroom, the eTAM showed that syllabus connectedness was the strongest predictor of usefulness. Therefore, teachers would consider *SpeedyRocket* useful if it is related to the educational content they are teaching in the classroom.

This means that not only does the usefulness of *SpeedyRocket* need to be obvious to the teacher; the usefulness would be assessed by how well the game is linked to the curriculum and not just how fun it is. *SpeedyRocket* must therefore present educational gains to the players in such a way that teachers would not feel it is a waste of time and effort. The TAM also suggested that engagement and learning opportunities is a strong predictor of perceived usefulness. This implies that *SpeedyRocket* must offer ways to engage pupils more and improve their learning of additional concepts thus enriching their learning experience. Another construct that explains perceived usefulness of teachers is the perceived ease of use. This requirement is discussed in the following section.

Ease of Use: Findings from the eTAM indicate that ease of use is the second strongest predictor of the intention of users to adopt digital educational games. Self-adequacy was found to be the strongest predictor of the perceived ease of use of the teachers. Although it is an established concept, ease of use is relative to the context of study and can be challenging to address for two main reasons. The first reason is that teachers' self-adequacy is a concept that measures how teachers assess themselves and may not truly represent their actual skills and efficacy. The other reason is similar to the first - self-adequacy varies from person to person, depending on the varying levels of self-efficacy and digital literacy, which means that while one teacher may consider a digital game easy to use, another may not find it so. This presents a challenge to the design requirements for *SpeedyRocket*. The eTAM also posits that experience with technology affects the perceived ease of use, but as with adequacy, this is not only self-reported, but also varies between teachers.

Therefore, to ensure ease of use of *SpeedyRocket*, the researcher assumed a low level of self-efficacy and no experience for all the teachers. The requirement then was that *SpeedyRocket* must be straightforward, and not contain any unnecessary complexities that would require teachers spending a lot of time learning how to use it, and feeling overwhelmed when something goes wrong. In addition to this, an information pamphlet as well as support materials about the game were sent to each of the teachers. Finally, the teachers were given some contact time and basic training with *SpeedyRocket* before they introduced it in the classroom. This included how to wake the tablet up from sleep, open the browser and load the game was given to them.

Enabling Environment: One other predictor of ease of use on the eTAM is an enabling environment. This was discussed with respect to the time constraints, availability of devices, Internet and electricity, and the availability of support to deal with problems that may arise during gameplay.

Many of the potential problems with enabling environments were addressed by the researcher while considering the generic requirements for the development of *SpeedyRocket*. In addition and in order to address the concerns of the teachers about time constraints, *SpeedyRocket* would have to provide short playing sessions that can be completed within the time allocated for mathematics on the schools' time tables.

6.5 Design of SpeedyRocket

SpeedyRocket was developed using JavaScript, html5 and CSS and could be supported by every browser that complies with the HTML5 standards. For the purpose of the research, the game was played on Google Chrome. The development of the game went through 14 iterations (all versions available online at www.ajayiopeyemi.com/research/speedyrocket) with testing and evaluation carried out at each stage. The 14th version was used in the research. In playing the game, participants were expected to navigate their way in space to reach their destination using the arrow keys. Before the rocket can launch, participants will have to calculate time and fuel values for flight based on distance and rocket speed. Players are to collect as much coin as they can to unlock other rockets, while avoiding obstacles that can destroy rocket health. A 5% error is allowed for flight timings if values are higher or lower than expected values. E.g. if expected flight time is 10hours, then values between (9.5 – 10.5) are allowed.

Mathematical elements and formulae

The mathematical elements and formulae incorporated in the game were:

Time = Distance/ Speed

Fuel Needed = Time x Fuel Consumption Rate

Parameters of distance, speed and fuel consumption rate were supplied for each stage.

The researcher undertook the design and development of SpeedyRocket. This was because of the peculiarities of the context of study and the need to engage teachers on the ground in the process. *SpeedyRocket* was designed to fit aspects of the mathematics curriculum. This was important, as its use/acceptance was dependent on teachers' acknowledging that it supports the classroom delivery of the mathematics curriculum. The learning outcomes of the game were drawn from the teachers' lesson notes. As the teachers informed the researcher, each mathematics period lasts for thirty minutes, which covers introduction, classwork, and corrections, this presents a strict constraint in terms of game time in the classroom.

The first decision the researcher had to make was about the game engine. Given the constraints of the study in particular the time-specific requirement of building *SpeedyRocket* around a particular curriculum content, the research had to make a trade-off between a near-perfect game and a working prototype suitable to sufficiently answer the research question. As important as the game is, it is a tool in understanding the research and not the goal of the research in itself. The researcher was therefore careful not to dedicate a large part of the research time allocation to the development of the game. The researcher was also aware of the time to test, make necessary changes and get familiar with whichever game engine selected to build the game. The choice of the game engine was based on a couple of factors. One is the programming language the researcher is familiar with. The researcher has programming experience in html, CSS, JavaScript and Python and so a natural affinity towards game engines that are based on the languages. This was to reduce the time it would take to learn a new language and develop a game in it.

Another factor considered was the type of game that would be developed. The researcher decided to make a 2D game as opposed to the currently more popular 3D games. While a 3D game would present more interesting and exciting graphics and possibly more engaging experience to the players, there were two considerations that made the researcher go for a 2D game instead. One is that the creation of 3D assets would require expertise that the researcher did not possess. Therefore, a substantial amount of time would have to be spent on learning how to create those. The second consideration was that a 3D game would require the end device to have high specifications that could run the game. Although at the time of the development, the researcher was not certain about the devices available for the game. The researcher planned to go with design specifications that could work on low-end devices.

One other major determinant of the game engine was the development adopted by the researcher. The researcher used the iterative design methodology. This method is well developed in game design (Gugerell and Zuidema, 2017; Adams, 2014; Salen and Zimmerman, 2004). It is one based on a cyclic process of prototyping, testing, analysing and refining a product or process. In iterative prototyping, each prototype is not discarded but used as the basis for the next iteration in the development (Dix et al, 2004). This was considered the most appropriate methodology as it afforded the researcher the flexibility to design, build, test and modify simultaneously and within a short time.

The game engine was therefore limited to a 2D platform with readily available events and behaviours and one that supports iterative prototyping and deployments to test. The researcher therefore considered Game studio, CoCo2D, gamesalad, Construct2D and Stencyl. Although these all support iterative prototyping, the researcher struck out CoCo2D as it requires the knowledge of C++ programming language, Stencyl and gamesalad as they do not offer enough flexibility and extension to create new games. Apart from the apparent shortcomings of these engines, Construct2D is free to use and offered a better level of flexibility with respect to create one's own events and behaviours.

Another major advantage of Construct2D to the researcher is its plugin feature. Construct2D plugin is in JavaScript – which is one of the languages the researcher is most comfortable with. This plugin feature helps the developer extend or create entirely new events and behaviours in Construct2D. One of the other major advantages of Construct2D is that it supports an extensive variety of devices and platforms. This was quite important, as the choice/availability of devices was not certain during the initial development of the game. The next section describes the iterative process of the game development. It is discussed under two main sub-headings – game functionality and interface design.

A. Game functionality

The first prototype of *SpeedyRocket* was evaluated and tested by 10 young people and 4 teachers in the United Kingdom. A link to the playable version of the game was emailed to them to play and give feedback. The researcher also provided devices to 7 young people who played the game while he was present and able to observe them. This stage of the evaluation was targeted at testing the functionalities of *SpeedyRocket*. This was a pragmatic decision as the researcher was based in the UK and those in Nigeria did not have devices on which to test and play the game at this stage of the research. Also, as the researcher was just testing the functionality, it was not critical that it was the intended target audience.

Three major functionality bugs were identified from the first iteration testing. The first is on the navigation – some of the players who played on small screen (mobile phone and small tablets) reported that the rocket disappeared whenever it moved to the far right of the screen. The second major bug was on the input box used for entering values, it was not configured to take more than one decimal place, and the restriction was not made apparent to the player. In addition to these, it was also impossible for players to go back to the previous screens without losing their initial entries on the main screen.

The testing of the game highlighted a major challenge with *SpeedyRocket*. The average time for the young people to find their way around the game, enter the calculated values and start playing the game was 8 minutes. This is almost all the time the teachers will allocate to the game in the classroom. The researcher identified the clarity of instructions as well as the location of parameters as issues to be fixed in order to potentially help reduce the game playtime in the game. The researcher was also able to address this by reducing the length of the actual playtime for each level within the game. The researcher fixed all the reported bugs, made some changes and launched another version of the game.

B. Interface Design

At the time the second version of *SpeedyRocket* was launched, the researcher had been able to secure some laptop computers with the target population in Nigeria to do some testing. This stage of the testing and evaluation focused on the look and feel of the user interface and other associated issues. The researcher worked with schoolteachers and pupils that were not part of the cohort for this research but had similar characteristics (the same region in Nigeria and similar demographics).

Although the main aim of this stage was to get input on the look and feel and the viability of the interface, the evaluation and testing here also elicited some functionality issues. These are discussed in details below:

i. *Navigation and Control*

The young people initially struggled with controlling the rocket in the game using the keys on the laptop computer. The researcher believed that this was due to them not being used to computers, as they became more comfortable after the second and third trials. However the researcher noted this as a potential issue as young people in the classroom may not have the time to practice using it during the actual study.

ii. *Clarity of goal and instructions*

The young people in Nigeria also struggled with navigating across four different screens to get all the parameters they needed to do the calculations in the game. Apart from the tedious activity it entailed, it was also highlighted as time wasting by some of the teachers. Another feedback from the evaluation was that the instructions were not clear enough to some of the young people and so the time it took for some of them to start playing was increased. The researcher created parameter button and a formula button on the main game screen to give players a one-stop location to get all the instructions and values they need to do the calculations. The game instructions were also broken down into multiple sentences and checked by a teacher for the appropriateness in the language used.

iii. *Mobile Controls*

After the testing with the teachers and the young people, some of them that took the link home with them reported that they could not play the game properly on their mobile phones. This was because the input control was not optimised for mobile devices. In order to accommodate different devices and provide a similar experience across different platforms; the researcher added a mobile switch button to the game home screen. The button when clicked changed the input control to on-screen touch navigation for touch screen devices. This catered for mobile phones, tablets as well as other touch screen devices.

iv. *History and Cache*

While sharing devices during the tests, players also noticed that it was not possible to reset scores, coins and levels. The researcher was aware that due to the limited devices, young people may have to use devices in turn especially from one school to the other. The researcher therefore added the ‘clear’ button to return the level of the previous player on the device and all counts and coins to zero.

6.6 Conclusion

This chapter presents the design and implementation of *SpeedyRocket,* a simple digital educational game to support the teaching of mathematics in the classroom. It explains why the decision was made to construct a new game rather than using an existing game. It then considers the game genres suitable for education and narrows down on a particular one, the adventure genre for use. It then presents the main design requirements for *SpeedyRocket* based on the findings and insights from the previous research including the proposed classroom environment, game engagement factors, and the results from the eTAM. This chapter ends with the description of the design rationale, iterative development process as well as the pragmatic consideration of the processes involved in the design and development. The next chapter presents the implementation process of *SpeedyRocket* in the classroom with particular focus on the participants, treatments administered, the procedure used and the evaluation of the implementation described in this chapter.

7 Chapter Seven: Implementation of SpeedyRocket in the Classroom

7.1 Introduction

This chapter presents the results and discussions around the implementation of *SpeedyRocket* in the classroom. It starts with outlining the experiment procedure and associated processes for using *SpeedyRocket* in the classroom environment. This is followed by the quantitative analysis of the pupils' engagement with mathematics using statistical methods on SPSSv22. It then goes on to present the qualitative classroom observation of the game play sessions carried out over two weeks with the experiment group. Results and findings from the focus group with twelve teachers are also presented. The final section provides a discussion of the results and the implications from this research study.

7.2 Research Participants

The implementation of *SpeedyRocket* for this study used the ideal research site features described by Rossman and Rallis (2011) to select the schools. The features included sites where:

i. Entry is possible
ii. There is a rich mix of the processes and people
iii. There is a possibility of building strong relations with the participants
iv. Ethical and political considerations are not overwhelming.

The schools are three rural schools located in Ado-Ekiti, a small town in southwest Nigeria. After initial contacts were made and the research project explained via phone calls, the administrations of the schools were keen to have the researcher come in and work and were interested in the potential use of technology in the classroom. The researcher was aware of the culture and intricacies of the society where the school was located and was able to communicate very well in the local dialect to explain things better as at when needed, and the teachers were also interested in developing a longer term working relationship for support in technology use and training. This research was conducted after ethical approval was obtained from the school management, and teachers involved in the research.

In terms of a rich mix, the school populations were mixed with respect to gender, social backgrounds and, also mathematics scores obtained by the researcher showed different achievement levels. Prior to going out to the schools, this researcher obtained ethical approval from Northumbria's University Faculty Ethics Committee. Information pamphlets were then provided to the parents through the pupils two weeks prior to the research, and the teachers were also fully briefed well ahead of time. Parents consented to the participation of their children/wards and the head teachers of the schools acted *loco parentis.* The researcher made contacts with the head teachers of the schools, who in turn briefed the teachers. The teachers had a briefing session and signed consent forms (Appendix 4). Altogether, a total of 69 people from the three schools participated in this research: 9 teachers and 60 pupils.

7.3 Research and Evaluation Design

The evaluation of this study adopted mixed data collection methods, combining qualitative and quantitative techniques – questionnaires, focus group and observations. These three were carried out with the pupils, while only the focus group was done with the teachers. The rationale for the mixed method with the pupils was its use in supporting the self-reported data obtained from the questionnaires to make results more accurate. The focus group with the teachers helped the researcher explore their perspective of the use of the game in an actual classroom as the initial work with them was merely based on their perception. The period of the intervention was the first time the teachers used technology to enhance their teaching practices.

The study adopted an experimental design approach (Campbell and Stanley, 2015) in the rollout of *SpeedyRocket* into the schools, and a mixed method approach was taken to data collection and the evaluation of its effectiveness on young pupils and their teachers. Pupils were randomly grouped into experimental and control groups. Papers labelled as TG 1- TG10 (Test group) and CG1 – CG10 (Control Group) were distributed in the classrooms across the three schools. As stated in Chapter 7, this research worked with the teachers, and the National curriculum and work-plan for mathematics in the school to align the subject of the game to the topic that was being done in the classroom during the period of the intervention – estimation with particular focus on calculating time, Speed, and distance.

For the two-weeks of this intervention, pupils in the control group and the experimental group participated in the usual mathematics period in the daily time table across the three schools. Each subject period was thirty minutes long. However, while pupils in the control group were involved in the usual thirty minutes traditional classroom, the experiment group had the traditional classroom teaching on estimation for fifteen minutes and played *SpeedyRocket* for ten minutes. Two weeks prior to this, the Mathematics Attitude questionnaire instrument was used to collect baseline data about the attitude of the 60 pupils to classroom mathematics. A short questionnaire was also used to gather the thoughts of the teachers about the practicalities of using games to teach mathematics alongside their usual teaching methods.

As highlighted in Chapter 2, pupils generally perform well in mathematics, even though they do not enjoy it. Therefore, this experiment intentionally omitted measuring the achievement levels of the pupils. This is because attitude to classroom mathematics was not the focus of the study and not mathematics achievement. The dependent variable was the pupils' attitude to mathematics and the independent variable were the pupils' use of *SpeedyRocket* or the non use of *SpeedyRocket.*

No compensation or benefits was associated with the experiments, and no risks were recorded but as stated in the information pamphlets, pupils were informed of their right to withdraw at any point without any consequences. Their responses were anonymised to protect privacy. Names of pupils were not recorded as the participants across both experimental and control groups maintained their codes on tablets, worksheets and questionnaires all through the period of the intervention.

A. Interventions

The research treatment was administered to the experimental group. The treatment consists of the digital educational mathematics game developed by the researcher, *SpeedyRocket* (described in section 7.3) and some worksheets (Appendix 5) with questions and working space for manual calculations for the pupils. The game was installed on *Microsoft* tablets and distributed pupils at the start of each mathematics period everyday for two weeks.

B. Instrumentation

As mentioned earlier, qualitative and quantitative instruments were used in collecting data. Attitude to mathematics questionnaire, focus groups, as well as classroom observation was carried out.

These instruments were discussed in details in Chapter 3.

C. Procedure

This study was conducted for 3 weeks in the second term of the schools' 2016/2017 academic session – October 2016. The selection of the schools was done in February 2016 based on the criteria presented in 6.3.1. Consent forms were obtained from teachers prior to the week the study started; head teachers also signed the *loco parentis* consent forms. Classification of the participants into control and experimental groups happened on the first day of the first week of the study. Using the attitude to mathematics questionnaire, a baseline data collection with the pupils took place on the second and third day of week one across the three schools. The participating teachers were also briefed about the research and associated activities as well as the structure of the experiment. The experimental group started playing the game on the 4^{th} day of the first week and continued till Friday of the second week. Post-attitude questionnaires were administered on the last day of the second week to participants, and the teachers' focus group also took place on that day.

7.4 Data Analysis

Three types of data were gathered through the course of the experiment. As mentioned in the previous chapter, baseline data was collected from all 60 participants across the 3 schools. This data was collected using an attitude to mathematics questionnaire. The questionnaire data sought to test the following hypothesis:

H_0: *Pupils that played SpeedyRocket in the classroom do not have a better attitude to mathematics in the classroom than those who did not play SpeedyRocket.*

The researcher also took video, photos and notes using a proforma from the classrooms during the game play to collect observation data. The observation data sought to answer the "what is going on here" question. The researcher was a member of the classroom settings for both the traditional classrooms and the *SpeedyRocket* classrooms where he observed the actions and reactions of the control and experiment groups over the two-week period. A follow-up focus group was conducted with the teachers to provide an insight into their thoughts and opinions about the use of *SpeedyRocket* in the classroom.

The data from the attitude questionnaire was entered into SPSS and the Wilcozon Signed-Rank test was carried out to test the hypothesis. Using an inductive approach, the focus group data was read, coded and grouped into themes that are related.

The following sections present more details of the analysis and the subsequent results.
Attitude to mathematics questionnaire

A. Demographics

The demographics of the 60 research participants are provided in Table 7.1

Age	Frequency (%)
8	26
9	36
10	29
11	9

Gender	Frequency (%)
Female	53%
Male	47%

Table 7.1 Demographics of the participants (N= 60)

B. Descriptive Analysis

The attitude to mathematics questionnaires was administered to the research subjects before and after the two-week intervention. As noted earlier, the subjects were grouped into two classes: experiment and control. The questionnaire measured attitude to mathematics using a 10-item scale. On the questionnaire, items 1 and 4 were negative, so the researcher converted them to positive and also reverted the responses of the participants to the questions to make analysis more straightforward. For the descriptive analysis, the responses were coded as *strongly agree = 4, agree = 3, neither = 2, disagree = 1, and strongly disagree = 0.*

The means of the scale in Table 7.2 indicate that the attitude and reported engagement of the participants is quite low. This is particularly true for item 9 (This mathematics class was worth my time and effort) for the experiment group baseline, and item 10 (I would talk to my teachers about a career that uses mathematics) for the control group baseline. The two most positive responses for the control and experiment groups (item 3 and item 4 respectively) were neutral (item 3: *M = 2.03;* item 4: *M = 2.53)* showing a generally poor attitude to mathematics in the classroom by the participants.

After the two weeks intervention, in which the control group received the normal traditional classroom delivery of estimation: speed, distance, time and fuel consumption, and the

	Item Description	Mean (Experiment)	Mean (Control)
1	*Mathematics classes are not boring*	1.97	1.53
2	I look forward to my mathematics classes	1.93	1.63
3	I am comfortable in my mathematics classes	2.07	2.03
4	*I love to attend mathematics classes*	2.53	2.00
5	I would like to have more mathematics classes	1.93	1.57
6	I learn interesting things in mathematics classes	1.96	1.60
7	I would like to know more about the topics we did in the mathematics classes	2.30	2.00
8	I really enjoyed completing tasks in my mathematics classes	1.73	1.83
9	This mathematics class was worth my time and effort	1.43	1.63
10	I would talk to my teachers about a career that uses mathematics	1.97	1.43

Table 7.2 Baseline Descriptive Statistics for Control and Experiment Group Attitude to Mathematics

experiment group received the traditional delivery as well as the *SpeedyRocket* game playing sessions, below are the mean scores for attitude to mathematics.

As shown by the post intervention means (Table 7.3), the responses of the experiment group to the attitude to mathematics questionnaires have improved and are more positive than those of the control group. However, these numbers are not sufficient to determine if a significant change has occurred among the groups within the two weeks, especially since it appears that the populations are not perfectly similar as demonstrated by the baseline data (Table 7.2). The researcher therefore decided to use a more robust statistical test to examine the differences, improvement and how significant they were.

	Item Description	Mean (Experiment)	Mean (Control)
1	*Mathematics classes are not boring*	3.00	1.43
2	I look forward to my mathematics classes	3.30	1.77
3	I am comfortable in my mathematics classes	2.97	1.63
4	*I love to attend mathematics classes*	3.13	2.10
5	I would like to have more mathematics classes	3.27	1.50
6	I learn interesting things in mathematics classes	3.30	1.70
7	I would like to know more about the topics we did in the mathematics classes	3.17	2.23
8	I really enjoyed completing tasks in my mathematics classes	3.27	1.50
9	This mathematics class was worth my time and effort	3.10	1.36
10	I would talk to my teachers about a career that uses mathematics	3.30	1.66

Table 7.3 Post Attitude to Mathematics Descriptive Statistics for Control and Experiment Groups (After two weeks)

C. Wilcozon Signed-Rank test

The Wilcozon Signed-Rank test is a non-parametric test carried out to measure or compare differences between two sets of data from the same participants from one point to the other or after the participants have been subject to one or more conditions. It is an alternative to the dependent t-test, which is a parametric test and assumes an approximate normal distribution.

In the case of this data, the normality assumption was violated, and so a Wilcozon Signed-Rank test was an appropriate alternative to use. The researcher carried out separated non-parametric repeated measures on control and experimental groups rather than a single one because he was keen to examine the two groups separately. More so, the baseline results for both groups showed that they had slightly different scores. It was therefore appropriate to treat the analysis in such manner.

A reliability analysis allowed the researcher to assess how well the items on the scale work together in representing the variable of interest in the sample. Following Archer et al (2015) and Mohammed and Waheed (2011), an appropriate method of creating high, medium and low ranges from a likert-scale is to create composite scores and assign it to a variable. This can be done when the items of the scale are weighted equally – which is true in the case of this study. The composite score is a representative of the variable – attitude to classroom mathematics. The intention of the researcher was to assess this as a variable and not assess the individual items on the scale as separate constructs. To get the composite attitude to mathematics score for the analysis, the researcher weighted all ten items equally, and the likert values were weighted as below:

Strongly agree (2)   Agree (1)   Neither (0)   Disagree (-1)   Strongly Disagree (-2)

Therefore, a response of "*strongly agree"* to the 10 items will produce an attitude score of 20; "*neither*" would produce 0 while "*strongly disagree"* would produce -20.
The composite attitude to mathematics score was then divided into three – -20 to 6 (low), 7-14 (medium) and 15-20 (high), and these were coded into SPSSv22 as 1,2 and 3 respectively. The Wilcozon Signed-Rank test for the control group was run and the results are presented as follows: Table 7.4 shows the descriptive statistics for the control group, the mean rank for the baseline was 1.13 (low attitude) and the mean rank for the post-test was also low attitude (1.20), albeit slightly higher than the pre-test. The rank table for the control group provides more details about the pre and post ranks.

	N	Mean	Std. Deviation	Max	Max
Control baseline	30	1.1333	.43417	1.00	3.00
Control After	30	1.2000	.48423	1.00	3.00

Table 7.4 Descriptive Statistics for Control Group

Table 7.5 provides some results on the comparison of participants before and after the two weeks. The table shows that 2 participants had lower ranks after the two weeks than before the two weeks, 4 had positive improvements in their ranks and 24 saw no change in their ranks. While, this gives a better insight into an absence of a change in the control groups' attitude to mathematics, it is the final statistical table that provided more information and the results to finally decide if there was a significant change at the end of the two weeks.

		N	Mean Rank	Sum of Ranks
Control After -	Negative Ranks	2[a]	3.50	7.00
Control Baseline	Positive Ranks	4[b]	3.50	14.00
	Ties	24[c]		
	Total	30		

Table 7.5 Rank table for control group

The Wilcoxon signed-rank test in table 7.6 showed that there was no significant change ($p < 0.05$) in the attitude of the participants of the control group before and after the 2 weeks ($Z = -0.816$, $p = 0.414$). This result agrees with those presented in Tables 7.4 and 7.5, that the post mean rank for the group stayed at *low* as the majority of the participants (80%) maintained their ranks.

	ControlAfter ControlBaseline
Z	-.816[b]
Asymp. Sig. (2-tailed)	.414

Table 7.6 Test Statistics Table

The Wilcozon Signed-Rank test for the experiment group was also run and the results are presented as follows:

	N	Mean	Std. Deviation	Max	Max
Experiment baseline	30	1.4000	.62146	1.00	3.00
Experiment After	30	2.3000	.79438	1.00	3.00

Table 7.7 Descriptive Statistics for Control Group

Table 7.7 shows that the mean rank for the pre-test was 1.4 (low attitude) while the mean rank for the post-test was 2.30 (medium attitude). The rank table (Table 7.8) also shows the breakdown of the changes amongst the participants; 1 of the participants had a negative post mean rank, 19 of the participants had more positive ranks and 10 maintained their ranks.

		N	Mean Rank	Sum of Ranks
Experiment After	Negative Ranks	1[a]	15.00	15.00
Experiment Baseline	Positive Ranks	19[b]	10.26	195.00
	Ties	10[c]		
	Total	30		

Table 7.8 Rank table for experiment group

The test statistics table (Table 7.9) shows a significant ($p < 0.05$) positive change (as shown by the rank table and post-means) in the attitude to mathematics ($Z = -3.464$; $p = 0.001$).

	Experiment after Experiment Baseline
Z	-.3.464[b]
Asymp. Sig. (2-tailed)	.001

Table 7.9 Test statistic table

The differences between the means of the responses of the control and experiment groups gave an indication of the differences in the two groups. Thus, we reject the null hypothesis and accept the alternate hypothesis that states that after two weeks, pupils who played *SpeedyRocket* had a better attitude to mathematics than those who did not play it. The following section presents the findings from observing the use of *SpeedyRocket* in the classroom.

7.5 Observation of *SpeedyRocket* gameplay

The aim of this research was to see how digital educational games can be used to provide an engaging experience for pupils in the mathematics classroom. The quantitative results and analysis presented in the sections above showed that young people who played digital educational games alongside their traditional mathematics lessons reported better attitude and enjoyment of the mathematics classroom. However the quantitative results do not provide any information about the changes in the dynamics between teachers and pupils as well as other changes in the classroom experience of the pupils. Using a pro forma, observation data was collected noted and written up after the class sessions, this was supported by recorded video taken from some of the classroom activities of both the traditional and the game classroom. The researcher collected observational data in order to ensure that the experience of the pupils with *SpeedyRocket's* could be explored and captured in situ and to support the data collected through the questionnaire given the concerns with self-reported data. The observation process allowed the researcher to better understand the context of the research and how it influenced the experiences and occurrences that may otherwise have escaped if another method had been used. Also, in the context of the pupils, there may have been elements they may have been unwilling or shy to talk about in an interview or focus group. Observation as well stops the bias from self-reported data. This section presents the key themes that emerged from the observations. Each theme presents the contrasts between the traditional classroom and the game classroom as well as the transformation that occurred with the digital educational game.

i. Increased Motivation and Enjoyment

One of the challenges teachers face in the classroom is that of motivating students (Cheng and Zhang, 2017). This is particularly the case with Science, Technology, Engineering and Mathematics (STEM) (Rissanen, 2014). As established earlier, even high achieving students may not be motivated to learn mathematics, and do it only because they know they have to, and then they drop the subject as soon as they think it is no longer important. But mathematics skills are becoming more important in today's world and they are central to success in other science careers.

Figure 7.1a Pupils from 'school A' during one of the play sessions

The traditional classroom, especially the upper primaries are boring. Kindergarten classes (3-5 ages) are exciting as pupils' activities and tasks are more engaging and fun. However, the fun reduces from primary one (age 6) up until primary 5 (10) where 'serious academics' is the order of the day. Little or no fun, exploration and discovery is done in the upper primary – this is the status quo in the classes. During the gameplay sessions, the first thing the researcher observed is the increased motivation, enthusiasm and excitement of the pupils that played *SpeedyRocket* to classroom mathematics. Admittedly, this difference may not have been necessarily because of *SpeedyRocket* but for the mere fact that they were using tablets in the classroom. The traditional mathematics classroom presented mathematics as a boring and dreadful subject. The teachers know this and the pupils do as well. Mathematics is not a subject many of the pupils looked forward to, so the excitement and enthusiasm that accompanied the mathematics period in the experiment group was obvious. With the control group, the usual reaction to the sound and announcement of the school bell for 'mathematics period' was the lack of enthusiasm and eagerness. There was also a visible difference in the amount of focus pupils in the experiment group had on classroom tasks. They looked 'more into it' than those in the traditional classroom.

The system of teacher writing on the chalkboard, explaining examples and giving pupils their own tasks to do is the style in the control classroom. Pupils are visibly disconnected and mostly participate because they have to. However, the experiment classrooms look more like the lower primaries and kindergarten classrooms, with pupils smiling, engaging and interested in both the play and the tasks. For these pupils, many of who may have been passive and could not wait for the mathematics period to be over, the game enhanced their learning experience and provided an opportunity to enjoy the classroom mathematics.

The game captured their attention and focus in contrast to the traditional classroom in which teachers have to keep asking them to focus. The motivation in the classroom made them more receptive and ready to learn.

The pupils were aware that it formed part of their usual mathematics period. They knew they were also doing tasks associated with the topic that was on the chalkboard, yet despite that, their interests in the mathematics topic grew as they played the game. They did the calculations on their worksheets with more enthusiasm, and the researcher noticed that it was because they knew they needed to use the results to 'power their rockets'. The application of the calculations were immediately imminent and the incentive to get these calculations right was also evident to them.

ii. Change In Young People's Perception Of Failure

In the traditional classroom setting in the school, the mathematics period starts with the teachers presenting the topic with examples for about ten minutes. After this, he/she then gives the class a set of exercises to do based on the examples. The teacher then collects the pupils' books, scores them and hands it back to them. The correction of the tasks is done on the chalkboard and students that missed some exercises write the corrections into the books. In Nigeria's primary education setting, performance position is widely used. There is a general sense (from teachers, pupils and parents) that some pupils are brilliant and smart while others are not. This assessment is based on the daily and weekly performance in classroom exercises. The report sheet at the end of the school term, which is cumulative of classwork, tests and exams, shows the positions of the pupils from 1st to last position – with brilliant students awarded prices at an event attended by teachers, pupils and parents. This end of term activity is also modelled in the classroom daily. Pupils who are not considered brilliant are often not expected to do well in mathematics.

Figure 7.1b Pupils from 'school A' during one of the play sessions

This attitude from teachers and other pupils in the classroom often discourage these pupils from engaging in the classroom. From observing the traditional mathematics classroom, the researcher could easily identify the pupils that are classed as brilliant and the ones that are classed as not so smart.

The fear of saying something wrong, failing, and being classed as 'dull' in the classroom isolates, stresses and disengages these students in the classroom. The practice in the classroom is that teachers share the scores of every pupil to the whole classroom. In becoming part of the classroom and in order to perform better, pupils end up being stressed and some even give up in responding to questions or assuming they do not 'know maths'. The stress from the fear of failure is often compounded by the insecurity they face. Not all pupils get the chance to show they are good at something in the classroom as teaching is fully theoretical and performance-based.

In the experiment group, pupils' confidence as well as comfort visibly increased. The game caused a decrease in the anxiety and stress that often accompanied mathematics lessons. Learning while having fun, without the pressure of getting it at once or according to a standard method on the chalkboard brought calmness and relaxation to the learning experience. Pupils were also more tenacious and persistent in solving problems. It was interesting that they knew they could find the solutions to the mathematics tasks. Failure was then a permanent stop for them but an invitation for them to try harder at their own pace without the pressure of being classed dull or slow.

From the observation, players enjoyed the flexibility and freedom to try as many times as possible to succeed as they played.

This is in support of some findings about game-based learning, especially simulations that argues that one of its values is the chance it provides to players to fail in a safe environment where their decisions do not cause catastrophic implications (Kongmee et al., 2012). The stigma in the traditional classroom associated with being the person the whole class is waiting on to progress to the next task was missing during the game-based learning sessions. It was alright for the pupils to learn at their own pace, and try things out and experiment until they were satisfied with their results.

iii. Personalised learning pathways

"I like it that way" and "this is how I want it"- these are examples of some phrases used during the gameplay sessions in the classroom In contrast to some implementation of digital game-based learning in the classroom, this study did not use a leader board, or anything similar to record achievement during game play. Primarily, this was to avoid discouraging pupils that may not make a lot of progress during game play from attempting to continue to try. It was also to allow the researcher to explore the actions and reactions of the pupils to the different dynamics in the game. Given that different engagement factors were built into *SpeedyRocket*, the researcher was keen to observe how the pupils interacted with the games with respect to the different factors.

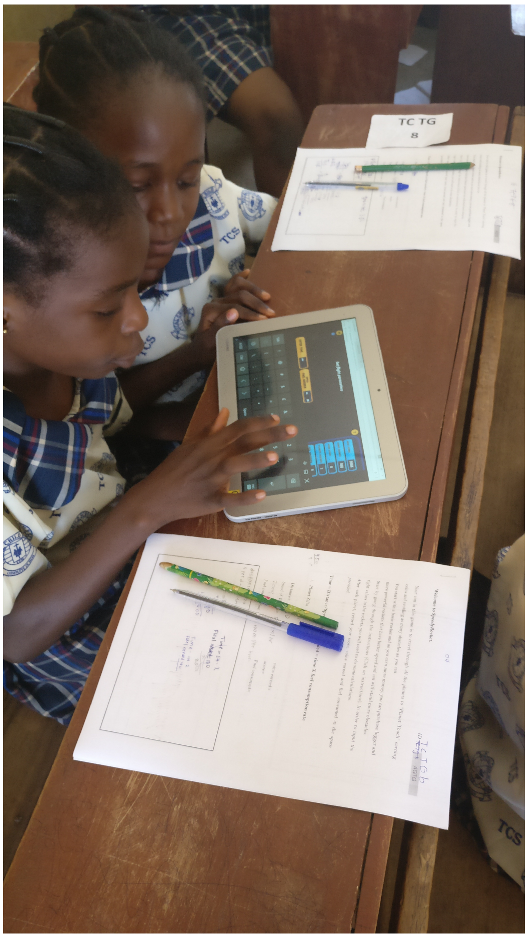

Figure 7.1c Pupils from ‘school B’ during one of the play sessions

One of the interesting observations from the gameplay is the different ways pupils chose to structure their play and how that presents different definitions of success. To some, success in the game was the accumulation of coins, while to others it was progression from one planet to another. While some pupils chose to earn more coins to buy a bigger rocket that could travel faster and help them make progress in the game, other pupils simply made more coins, and stayed on the same level. They appeared to be more fascinated by the rewards but less bothered about completing the levels. Another example of this is with the creativity feature added to *SpeedyRocket.* While some pupils spent time designing their rockets, and naming it, other players skipped the process and just wanted to start the game and get on with it. The pupils interacted with the games in different ways and this reinforces what the researcher highlighted in Chapter 5 about the engagement factors. Players tend to engage with those elements they find engaging and fascinating, and since everybody is not the same, engagement factors too will differ from one person to another.

iv. Collaboration and cooperation in the classroom

As noted earlier, the traditional classroom, especially the upper classes is mostly quiet apart from the teacher's voice explaining or passing instructions to the pupils. The class captain often keeps a list of 'noise-makers' who are punished by the teacher at some point during the day. Alongside this quietness is a high spirit of competition, as the pupils' performances are assessed by who gets the highest score in classroom tasks. However, this competition is not the healthy form of competition and it is not almost impossible to see pupils helping each other out or being involved in teamwork.

In contrast to this dynamic, in the experiment mathematics classroom, collaboration and teamwork were apparent. Pupils, knowing there was no noisemakers list being written had the freedom to be expressive. The usual calm down and "face your work" in the traditional classroom was overturned. The expressions came in form of cooperation but also competition.

It was interesting to observe some of the pupils who have completed some arithmetic calculations on their worksheets, or successfully navigated one of the planets offered to help their colleagues through the same process. The pupils shared advice and tips on how to make progress in the game. This cooperation did not remove competition as some players who offered to help and share tips on how to make progress in the game, still celebrated their wins and advancements over the players they helped. Some of the pupils took up leadership positions in the classroom, sometimes jumping out of their desks to go across and help others navigate a difficult path or do some arithmetic.

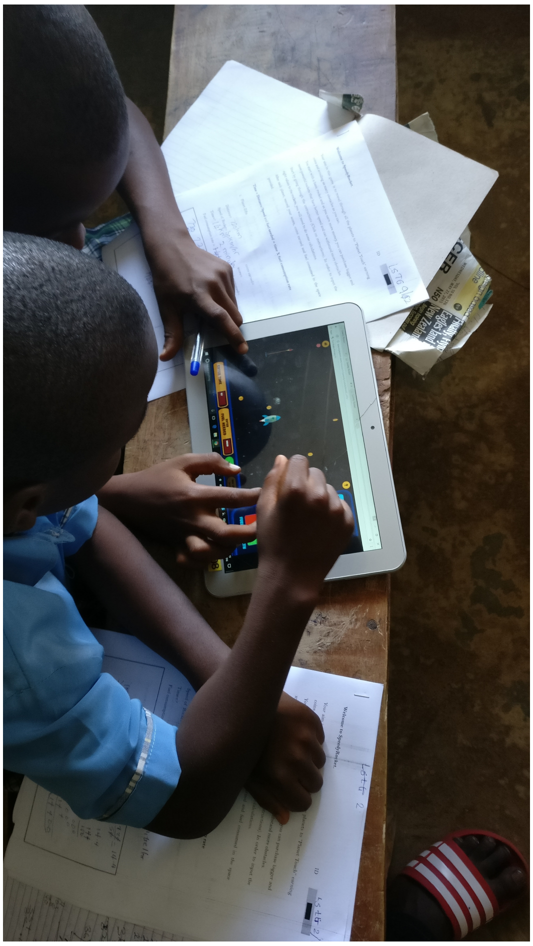

Figure 7.1d Pupils from 'school C' during one of the play sessions

SpeedyRocket helped to break the barrier of communication in the classroom as pupils engaged and interacted with one another. This change was not acceptable to some of the teachers. It was one of those things that challenge the fundamental structure of classroom setup in the schools.

v. Power shift in the classroom

This is perhaps one of the most apparent changes the researcher observed between the control and experiment mathematics classrooms. It was also the second most challenging changes (after interactivity) for the teachers to accept. In the traditional classroom, teachers are the 'sage on stage'. They are considered to be the 'know it all' and almost all of the time, instructions are handed down to the pupils. The teachers do most of the talking while the pupils respond once in a while to questions (from the teachers). The questions as well most of the times are close ended like "do you understand" and "is this right". These questions often do not require any thinking from the pupils who mostly chorus "yes" or "no" depending on what they think the teacher wants to hear. The pupils are mostly recipients and consumers and therefore play the supporting role in the classroom. Due to this perspective and image of the teachers as 'know it all', pupils do not question styles, methods or anything the teachers write on the board. Those things are considered to be sacrosanct and final. This power position of teachers means that pupils are largely excluded from the creative process of knowledge in the regular traditional classroom.

This dynamic changed in the experiment classroom. Apart from the improvement in the enthusiasm of the pupils, the power balance in the classroom was shifted as power moved to the pupils. It increased the interest, participation and involvement of pupils in the classroom compared to the traditional control classroom. Pupils took a greater responsibility for their learning and teachers played a supervisory role as opposed to the driver role. As mentioned earlier, this was strange to the teachers, who are used to doing most of the talking while students looked on. These teachers now had to look on as pupils played the game and found ways around the tasks by themselves. The teachers were not completely left out of the process, but they moved on from being the 'sage on the stage' to being a 'guide on the side'.

7.6 Focus Group with Teachers

There was a short fifteen minutes focus group at each of the participating school with the teachers. One hour was planned but the study already took a considerable amount of time from the teachers and they wanted the researcher to make the focus group fast. Firstly, the researcher asked to confirm if the teachers have played the game. He also asked what they liked/disliked about the game and if they would and how they would use the game in their classrooms. They were also asked if there were changes they would like to make to the design of *SpeedyRocket*. The results of the focus groups are presented in this section.

i. *Teachers' perspectives about the usefulness and appropriateness of SpeedyRocket*

Responses show that the teachers found *SpeedyRocket* interesting and engaging in the classroom. Some of the responses include:

"*The game is interesting"*

While some of the teachers actually enjoyed playing SpeedyRocket themselves, some of the responses suggest that even though some of the teachers themselves are sceptical about games and express their dislike for it, they commented on enjoying the experience, probably due to the effect it had on the pupils:

"*I enjoyed the game, and although I don't actually like games, I prefer reading to games"*

"It is interesting, and the pupils find it interesting"

The teachers are well aware of the concerns about engagement in the classroom and the perspectives that some pupils have about how boring mathematics is. Some of the responses indicate that the teachers consider *SpeedyRocket* to be useful in bringing more engagement into the mathematics lessons.

"well, I believe it makes mathematics lively for them and also improves their interest in solving mathematics, I believe it can help them"

"some of them that do not really love mathematics and they love playing games, if..maybe that can actually attract them, maybe."

Teachers also thought *SpeedyRocket* was not only useful for play, but also for learning mathematics:

"My opinion is that it teaches them how to calculate some things, like speed and time, because they have to do it to play the game, and manoeuvring from one problem to the other maybe moving from all the barriers, those are all useful"

There were indications that some of the reservations some teachers had were about the actual way their curriculum content could be integrated into games. However, the teachers were also quick to spot the difference between *SpeedyRocket* and the other games they have been used to and how they think *SpeedyRocket* is valuable to the learning process:

"actually it is very very interesting like number 1, It brings a kind of impression that you are doing something useful, and then I like the calculation you have to do unlike other games that you just play, it is interesting but, someone has to learn it well before using it"

This suggests that the value of *SpeedyRocket* to the teachers is not just based on fun but also on the curriculum connectedness it offers. This is not surprising as results of the extended Technology Acceptance Model shows that perceived usefulness is central to the behavioural intention of teachers to use digital educational games in the classroom.

"The game is very okay, most especially, the calculation, you need to learn calculation to do the game which is good"

"you see those ones that have had the experience now, to solve question on this distance will be very easy for them, they will find it even more interesting that others that have not played it, it makes mathematics interesting for them"

However, the responses of the teachers also suggested that they consider *SpeedyRocket* a tool to enhance the teaching and not to replace it. Having observed how pupils played, and did the necessary calculations, some of the teachers were able to see where game-based learning lies in the delivery of educational lessons in the classroom:

"It is useful in boosting their morale about what has been taught normally, it can boost their learning abilities, you see when they see that you are on your way, they are usually happy that the games master is coming"

"we can add it to it as he has said (as the other teacher said) *but it should be supplementary and not a replacement"*

These responses indicates that *SpeedyRocket* usefulness in creating an engaging classroom experience through which learners can co-create knowledge by actively participating in their own learning experience is clear to the teachers.

ii. Teachers' intention to use SpeedyRocket in the classroom

When the researcher asked if teachers would like to use *SpeedyRocket* in their classrooms, there were mixed responses. While some reasoned that the mere fact that pupils enjoyed playing it is a reason to adopt *SpeedyRocket,* other teachers put the responsibility of that decision on the management suggesting that they would rely on the school to tell them what to do:

"If they include it in their curriculum, yes, children love playing game, if the school can provide the technology, then yes"

"If it can be added to the timetable, so we know and plan for it, we all know many of them like the game…"

These responses also indicate that teachers place some value on administrative support and leadership interest in using digital games in the classroom. Teachers seem like they will not on their own pioneer the use of *SpeedyRocket* in the classroom without the school administration adding it to the timetable or work plan. This may be because even though using game-based learning is innovative, teachers would be accessed on the completing the curriculum and not necessarily on engaging classroom experience.

However, most of the teachers were not so positive about adopting it for use in the classroom as they cited some interesting reasons. The responses confirm that their scepticism about the use of games to teach is not about the usefulness of the tools but about the facilitating conditions necessary to make the use smooth and successful.

"...but because of the time factor, it may be difficult incorporating it, it is okay, because it teaches something, it is good".

"..there is no enough time. It is useful for them to learn fast, but there is no time for it at the moment"

"….but the time is the main challenge"

Teachers talked more on the time constraint more than any other thing. This is despite the fact that the design of *SpeedyRocket* consciously took into considerations the time factor with teachers' schedules and timetable in mind. During the implementation, careful planning was also done to ensure that time for other subjects were not used by the mathematics period.

There were recommendations to use *SpeedyRocket* outside the mathematics classroom and move it to an after school supplementary class.

"I still mentioned the time issue, the learning time is the challenge, we take mathematics Monday to Thursday, if we can use the free period on Friday around 12-12:30 as a supplementary something, so we can use the period to be doing it maybe once in a week, not everyday".

As mentioned earlier, covering the term or year curriculum appeared to be the priority of the teachers, as that is the success metric for the academic year. The perceived struggle that will accompany using *SpeedyRocket* and completing curriculum requirements is a challenge for digital game-based learning adoption. Nevertheless, some responses suggest that while teachers reported time as a challenge to adoption, the real challenge is their own technology-efficacy, as one of the teachers said:

"The major problem I think we will have is..even we the teachers, not to talk about the pupils now, we are not so familiar with such a thing so the same thing the pupils, if it is what they have been doing before, its what they can do and it will enhance their learning, but with the present situation like myself I am not so familiar with it, I was asking yesterday, which one did you say we should catch, so if I want to teach the pupils, I would want to know it first myself before teaching them. If we know it before, it would be easy to plan how to use it".

And seeing themselves as the custodian of that knowledge and expertise in the classroom, there is a feeling that if they cannot use the game very well, then their pupils are going to struggle with it. Interestingly some other comments also showed that the teachers were also concerned about the efficacy of their pupils and not just their own. There seem to be concern about the period between when the game is introduced and when pupils can start using it with as little support as possible. One teacher said:

" Time is the first challenge, number 2, before the pupils could get something out of it, like the one they were given, on the first day, only one person (in a class of 10) tried to get it right

very well, the second day about 2 or 3 of them, so before getting it, it might take time, and like I said the other time, a topic is majorly for a week, so out of a week, if you are taking 2-3days for only to do calculation using games, you know it would be taking most of the time"

"Based on what I have seen, it will take a lot of time, because each step counts, to the teacher, every minute counts, and apart from the time, in Nigeria, you know we have the rural and urban areas, those people that are living in the rural areas are not familiar with the computers or the use of the computer game…the time is not enough for us to be using it all the time, and they should see it as a supplement, not the sole for learning, just addition that ok we should not be using it everyday, just an addition"

"….It is time consuming, and it takes them a while to get used to it. As you can see now that it is different from when they started, you see them now improving bit by bit"

Once again, in the above statements, the time challenge is seen to be related to the efficacy concerns. Invariably, the more the pupils get at navigating the game and using the devices, the less challenge the time poses.

"Using game in mathematics right, they find it quite difficult to calculate some sums in computer when they are not really familiar with the use of computers like that, because of the situation in Nigeria, many of them are not computer literate and have not been familiar with the use of computers so they have found it somehow difficult at the beginning but as time went on, I believe in this generation, pupils learn very fast and I believe with the help of traditional teaching, they would improve".

Some of the teachers therefore are positively disposed to using *SpeedyRocket* in their mathematics classroom, on the condition that they would have the chance to learn it, and be prepared to support their pupils

"First, the teacher has to understudy the game, the same way that if you want to take a topic, you have to know that topic, you have to learn it before coming to class to teach them, so the idea is for the teacher to learn what that game is according to the topics before coming to the class to use it"

Learning, training and getting used to it came out really strongly during the focus group – for the teachers:

"....I think everything is fine, to me, the only lacking bit is the learning (training) had it been that one has been taught before, I was telling my colleague that it is not like the one we play on my phone that you just need to turn, this one you have to look at where you are going".

And for the pupils as well:

"They just need to be able to get familiar with the platform, I do not have a problem with using the game in the classroom, but being familiar is important because they just started using it, gradually they can learn it".

Another teacher mentioned the importance of seminars and workshops in providing more background and information to the teachers about the usefulness of game-based learning before they are asked to use it:

"before they can introduce it in Nigeria, we have to organise a seminar/workshop and tell the teachers, this is how you use it, these are the advantages of it".

iii. ***Teachers' concerns about the use of tablets in the classroom.***

Apart from the time constraints on the teachers to use game-based learning in the classrooms, the teachers commented on some of the other difficulties they experience during the course of the experiment. There were concerns about the suitability of the devices that *SpeedyRocket* was played on, and the experience with using technology generally, as one teacher said:

"Although the design is good, but the tablet is confusing to them, an analog control would be better. The control is the problem".

This may not be unconnected with the way some of the pupils struggled on the first day to get used to navigating *SpeedyRocket's* interface and manipulating objects in it. The importance of practise is once again highlighted here with respect to the devices and the experience of the pupils with *SpeedyRocket:*

"first, there is a need to get them familiar with the devices, because it is then that they can maximise the use"

However, one factor that teachers feel hamper practice is the access to tablets and computers. The importance of experience as well as the availability of devices was also mentioned in evaluation of the extended TAM under the enabling environment and experience with technology constructs. Retrospectively, teachers commented that the unavailability of the devices is a challenge to the adoption:

"…because one of the things I mentioned before is unavailability of devices, had it been that we have access to the devices and they have been using it, time would be enough because it will just be normal, but this one, infact the first day you saw the way they were doing on the devices, you yourself you would know that they are not familiar with it, so one of the things I said is time challenge and the unavailability…partially, now that they have been using it they know how use it".

Another teacher said:

"I think one of the problems people will have these days is that they don't really have access to some of these things, no laptop, or someone that has never operated a computer before, even forget the fact that they you have, it can be difficult for you, moving from one place to the other, but if you are familiar with some of these things, mere telling you, do this, press this, you will get it".

Teachers were however positive that with better access to tablets and computers, and more experience using it, the digital literacy of the pupils can overtime smoothen their ease of use of game-based learning:

"…I think some of them are not really familiar with it, but since they can learn fast…"

One other teacher commented that:

"Using game in mathematics right, they find it quite difficult to calculate some sums in computer when they are not really familiar with the use of computers like that, because of the situation in Nigeria, many of them are not computer literate and have not been familiar with the use of computers so they have found it somehow difficult at the beginning but as time went on, I believe in this generation, pupils learn very fast and I believe with the help of traditional teaching, they would improve"

Discussion

The findings from this chapter show compelling evidence that digital educational games can improve the attitude to and engagement with mathematics of young people in the classroom. The components of the ARCS model were significantly improved as shown in the results of the post questionnaires. Particular items like "looking forward to my mathematics classes", and "learning interesting things in mathematics classes" were evidenced through the improved scores of the results of the post questionnaires with the experiment group.

Games have the capacity to create interests in subjects and careers that are experiencing shortages – especially STEM careers. Item 10 - I would talk to my teachers about a career that uses mathematics, presented a significant improvement too. This suggests that digital educational games can stir up interests in not just classroom mathematics but also in related careers. It appears useful for young people to see the application of the subjects and lessons they learn in school to the real world.

A challenge in STEM teaching and learning today is the way lessons are designed and passed on to students. This is particularly a problem in regions where practical science knowledge is not readily available and the economic environment limits the access of pupils to practical lessons. A possible reason why young people find mathematics and some other STEM subjects uninteresting is the enormous scientific contents and phenomenon they consist of, which may not make sense if they cannot relate to them or see their applications. This study suggest that digital educational games can potentially bridge the gap between the practical knowledge and the theoretical understanding by presenting the educational concepts and application in more engaging ways. Results of this study suggest that digital technologies stand in a good position and offer a couple of potential solutions to this problem.

One of the challenges of mathematics is the abstract level of presentation sometimes that goes on in the classroom (as observed by the researcher), in contrast to the usual teacher-to-pupil delivery, the pupils were more engaged and involved in the classroom, figuring things out and constructing knowledge by and with themselves. A very interesting discovery was the confidence that the learning process produced with the pupils that are usually quiet and less responsive in the traditional classroom. As noted earlier, the game playing session also created an atmosphere of cooperation and competition. This research argues that both can be well blended to provide an engaging experience for pupils in the classroom. Pupils learn in different ways and one way educators can create a better learning experience is to ensure the learning environment provides different pathways and possibilities for the different kinds of learners.

Findings from this chapter also support the finding from the extended technology acceptance model. From the experience of the teachers in the game-based learning sessions, they could see the usefulness of *SpeedyRocket*. While some considered it useful just in engaging and exciting the pupils, some other teachers saw its usefulness in delivering curriculum-based content. However, willingness to adopt it in their classrooms still appears to be an issue: one which appears not to be about the usefulness, but about the ease of use, their own efficacies and those of their pupils, which can all be termed as digital literacy. Post using the game, the concerns of the teachers were mostly about first, the time constraints their timetables present, and two, the skills they need to use the game in their teaching practice – the same concerns they expressed initially before the development of the game. During the design and development of *SpeedyRocket,* the researcher, with an understanding of the time available for each subject in the school day, built the game in such a way that it was relatively short so it could be integrated easily into the classroom, however, the teachers still felt it still took a considerable amount of time to use. The other challenge, which is the skills they need to use the game with their pupils, was addressed with a tutorial, and a text guide on the functionalities of the game.

The various responses of the teachers about time constraints provided an insight into the real problem as highlighted in the focus groups results presented in the previous section. It appears that the fundamental problem is not time, but self-efficacy and digital literacy. Some of the teachers particularly referred to the time to learn how to use the game as the challenge with time, not necessarily the time it takes to use the game in the classroom. While their responses suggested that the young people got used to the game quickly and were using it well, they worried that they might not be able to get familiar with it in a similar time frame. It is worthy of note that digital literacy and self-efficacy goes hand in hand. The teachers were aware that the researcher was around in the room to handle any issues that came up while they used the game, but were concerned about their ability to deal with any technical difficulty that comes with the use of the game without support. Likewise, the fact that they had the guide that showed them how to use the *SpeedyRocket* and they underwent a briefing and training session, yet felt inadequate to use it suggests that the inadequacy may not necessary be about *SpeedyRocket*, but technology generally. This is consistent with the findings and recommendations in Chapter 5 about training and support. In the use of digital educational games in the classroom, it is recommended that training be holistic, and not just about the tool to be used. Teachers need to feel confident in their ability to deal with eventualities, unplanned disruptions, as well as familiar technical issues. The first step to dealing with this might be, to understand that they may not be able to handle every difficulty and they may have to turn to their pupils, or other colleagues for help.

Digital educational games are useful tools in the mathematics classroom. They can be used to deliver curriculum content, engage the classroom in constructive activities that improve confidence, and also create interest in particular careers. However, their integration needs to be well thought-out and one that carefully considers the learners and their preferences, but also the role of the teachers.

7.7 Conclusion

This chapter presents the analysis, results and discussions of the implementation of *SpeedyRocket* in the classroom. The results from the quantitative analysis of the questionnaires are discussed. This is followed by the analysis and presentation of the results from the classroom observations and the teachers' focus group. A final discussion of these results and findings is provided. The quantitative results from the pupil questionnaires show that *SpeedyRocket*, the game used for the experiment, is useful in improving attitude of pupils to mathematics in the classroom. The classroom observation shows that the use of *SpeedyRocket* improved classroom engagement and interaction and provided a more individualised learning experience for the pupils. Most importantly, digital educational games are found to be useful tools in breaking down barriers and getting young people to be active participants in the learning and teaching of mathematics. The focus group with the teachers shows that while they report an understanding and appreciation of the game's usefulness, they also have concerns about the ability and efficacy of both the pupils and themselves to maximise the use of the digital educational game in the classroom.

8 Chapter Eight: Conclusion and Reflection

This chapter presents the key contributions to knowledge and provides a summary of the main thesis. In Chapter One, the researcher presents the problem statement and a rationale for this research. The research questions are presented and an outline of the structure of the thesis is provided. In Chapter Two, a literature review is presented to demonstrate the various themes and current understanding around the concepts the researcher identified as central to the research. These include mathematics education, game-based learning and the acceptance of technology by teachers. Chapter Three presents the research methodology and the various techniques employed to answer the research questions. In Chapter Four, the researcher develops a conceptual framework on factors that engender engagement in games. Chapter Five presents an extension of the TAM that sought to understand the behavioural intention of teachers to use digital educational games in the classroom. *SpeedyRocket,* a prototype digital educational game to teach mathematics was developed and its design and implementation is discussed in Chapter Six. Chapter Seven provides an evaluation of the implementation of *SpeedyRocket*. This chapter concludes this thesis of eight chapters with a review of the original research questions, a summary of the main original contributions to knowledge, the limitations and challenges of the study, suggestions for future work and research direction, and reflections of the researcher on the study as a whole.

8.1 The Study

The overall aim of this study was to contribute to the discussion and literature around digital game-based learning. It focuses specifically on exploring how digital educational games can be used to provide an engaging experience for pupils in the mathematics classroom. This study provides more evidence to support the use of digital games in formal primary education by showing significant improvements in the engagement of cohorts of young people that played the game versus those that did not. This section considers the original research questions presented in Chapter One and the responses to them based on the research conducted in this study.

How can digital educational games be designed and developed to engage players?

This first research question was 'how can digital games be designed and developed to engage players?' The research conducted to answer this question was presented in Chapter Four of this thesis and focused on the engagement and enjoyment of digital games. Research into engagement factors and engagement in digital educational games are not many as compared to those on learning effectiveness. One explanation for this is the focus of digital educational games on delivery educational value rather than providing an enjoyable experience to the players. This research considered the factors that draw young people to video games, engage them while playing and keep them interested in the game and return to play it again and again. Using two data collection techniques of a questionnaire and an interview, the researcher explored the motivations of young people for playing casual games in order to inform how digital educational games could be made to be more fun and engaging. The responses of the young people involved in this research were mined for these motivations.

The results showed the following factors were important: clarity of goal; thematic appeal; visual appeal; rewards; feedback; social interaction; creativity; challenge; and immersion.

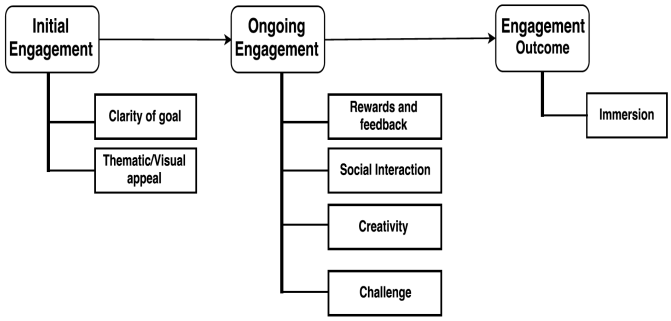

Figure 4.4 Game Engagement Framework

This research found out that these factors are the ones that support players' engagement in game play. The factors were thereafter created into an engagement framework, split into on-going engagement factors and the engagement outcome. The engagement framework gives a breakdown of the factors that are needed to initially draw and engage players, those that are useful in sustaining their interest and the factors that make for longer-term engagement and immersion.

This research posits that building digital educational games around the factors should make the games more interesting and engaging to young people, thereby solving the inherent problem most digital educational games have, that they are boring and players do not find them interesting to play. Most importantly it maintains that despite the fact that digital educational games are games with a purpose –which is learning, they need to maintain the sense of 'play' (Rieber, 1996) by keeping the fun bits. This is important if the games will engage players, especially players who are used to playing fun and interesting casual games.

What are the factors that determine the acceptance of digital educational games by teachers?

Having established the role of the teachers in the use of digital games in the classroom, it was important to understand the acceptance process of digital educational games by the teachers. The research conducted to explore this question is presented in Chapter Five of this thesis. There were two parts to answer this question. First, the researcher adopted the Technology

Acceptance Model as a framework to explore the constructs that determine the acceptance or otherwise of digital games by teachers in the classroom. The researcher modified the original TAM to adapt it to look specifically at digital games for learning based on the results of the semi-structured interviews

Secondly, the researcher tested out the extended TAM in a questionnaire administered to 220 teachers. Sets of hypotheses were developed from the extended TAM and were tested statistically. The results indicate that the model provided an understanding of the factors that predict the acceptance of digital educational games by teachers. Most importantly, the answer to the research question also indicated the strength of each of the factors on the intention of teachers to use digital educational games in the classroom. It also presented the mediating factors on the constructs as well as implications for the preparatory work with teachers that should precede the introduction of digital educational games to them.

This approach of combining the results from previous studies together with interviews from the targeted group enabled the key variables/constructs to be identified. Independent evaluation by a group of experts gave further confidence in the model. The modified TAM is a useful instrument for exploring the attitude of teachers to using digital games for learning and teaching, and highlighting the key areas which require support and input to ensure teachers are ready to accept and use this technology in their classroom practice.

What is the effect of digital educational games on the attitude to mathematics of pupils in the classroom?

Following the development of a prototype game- *SpeedyRocket,* the researcher wanted to know if the game had any effect on the attitude to classroom mathematics of young people. The researcher answered this question in Chapter Seven of this thesis. Working with the functional, non-functional and usability requirements drawn from the backgrounds studies (described in Chapters Four and Five), a digital educational game - *SpeedyRocket* was developed. Working with two groups – one that used the game and the other that did not, the researcher sought to find out if the game had any effect on the attitude of pupils that played the game to classroom mathematics.

To start with, a baseline of the attitude to mathematics of the two groups was collected. The experiment group was then administered with *SpeedyRocket* for two weeks. Using Wilconzon signed-rank test to compare differences in reported attitude of the sampled population, results indicated that the experiment group had a better post-attitude to mathematics score than the control group**.** Classroom observation also suggests that the use of *SpeedyRocket* provided a platform for better engagement, interaction, cooperation and collaboration. These all showed a more positive attitude to mathematics in the classroom.

8.2 Summary of contributions to knowledge

Game-based learning research has received a considerable amount of focus from academics and practitioners as well. However, this study is unique in a number of different ways: the research draws on educational research that states that interests are formed quite early in the educational journey of a child, and so interventions to improve attitude should target early ages too. In contrast to other empirical works around the effects of game-based learning, this study focused on primary school pupils. Furthermore, this research focused on the Nigeria context, one that has unique characteristics and peculiarities with respect to general awareness and use of technology in education. These peculiarities yielded interesting results and new perspectives on the use of digital educational games in the classroom,

The aim of this study is to provide an answer to the thesis title: how can digital educational games be used to support engagement with mathematics in the classroom? The researcher has answered this question in this thesis, and made significant contributions to knowledge in the process. This study is significant in four major areas:

i. Digital educational games and traditional classroom dynamics

The specific contribution of this research is the understanding and insight it provides into the changes in the classroom dynamics when digital educational game was introduced. Most of the research into digital educational games has been carried out in classrooms in developed countries where the culture is different than in Nigeria. The results of the impact of digital educational games cannot be generalised especially when the peculiarities of the context are considered. This research opens up a window of understanding by providing a rich qualitative account of the changes that occur in a classroom with the introduction of digital educational games. These changes are highlighted in chapter 7 of this thesis; however, the most important change perhaps is the shift in the power balance in the classroom. The use of *SpeedyRocket* in the traditional classroom ‘gave voice to the pupils’, and although it did not silent the teachers, it was not the most comfortable situation for them. This is an explanation to their reluctance to positively respond to the possibility of continuing to use digital educational games in the classroom.

In addressing the main research aim – ‘How games can be used to provide an engaging experience for pupils in the mathematics classroom’, this research found out that it is no enough to design engaging games, it is equally as important to carefully consider the status quo and how the innovation would affect the dynamics. Much more than that, it is important to prepare the stakeholders for the changes that may likely occur.

This finding provides a profound implication for digital games in teaching and learning and also digital technology generally in education in Nigeria. Amidst several calls to adopt innovative tools and integrate them to solve existing problems in the classroom, it is should not be a rushed activity as this risk creating more problems. It should be well planned and structured. The findings of this research suggest that mathematics in itself may not be the challenge, but the delivery of the subject and the inherent structure of classroom practice in Nigeria. It implies that for young people to be better engaged in the classroom, barriers to communication, sharing, cooperation and collaboration should be broken. While digital educational games are great tools to do this, teachers do not necessarily have to use games to change the dynamics. However, there is need for them to first acknowledge the need for better classroom experience and understand where they stand in making that happen. Closely linked to this implication is more insight in the area of first and second order barriers initially discussed in chapter 2. Many of the previous research as to why the technology adoption and integration is slow in Nigeria has focused on factors such as unavailability of devices, infrastructural development and government policies. However, this research brings into limelight the issues around teachers’ readiness and their concerns about the potential disruption to the status quo.

ii. Game engagement framework

Firstly, this study adds to existing literature on empirically informed engagement factors in games. As highlighted earlier, design of digital entertainment games is a fast pace moving field with designers and developers rolling out more advanced games more than ever before. Whereas other studies focussed on adults, this research work was focused on engagement factors for young people. It provides insight for not just other developers of educational games, but also content creators for educators. In addition, the engagement framework provides a distinction for the three levels of engagement - initial engagement, on-going engagement and the sustained outcome of engagement, which is immersion. This shows these factors grouped under three main categories:

Initial engagement, on-going engagement and engagement outcome. Initial engagement factors are those that appear to be antecedents to engagement, they precede and tend to trigger engagement. Motivation is the basis for initial engagement. This motivation can either be powered by thematic/visual appeal as well as interest in the subject of the game (extrinsic) or clarity of goals, objectives and aims of the game. On-going engagement factors help sustain engagement by providing rewards and feedback, a reasonable level of challenge, a way for players to be socially active during gameplay and ways for them to be creative. Given that the goal of engagement is immersion, it is expected that if on-going engagement can be sustained long enough, a player will get to the level of immersion.

This distinction provides a guide on where focus should be placed while developing digital educational games for the classroom. As highlighted earlier in the research, unlike casual games, budgets for creating educational games are usually small. This stratification helps put focus on where the available resources should focus on in the development of a digital educational game. Apart from its value to game development, the engagement factors also provide knowledge for how better engagement can be brought into the traditional classroom. This is useful for teachers trying to create a better experience on interaction and enjoyment in their classrooms.

iii. Teachers' technology acceptance in the classroom

The extended TAM developed by the researcher is a contribution to knowledge. The TAM was adapted using existing models and an empirical work with current teachers within the context of study. More importantly, the extended TAM was re-focused to work for not just technology but specifically for digital educational games.

For researchers and designers, the results of this study provide insights into how teachers accept the use of digital educational games. It provides an understanding of the characteristics of teachers and how these influence their disposition to the adoption of digital educational games for classroom use. Although this work is all within the context of the schools in Nigeria, the insights acquired may differ in other settings, however, the extended TAM could be easily modified to other settings. More specifically, this study provides this understanding for environments where technology is not very common and elicits teachers' concerns to adoption, use and effectiveness.

This work also highlights the importance of usefulness to the teachers' acceptance or otherwise of a new technology. While focus has been placed on training teachers to ease of use and digital literacy for teachers, this study argues that the more useful the teachers find the technology, the less difficult they perceive it to be. It also argues that teachers need to be carried along through all the activities in the process of developing a technological tool to be used in the classroom. Being carried along is much more important than be trained to use. This is particularly useful for school administrators and policy makers who sometimes want teachers to use technology in the classroom simply because it is a common practise.

iv. Development of *SpeedyRocket*

This study presents a prototype game designed and developed using the findings from the work with young game players and with teachers. This provides useful insights into how educational content can be embedded in digital educational games that will be acceptable to teachers and fun for pupils for use in the traditional classroom. The attempt to blend both learning and fun in the prototype game provides implications for designers looking to create similar solutions. The development of *SpeedyRocket* was done with limited resources, and specific focus on the context it was to be used in. It particularly sought to address the concerns of the teachers about time constraints, availability of technical infrastructure and expertise. The implementation was however successful, as the game was used well in the classroom for two weeks. The develop process and guidelines provides a model for educators or developers looking to create digital educational games for environments and contexts such as that.

v. Assessment of game-based learning

Finally, this study has investigated the effects of a digital educational game on the attitude to mathematics of young people (8-11 years old). The results from the experiment provide insights into the benefits of digital educational games in the mathematics classroom. The implementation of the game in a classroom setting can be used to create more a more engaging experience compared to the traditional classroom in Nigeria. Unlike other studies that looked at achievement as well as aspirations, this study evaluated only attitude to and engagement with mathematics in the classroom and the effect *SpeedyRocket* had on it.

As established earlier in this thesis, young people fear mathematics, and find it hard to relate to. This is despite the fact that examination scores of the young people in this study was above average, however, teachers maintain that young people see mathematics as abstract, boring and unconnected to the real world. The poor attitude could possibly potentially deter further interest in mathematics-related degrees and career paths.

In all, this study contributes to the literature and research game-based learning and use in the classroom by providing a well-grounded empirical study into how digital games can be designed for teaching and learning educational content in the classroom. The limitations and suggestions for future studies are presented in the next sub-section.

8.3 Research limitations

As with other research studies, this study had some limitations and shortcomings. These shortcomings could be addressed in future work.

i. Game engagement framework

The game engagement framework was developed from work with regular gamers. While this was a reasonable approach given the kind of questions used to get the factors, this may raise some concerns about the validity of its findings across non-regular gamers as well as non-gamers. In addition to this, research has shown that males and females play games differently and may also be motivated by different factors. This research did not consider these differences in the development of the engagement framework.

ii. SpeedyRocket's design

The design of the game is limited in its scope and functionalities. The researcher designed and developed *SpeedyRocket* in a relatively short period of three months. This is partly because the game itself was a tool in the research and not an end in itself. It was a pilot game rather than a fully finished product. Even though tasks in *SpeedyRocket* teach arithmetic and estimation, it was primarily developed around a single topic in the mathematics curriculum, and at such may not be relevant for more than two weeks during the span of the topic in the classroom.

iii. Learning effectiveness

Although it was the researcher's plan for this research to focus on the engagement opportunities of digital educational games, it still presented as a limitation of this study. The researcher did not consider if any changes occurred in the performances of the experiment group versus the control group and if there were indications that using digital educational tools provided not just better engagement but also learning effectiveness.

iv. Sample representation

Findings from this research cannot be generalised as the population of study was not representative of the research sample, and may produce different results if taken into another context.

8.4 Future research directions

i. Game engagement framework

This research has produced a game engagement framework that is valid in a particular context and has used it in developing a digital educational game that engaged pupils in another context. A future study could look at a more balanced and representative population and the effect of the different levels of affinity and engagement with digital games. It will be useful to consider how the gender differences influence the factors on the game engagement framework, and if there are particular factors that are more common with females or males. Testing the engagement factors with a wider range of age would also improve the robustness of the framework.

ii. *SpeedyRocket's* design and usage

A study that focuses more on the development of a digital educational game can potentially take the engagement factors, and the recommendations for design in Chapters 4, 5 and 6 and further develop the SpeedyRocket game or develop something entirely different. The design process would benefit from a more focused approach, more time and more resources. Other future work may extract the key components from *SpeedyRocket* and its implementation to provide guidance to other digital educational game design and development. This could be for mathematics or for another subject.

iii. Learning effectiveness of digital educational games

While this research provided an understanding of how digital educational games can be used to improve engagement in the classroom, further work could look at the impact of the game on learning effectiveness. Given that ultimately, this is the goal of a classroom teacher, it would be useful to evaluate the learning effectiveness that digital educational games provide. In addition, further research could consider the impact of better engagement on learning effectiveness using empirical studies. This would provide more rationale for using digital educational games in the classroom.

iv. Sample selection

This research was set in a particular context. Further research can use the tools the researcher has developed with a wider or different sample. Some of this may include:

- Doing more of this intervention with different groups of young people.
- Exploring the impact of individual differences like age, gender, and technology proficiency on the results.
- External control group (to the population under study) could be used to control Hawthorns effect (McCambridge et. al., 2014)
- A fully randomised sampling selection method could be employed.

v. Extended Technology Acceptance Model

The extended TAM developed as part of this research could be used with a different set of teachers. It could be adapted for use in other digital educational game settings e.g. with older children, at university, colleges etc.

8.5 Interface with wider research community and research impact

During the course of this study, the researcher shared and disseminated ideas and findings from this study with the wider research community both locally and internationally. At the early stages of this research, the researcher presented at the IEEE International Conference on interactive Mobile Communication, Technologies and Learning (IMCL 2015) in Thessaloniki, Greece. This research was presented as a game business proposal at the EngineeringYes Research Competition that took place at Birmingham in May 2015. A viable 5-year business plan was developed for the research output (an immersive-engaging game). It won two prizes: The Elevator Pitch prize and the Peer Peview prize.

A poster presentation submitted to the International Communication Association (ICA) 66th Conference was awarded the best poster in the Games Studies Division of the conference. The researcher also gave a paper presentation at the 2016 IEEE Frontiers in Education Conference in Philadelphia. In the later stages of the study, the researcher got a paper accepted that was presented at the IEEE 2016 EDUCON. The feedbacks and comments from these presentations were inputs into this research.

With regards to practice and impact, the research gave a three-day workshop in partnership with Microsoft and the Nigerian government in April 2017, on how technology can be used to foster better engagement in the classroom. 83 teachers from attended the workshop across two states of the country. On the third day of the workshop, the teachers were trained on how to use *SpeedyRocket*, the game developed as a result of this research. Finally, based on the findings of this research, two undergraduates projects in Northumbria University are currently looking at different elements of the engagement framework and investigating their individual effects in the effectiveness of digital educational games.

During the course of this PhD (year 1 and year 2), the researcher worked as a part-time research assistant on the NUSTEM project (https://nustem.uk/). Drawing from knowledge and skills gained from the PhD study, the researcher developed tools and methods to capture and analyse all kinds of data (qualitative and quantitative) from school activities and interventions. The researcher employed the use of books and articles sourced from the university library to inform the development of the research tools and the analysis of the results. The researcher was involved in the review of literature to inform the approach and methods for the research. However, the researcher's work was specifically on the analysis and evaluation of data from secondary schools to inform the level of science capital (Archer et. al., 2015) amongst young people in the region.

Towards the end of the PhD, the researcher started working full-time as a postdoctoral researcher on the BRIDGE project (http://www.gateshead.ac.uk/bridge/). This researcher has been working on planning and organising the project's research, reviewing relevant literatures, conducting interviews and administering questionnaire. He has also been setting evaluation plans for assessing the impact of the project against success metrics. The researcher's exposure to fieldwork and widening participation initiatives was critical to success recorded in these jobs to date.

The main papers published from this PhD are:

i. O. Dele-Ajayi, R. Strachan, A. Pickard and J. Sanderson, "Girls and science education: Exploring female interests towards learning with Serious Games a study of KS3 girls in the North East of England," *2015 International Conference on Interactive Mobile Communication Technologies and Learning (IMCL)*, Thessaloniki, 2015, pp.364-367. doi: 10.1109/IMCTL.2015.7359620

ii. O. Dele-Ajayi, J. Sanderson, R. Strachan and A. Pickard, "Learning mathematics through serious games: An engagement framework," *2016 IEEE Frontiers in Education Conference (FIE)*, Erie, PA, USA, 2016, pp. 1-5. doi: 10.1109/FIE.2016.7757401

iii. O. Dele-Ajayi, R. Strachan, J. Sanderson and A. Pickard, "A modified TAM for predicting acceptance of digital educational games by teachers," *2017 IEEE Global*

Engineering Education Conference (EDUCON), Athens, 2017, pp.961-968. doi: 10.1109/EDUCON.2017.7942965

8.6 Reflections on the Researcher's Experience: Lessons Learnt and Knowledge Acquired.

This PhD study challenged the researcher in ways he had never experienced before. Navigating a challenging doctoral project that draws on disparate fields, sitting at the junction of educational technology, game development and pupils' engagement has made him a better grounded researcher than he was when he started.

Firstly, this journey has exposed the researcher to various new research methods, experiences and knowledge. Before this study, the researcher had done only software development and basic quantitative research projects. Coming from a very technical bachelor's and master's background, this PhD was the researcher's first main experience of empirical research methods. Although the researcher struggled initially with the different complexities, the researcher was able to pull through successfully as a result of support and exposure to experienced researchers in the university and beyond.

Also, during the course of this research, the researcher carried out systematic literature reviews, and performed various qualitative and quantitative data analysis, as he had never done previously. The researcher learnt new methods of analysis using SPSSv22 and the interpretation of statistical results. In addition to these, the researcher improved on his critical thinking, problem solving and independent research skills.

For the first time in this researcher's career, he interacted with pupils and teachers within and outside the classroom. Before now, the researcher had only experienced desktop studies and some minor work with gathering software requirements from clients and businesses. This study stretched the researcher beyond his comfort zone and made him interact and work with people on a deeper level than before.

Time management was also a key skill the researcher learnt in the course of this PhD study. The process of getting an ethical approval to start the fieldwork part of this research took five months; this was a significant part of the time allocated for the research. That meant the researcher had to re-organise the plan several times during the research.

In doing research in a challenging environment like Ado-Ekiti in Nigeria, the researcher learnt how to be resilient and improvise when it is needed. Working with technology in the classroom with teachers and pupils who did not have much experience with some of the tools and terms presented a new level of challenge to the researcher. The researcher improved his skills on communicating technical terms in simple ways as well as classroom presentation and engagement.

In all, this PhD study has made this candidate a better researcher over the past three years. The good, the challenges and the trills of the journey have all contributed to making the experience a rewarding and enjoyable one.

8.7 Summary

This chapter provides the main original contributions to knowledge, key conclusions and suggestions for future work for this research study. The researcher presents each of the original research questions and summaries how the research from this study has responded to each of them. From this it has presented a summary of the main original contributions to knowledge from this research. Finally this chapter has discussed the lessons learnt, the research challenges and limitations and the key recommendations for future research studies. It outlines the main dissemination of the research to date and concludes with the reflections of the researcher on the research study.

REFERENCES

1. Abdullah, F. and Ward, R., 2016. Developing a General Extended Technology Acceptance Model for E-Learning (GETAMEL) by analysing commonly used external factors. Computers in Human Behavior, 56, pp.238-256.
2. Acharya, A.S., Prakash, A., Saxena, P. and Nigam, A., 2013. Sampling: Why and how of it. Indian Journal of Medical Specialties, 4(2), pp.330-333.

3. Achinstein, B., & Ogawa, R. (2006). (In) fidelity: What the resistance of new teachers reveals about professional principles and prescriptive educational policies. Harvard Educational Review, 76(1), 30–63.
4. Achinstein, B., & Ogawa, R. (2006). (In) fidelity: What the resistance of new teachers reveals about professional principles and prescriptive educational policies. Harvard Educational Review, 76(1), 30–63.
5. Adams, E. (2014). Fundamentals of game design. Pearson Education.
6. Adebule, S.O., 2004. Gender differences on a locally standardized anxiety rating scale in mathematics for Nigerian secondary schools. *Nigerian Journal of counselling and applied psychology*, *1*(2), pp.22-29.
7. Adebule, S.O., Onijigin, E.O., Balogun, E.A. and Adebule, H.T., 2016. An Evaluation of Low and High Achievements in Mathematics in Ekiti State Secondary Schools. Journal of Educational Policy and Entrepreneurial Research, 3(6), pp.9-20.
8. Adegoke, B.A., 2012. Impact of interactive engagement on reducing the gender gap in quantum physics learning outcomes among senior secondary school students. *Physics Education*, *47*(4), p.462.
9. Aderokun Asaaju, O. (2015). The Inconsistency of Nigeria's Education System and Its Implication for Curriculum Implementation. Journal of US-China Public Administration, 12(3), 167–179. https://doi.org/10.17265/1548-6591/2015.03.001
10. Adetula, D.T., Adesina, K., Owolabi, F.O.L.A.S.H.A.D.E. and Ojeka, S., 2017. Investment in Education for the Nigerian Economic Development. *Journal of Internet Banking and Commerce*.
11. Adimora, D.E., Nwokenna, E.N., Omeje, J.C. and Eze, U.N., 2015. Influence of Socio-Economic Status and Classroom Climate on Mathematics Anxiety of Primary School Pupils. Procedia-Social and Behavioral Sciences, 205, pp.693-701.
12. Adolphus, T. (2011). Problems of teaching and learning of geometry in secondary schools in Rivers State, Nigeria. International Journal of Emerging Sciences, 1(2), 143–152.
13. Agogo, P.O. and Achor, E.E., 2014. Sustaining Children's Interest in Basic Science and Technology in Nigerian Junior Secondary Schools for Sustainable Science and Technology Development.
14. Aitken, J. E., & Neer, M. (1992). A faculty program of assessment for a college level competency-based communication core curriculum. Communication Education, 41(3), 270–286.
15. Ajai, J.T. and Imoko, B.I., 2015. Gender differences in mathematics achievement and retention scores: A case of problem-based learning method. International Journal of Research in Education and Science, 1(1), pp.45-50.
16. Ajayi T.D, Mbah U.L, Gokum D.K. Computer- Aided Instruction Usage and Primary Schools Pupils' Attitude and Performance in Mathematics in Jos Metropolis Plateau State, Nigeria. Asia Pacific Journal of Multidisciplinary Research, Vol. 5, No. 4, November 2017. Pp 76-82
17. Ajayi, O., Audu, C. and Ajayi, E., 2017. Influence of Class Size on Students' Classroom Discipline, Engagement and Communication: A Case Study of Senior Secondary Schools in Ekiti State, Nigeria Mathematics Education, 7(5), 324–326.
18. Ajzen Icek. 1991 From intentions to actions: a theory of planned behaviour. Organisation. Behavior. Decision. Process., 50 (1991), pp. 179–211
19. Ajzen, I., 1985. From intentions to actions: A theory of planned behavior. In Action control (pp. 11-39). Springer Berlin Heidelberg.
20. Akiri, A.A., 2014. Utilisation of local inputs in the funding and administration of education in Nigeria. *Research in Education*, *91*(1), pp.1-11.

21. Akpabio, E. and Ogiriki, I.B., 2017. Teachers use of Information and Communication Technology (ICT) in Teaching English language in Senior Secondary Schools in Akwa Ibom State.
22. Al-Adwan, A., Al-Adwan, A. and Smedley, J., 2013. Exploring students acceptance of e-learning using Technology Acceptance Model in Jordanian universities. International Journal of Education and Development using Information and Communication Technology, 9(2), pp. 4-18.
23. Aldrich, C. (2009). Virtual worlds, simulations, and games for education: A unifying view. Innovate: Journal of Online Education, 5(5), 1.
24. Aldunate, R. and Nussbaum, M., 2013. Teacher adoption of technology. Computers in Human Behavior, 29(3), pp.519-524.
25. Alessi S. M. & Trollip, S.R. (2001). Multimedia for learning: Methods and development (3rd Ed.). (214, 254-257). Boston: Allyn & Bacon.
26. Ali, L., Asadi, M., Gašević, D., Jovanović, J. and Hatala, M., 2013. Factors influencing beliefs for adoption of a learning analytics tool: An empirical study. Computers & Education, 62, pp.130-148.
27. All, A., Castellar, E.P.N. and Van Looy, J., 2015. Towards a conceptual framework for assessing the effectiveness of digital game-based learning. Computers & Education, 88, pp.29-37.
28. Allmendinger, J. (2002). Abschied von der Männerdominanz? Zur Situation von Nachwuchswissenschaftlerinnen an deutschen Hochschulen [The end of male dominance? The situation of young female researchers at German universities]. In D. Rippl, & E. Ruhnau (Eds.), Wissen im 21. Jahrhundert: Komplexität und Reduktion [Knowledge in the Twenty-First Century: Complexity and Reproduction (pp. 105–122). München: Fink.
29. Alvarez, J. (2007). serious game : Cultural approaches , pragmatic and formal (Doctoral dissertation, Toulouse 2).
30. Ammermüller, A., & Lauer, C. (2007). Bildung und nationale Prosperität [Education and national prosperity]. In K. A. Heller, & A. Ziegler (Eds.), Begabt sein in Deutschland [Being gifted in Germany] (pp. 31–48). Münster: LIT
31. Amory, A. (2001). Building an educational adventure game: theory, design, and lessons. Journal of Interactive Learning Research, 12(2), 249-263.
32. Amuseghan, S. A. (2007). ESL curriculum in secondary schools in Nigeria: Issues and challenges towards communicative competence. Nebula, 4(2), 319–333.
33. Anderson, S.P., 2011. Seductive Interaction Design: Creating Playful, Fun, and Effective User Experiences, Portable Document. Pearson Education.
34. Anekwe, J.U. and Williams, C.H.E.T.A., 2014. Educational Technology in Nigeria Universities: Statues Quo and Visions for the Future. AFRREV STECH: An International Journal of Science and Technology, 3(1), pp.128-149.
35. Annetta, L. A. (2010). The “I's” have it: A framework for serious educational game design. Review of General Psychology, 14(2), 105.
36. Annetta, L.A., Minogue, J., Holmes, S.Y. and Cheng, M.T., 2009. Investigating the impact of video games on high school students’ engagement and learning about genetics. Computers & Education, 53(1), pp.74-85.
37. Archer, L., Dawson, E., DeWitt, J., Seakins, A. and Wong, B., 2015. “Science capital”: A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. Journal of Research in Science Teaching, 52(7), pp.922-948.
38. Arnab, S., Brown, K., Clarke, S., Dunwell, I., Lim, T., Suttie, N., ... & De Freitas, S. (2013). The development approach of a pedagogically-driven serious game to support

Relationship and Sex Education (RSE) within a classroom setting. Computers & Education, 69, 15-30.
39. Asikhia, O.A., 2010. Students and teachers' perception of the causes of poor academic performance in Ogun State secondary schools [Nigeria]: Implications for counseling for national development. European Journal of Social Sciences, 13(2), pp.229-242.
40. Asubiojo, R.O. and Ajayi, J.A., 2017. The Role of Information and Communication Technology in Enhancing Instructional Effectiveness in Teachers' Education in Nigeria. KIU Journal of Social Sciences, 3(2), pp.289-295.
41. Avong, H.N., 2013. Poor performance in mathematics among senior secondary school students in Kaduna state: What's to blame. Journal of Research in National Development, 11(2), pp.319-324.
42. Awofala, A.O., 2014. Examining Personalisation of Instruction, Attitudes toward and Achievement in Mathematics Word Problems among Nigerian Senior Secondary School Students. International Journal of Education in Mathematics, Science and Technology, 2(4), pp.273-288.
43. Ayeni, A.J., 2017. Teachers' Classroom management and Quality Assurance of Students' Learning Outcome in Secondary Schools in Ondo State, Nigeria. Journal of Social and Administrative Sciences, 4(2), p.166.
44. Aziz, N. and Rahman, N.A., 2017, July. Use of ICT in indigenous primary school classroom: A case study of teachers' expectations and experiences. In Research and Innovation in Information Systems (ICRIIS), 2017 International Conference on (pp. 1-4). IEEE.
45. Babikkoi, M.A., 2014. EFFECT OF RELIGION ON THE CHOICE OF ENGLISH LANGUAGE LEARNING STRATEGIES USED BY SECONDARY SCHOOL STUDENTS IN NIGERIA. *3 rd ILANNS*, p.11.
46. Backlund, P. and Hendrix, M., 2013, September. Educational games-are they worth the effort? A literature survey of the effectiveness of serious games. In Games and virtual worlds for serious applications (VS-GAMES), 2013 5th international conference on (pp. 1-8). IEEE.
47. Baek, Y.K., 2008. What hinders teachers in using computer and video games in the classroom? Exploring factors inhibiting the uptake of computer and video games. CyberPsychology & Behavior, 11(6), pp.665-671.
48. Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. Psychological review, 84(2), pp.191-215.
49. Bano, M., Zowghi, D., Kearney, M., Schuck, S. and Aubusson, P., 2018. Mobile learning for science and mathematics school education: A systematic review of empirical evidence. Computers & Education, 121, pp.30-58.
50. Barbosa, A. F., & Silva, F. G. (2011, November). Serious Games: design and development of OxyBlood.
51. Barkley, E.F., 2018. Terms of Engagement: Understanding and Promoting Student Engagement in Today's College Classroom. In Deep Active Learning (pp. 35-57). Springer, Singapore.
52. Barksdale, C.J., 2017. Examining the relationship between classroom climate and student achievement of middle school students (Doctoral dissertation).
53. Barr, M., 2017. Video games can develop graduate skills in higher education students: A randomised trial. Computers & Education. In Print
54. Barrow, R. (2015). Giving teaching back to teachers: A critical introduction to curriculum theory. Routledge.

55. Basit, T., 2003. Manual or electronic? The role of coding in qualitative data analysis. Educational research, 45(2), pp.143-154.
56. Baturay, M.H., Gökçearslan, Ş. and Ke, F., 2017. The relationship among pre-service teachers' computer competence, attitude towards computer-assisted education, and intention of technology acceptance. International Journal of Technology Enhanced Learning, 9(1), pp.1-13.
57. Bature, I.J., Atweh, B. and Treagust, D., 2016. Inclusivity: An Effective Tool for Achieving Quality Mathematics Classroom Instruction in Nigerian Secondary Schools. Universal Journal of Educational Research, 4(1), pp.173-180.
58. Becker, K., 2007. Digital game-based learning once removed: Teaching teachers. British Journal of Educational Technology, 38(3), pp.478-488.
59. Becker, K., 2007. Pedagogy in commercial video games. Games and simulations in online learning: Research and development frameworks, Hershey, PA: Information Science Publishing.
60. Begg, A., 2015. Constructivism: An overview and some implications.
61. Behm-Morawitz, E., & Mastro, D. (2009). The effects of the sexualization of female video game characters on gender stereotyping and female self-concept.Sex roles, 61(11-12), 808-823.
62. Bell (2010) "Women in science: The persistence of gender in Australia." Higher Education Management and Policy. OECD Publishing. 22(1):1-19.
63. Bernard, H.R., 2002. Qualitative data analysis I: Text analysis. Research methods of anthropology, pp.440-448.
64. Bhana, D. (2005). "I'm the best in maths. Boys rule, girls drool." Masculinities, mathematics, and primary schooling. Perspectives in Education, 23, 1–10.
65. Bierman, K.L., 2011. The promise and potential of studying the "invisible hand" of teacher influence on peer relations and student outcomes: A commentary. Journal of Applied Developmental Psychology, 32(5), pp.297-303.
66. Billett, S. (2003). Vocational curriculum and pedagogy: an activity theory perspective. European Educational Research Journal, 2(1), 6–21.
67. Billieux, J., Van der Linden, M., Achab, S., Khazaal, Y., Paraskevopoulos, L., Zullino, D. and Thorens, G., 2013. Why do you play World of Warcraft? An in-depth exploration of self-reported motivations to play online and in-game behaviours in the virtual world of Azeroth. Computers in Human Behavior, 29(1), pp.103-109.
68. Bingimlas, K.A., 2009. Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. Eurasia journal of mathematics, science & technology education, 5(3).
69. Birks, M. and Mills, J., 2015. Grounded theory: A practical guide. Sage.
70. Blackwell, C.K., Lauricella, A.R. and Wartella, E., 2014. Factors influencing digital technology use in early childhood education. Computers & Education, 77, pp.82-90.
71. Bolaji, S.D., 2014. Intent to Action: Overcoming Barriers to Universal Basic Education Policy Implementation in Nigeria.
72. Bolick, C.M. and Bartels, J., 2014. Classroom management and technology. E. Emmer, & E. Sabornie, Handbook of Classroom Management, pp.479-495.
73. Borderie, J. and Michinov, N., 2016. Identifying Flow in Video Games: Towards a New Observation-Based Method. International Journal of Gaming and Computer-Mediated Simulations (IJGCMS), 8(3), pp.19-38.
74. Bornstein, D.A.V.I.D., 2011. A better way to teach math. The New York Times. Retrieved online s, p.2011.
75. Botcherby, S., & Buckner, L. (2012). Women in Science, Technology, Engineering and Mathematics: from Classroom to Boardroom. UK Statistics.

76. Boticki, I., Baksa, J., Seow, P. and Looi, C.K., 2015. Usage of a mobile social learning platform with virtual badges in a primary school. Computers & Education, 86, pp.120-136.
77. Bourbia, R., Gouasmi, N., Hadjeris, M., & Seridi, H. (2014). Development of Serious Game to Improve Computer Assembly Skills. Procedia-Social and Behavioral Sciences, 141, 96-100.
78. Bourgonjon, J., De Grove, F., De Smet, C., Van Looy, J., Soetaert, R. and Valcke, M., 2013. Acceptance of game-based learning by secondary school teachers. Computers & Education, 67, pp.21-35.
79. Boyle, E. A., Connolly, T. M., Hainey, T., & Boyle, J. M. (2012). Engagement in digital entertainment games: A systematic review. Computers in Human Behavior, 28(3), 771-780.
80. Boyle, E.A., Hainey, T., Connolly, T.M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C. and Pereira, J., 2016. An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. Computers & Education, 94, pp.178-192.
81. Braghirolli, L.F., Ribeiro, J.L.D., Weise, A.D. and Pizzolato, M., 2016. Benefits of educational games as an introductory activity in industrial engineering education. Computers in Human Behavior, 58, pp.315-324.
82. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.
83. Bristol, T.J. and Zerwekh, J., 2011. Essentials of e-learning for nurse educators. FA Davis.
84. Broken Sword: The Shadow of the Templars. Developed by Revolution Software, Ltd. Published by Virgin Interactive Entertainment. Platform: PC. 1996.
85. Brown, J. S., & Adler, R. P. Minds on fire: Open education, the long tail and Learning 2.0, 2008 Educause Review 43 (1).
86. Bryant, J. and Fondren, W., 2009. Psychological and communicological theories of learning and emotion underlying serious games. Serious games: Mechanisms and effects, pp.103-116.
87. Bryant, Jennings, and Wes Fondren. "Psychological and communicological theories of learning and emotion underlying serious games." Serious games: Mechanisms and effects (2009):103-116.
88. Bryce, J., & Rutter, J. (2002). Killing like a girl: Gendered gaming and girl gamers' visibility. In Paper presented at the Computer Games and Digital Culture Conferences.
89. Bryman, A., & Bell, E. (2015). Business research methods. Oxford University Press, USA.
90. Brzycki, D. and Dudt, K., 2005. Overcoming barriers to technology use in teacher preparation programs. Journal of Technology and Teacher Education, 13(4), p.619.
91. BT (2015) Explore the world's largest collection of playable computer games. Available http://home.bt.com/tech-gadgets/tech-news/explore-the-worlds-largest-collection-of-playable-computer-games-11363982683155 [Accessed 15/11/17]
92. Burke, P.F., Schuck, S., Aubusson, P., Kearney, M. and Frischknecht, B., 2017. Exploring teacher pedagogy, stages of concern and accessibility as determinants of technology adoption. Technology, Pedagogy and Education, pp.1-15.
93. Butler, A.C., Marsh, E.J., Slavinsky, J.P. and Baraniuk, R.G., 2014. Integrating cognitive science and technology improves learning in a STEM classroom. Educational Psychology Review, 26(2), pp.331-340.

94. Butler, Y. G., Someya, Y., & Fukuhara, E. (2014). Online games for young learners' foreign language learning. ELT Journal, 68(3), 265-275.
95. Calderón, A. and Ruiz, M., 2015. A systematic literature review on serious games evaluation: An application to software project management. Computers & Education, 87, pp.396-422.
96. Calisir, F., Altin Gumussoy, C., Bayraktaroglu, A.E. and Karaali, D., 2014. Predicting the intention to use a web-based learning system: Perceived content quality, anxiety, perceived system quality, image, and the technology acceptance model. Human Factors and Ergonomics in Manufacturing & Service Industries, 24(5), pp.515-531.
97. Calvert, S.L., Appelbaum, M., Dodge, K.A., Graham, S., Nagayama Hall, G.C., Hamby, S., Fasig-Caldwell, L.G., Citkowicz, M., Galloway, D.P. and Hedges, L.V., 2017. The American Psychological Association Task Force assessment of violent video games: Science in the service of public interest. American Psychologist, 72(2), p.126.
98. Campbell, D.T. and Stanley, J.C., 2015. Experimental and quasi-experimental designs for research. Ravenio Books.
99. Carnagey, N. L., Anderson, C. A., & Bushman, B. J. (2007). The effect of video game violence on physiological desensitization to real-life violence. Journal of Experimental Social Psychology, 43(3), 489-496.
100. Castellar, E.N., All, A., De Marez, L. and Van Looy, J., 2015. Cognitive abilities, digital games and arithmetic performance enhancement: A study comparing the effects of a math game and paper exercises. Computers & Education, 85, pp.123-133.
101. CBN(2010) https://www.cbn.gov.ng/OUT/2011/publications/statistics/2010/index.html
102. Cecez-Kecmanovic, D. and Webb, C., 2000. Towards a communicative model of collaborative web-mediated learning. Australasian Journal of Educational Technology, 16(1).
103. Chang, C.T., Hajiyev, J. and Su, C.R., 2017. Examining the students' behavioral intention to use e-learning in Azerbaijan? The General Extended Technology Acceptance Model for E-learning approach. Computers & Education, 111, pp.128-143.
104. Chau, M., Wong, A., Wang, M., Lai, S., Chan, K. W., Li, T. M., ... & Sung, W. K. (2013). Using 3D virtual environments to facilitate students in constructivist learning. Decision Support Systems, 56, 115-121.
105. Chen, C.H., 2008. Why do teachers not practice what they believe regarding technology integration?. *The journal of educational research*, *102*(1), pp.65-75.
106. Chen, F.H., Looi, C.K. and Chen, W., 2009. Integrating technology in the classroom: a visual conceptualization of teachers' knowledge, goals and beliefs. Journal of Computer Assisted Learning, 25(5), pp.470-488.
107. Chen, S. and Li, S., 2011. Recent Related Research in Technology Acceptance Model: A Literature Review. Australian Journal of Business and Management Research, 1(9), pp.124-127.
108. Cheng, H.Y. and Zhang, S.Q., 2017. Examining the relationship between holistic/analytic style and classroom learning behaviors of high school students. European Journal of Psychology of Education, 32(2), pp.271-288.
109. Cheng, M.T., Lin, Y.W., She, H.C. and Kuo, P.C., 2017. Is immersion of any value? Whether, and to what extent, game immersion experience during serious gaming affects science learning. British Journal of Educational Technology, 48(2), pp.246-263.

110. Cheng, P.H., Yang, Y.T.C., Chang, S.H.G. and Kuo, F.R.R., 2016. 5E mobile inquiry learning approach for enhancing learning motivation and scientific inquiry ability of university students. IEEE Transactions on Education, 59(2), pp.147-153.
111. Cheok, M.L. and Wong, S.L., 2015. Predictors of e-learning satisfaction in teaching and learning for school teachers: A literature review. International Journal of Instruction, 8(1), pp.75-90.
112. Cheung, R. and Vogel, D., 2013. Predicting user acceptance of collaborative technologies: An extension of the technology acceptance model for e-learning. Computers & Education, 63, pp.160-175.
113. Choi, E., Lindquist, R. and Song, Y., 2014. Effects of problem-based learning vs. traditional lecture on Korean nursing students' critical thinking, problem-solving, and self-directed learning. Nurse education today, 34(1), pp.52-56.
114. Choi, G. and Chung, H., 2013. Applying the technology acceptance model to social networking sites (SNS): Impact of subjective norm and social capital on the acceptance of SNS. International Journal of Human-Computer Interaction, 29(10), pp.619-628.
115. Chung-Yuan, H., Meng-Jung, T., Yu-Hsuan, C. and Liang, J.C., 2017. Surveying in-service teachers' beliefs about game-based learning and perceptions of technological pedagogical and content knowledge of games. Journal of Educational Technology & Society, 20(1), p.134.
116. Churchill, D. and Wang, T., 2014. Teacher's use of iPads in higher education. *Educational Media International*, *51*(3), pp.214-225.
117. Clark, R.C. and Mayer, R.E., 2016. E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning. John Wiley & Sons.
118. Clearwater, D., 2011. What defines video game genre? Thinking about genre study after the great divide. Loading..., 5(8).
119. Cohen, L., Manion, L. and Morrison, K., 2002. Research methods in education. routledge.
120. Conde, M.A., García-Peñalvo, F.J., Rodríguez-Conde, M.J., Alier, M., Casany, M.J. and Piguillem, J., 2014. An evolving Learning Management System for new educational environments using 2.0 tools. Interactive Learning Environments, 22(2), pp.188-204.
121. Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T. and Boyle, J.M., 2012. A systematic literature review of empirical evidence on computer games and serious games. Computers & Education, 59(2), pp.661-686.
122. Cooke, M. and Moyle, K., 2002. Students' evaluation of problem-based learning. Nurse Education Today, 22(4), pp.330-339.
123. Cooper, T. (2007). Nutrition game. In Proceedings of the Second Life education workshop (pp. 47-50).
124. Cowley, B., Fantato, M., Jennett, C., Ruskov, M., & Ravaja, N. (2014). Learning When Serious: Psychophysiological Evaluation of a Technology-Enhanced Learning Game. Journal of Educational Technology & Society, 17(1), 3-16.
125. Crocco, F., Offenholley, K. and Hernandez, C., 2016. A proof-of-concept study of game-based learning in higher education. Simulation & Gaming, 47(4), pp.403-422.
126. Croninger, R. G., Buese, D., & Larson, J. (2012). A Mixed-Methods Look at Teaching Quality: Challenges and Possibilities from One Study. Teachers College Record, 114(4), n4.
127. Csikszentmihalyi, M., 1990. The domain of creativity.

128. Csikszentmihalyi, Mihaly. Flow: The psychology of happiness. Random House, 2013.
129. Cviko, A., McKenney, S. and Voogt, J., 2014. Teacher roles in designing technology-rich learning activities for early literacy: A cross-case analysis. Computers & education, 72, pp.68-79.
130. D., Crombez, G., ... & De Bourdeaudhuij, I. (2014). A meta-analysis of serious digital games for healthy lifestyle promotion. Preventive medicine,69, 95-107.
131. D'Apice, C., Grieco, C., Liscio, L. and Piscopo, R., 2015. Design of an Educational Adventure Game to teach computer security in the working environment. In DMS (pp. 179-185).
132. Davies, P. J. & Hersh, R. (2012). The Mathematical Experience. Boston: Mifflin Company.
133. Davis Jr, F.D., 1986. A technology acceptance model for empirically testing new end-user information systems: Theory and results (Doctoral dissertation, Massachusetts Institute of Technology).
134. Davis, F. D. (1989). "Perceived usefulness, perceived ease of use, and user acceptance of information technologies." MIS Quarterly, 13(3), pp. 319–340.
135. De Freitas, S. and Oliver, M., 2006. How can exploratory learning with games and simulations within the curriculum be most effectively evaluated?. Computers & education, 46(3), pp.249-264.
136. De Freitas, S. I. (2006). Using games and simulations for supporting learning.Learning, media and technology, 31(4), 343-358.
137. De Paolis, L. T. (2012, July). Serious Game for Laparoscopic Suturing Training. In Complex, Intelligent and Software Intensive Systems (CISIS), 2012 Sixth International Conference on (pp. 481-485). IEEE.
138. De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J. and Pagés, C., 2014. An empirical study comparing gamification and social networking on e-learning. Computers & Education, 75, pp.82-91.
139. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the selfdetermination of behavior. Psychological Inquiry, 4, 227–268.
140. Denisova, A., Guckelsberger, C. and Zendle, D., 2017, May. Challenge in Digital Games: Towards Developing a Measurement Tool. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (pp. 2411-2419). ACM.
141. Deshpande, Y., Bhattacharya, S. and Yammiyavar, P., 2012, December. A behavioral approach to modeling Indian children's ability of adopting to e-learning environment. In IEEE 4th International Conference on Intelligent human computer interaction (IHCI), pp. 1-7.
142. DeSmet, A., Van Ryckeghem, D., Compernolle, S., Baranowski, T., Thompson, D., Crombez, G., Poels, K., Van Lippevelde, W., Bastiaensens, S., Van Cleemput, K. and Vandebosch, H., 2014. A meta-analysis of serious digital games for healthy lifestyle promotion. *Preventive medicine*, *69*, pp.95-107.
143. Dhindsa, H. S., & Shahrizal-Emran (2011). Using interactive whiteboard technology-rich constructivist learning environment to minimize gender differences in chemistry achievement. International Journal of Environmental & Science Education, 6 (4), 393-414.
144. Dickey, M. D. (2006). Girl gamers: The controversy of girl games and the relevance of female-oriented game design for instructional design. British journal of educational technology, 37(5), 785-793.

145. Dill, K. E., & Thill, K. P. (2007). Video game characters and the socialization of gender roles: Young people's perceptions mirror sexist media depictions. Sex roles, 57(11-12), 851-864.
146. Dix, A. J., Finlay, J., Abowd, G. D., & Beale, R. (2004). Human computer interaction (3rd ed.). Harlow, UK: Pearson Education Limited.
147. Domingo, M.G. and Garganté, A.B., 2016. Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom. Computers in Human Behavior, 56, pp.21-28.
148. Dougherty, K., 2015. Understanding Factors that Influence College Faculty in Deciding to Adopt Digital Technologies in their Practice (Doctoral dissertation, University of Ontario Institute of Technology (Canada)).
149. Dumitrache, A., & Almăşan, B. (2014). Educative Valences of Using Educational Games in Virtual Classrooms. Procedia-Social and Behavioral Sciences, 142, 769-773.
150. E. Adams, Fundamentals of game design. Pearson Education, 2013.
151. Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. Educational Psychologist, 44(2), 78–89.
152. Egenfeldt-Nielsen, S. (2007). Educational potential of computer games. New York: Continuum Press.
153. Ekundayo, H.T. and Kolawole, A.O., 2013. Stress among secondary school teachers in Ekiti State, Nigeria. *Journal of Educational and Social Research*, *3*(2), p.311.
154. El Saadawi, G.M., Tseytlin, E., Legowski, E., Jukic, D., Castine, M., Fine, J., Gormley, R. and Crowley, R.S., 2008. A natural language intelligent tutoring system for training pathologists: Implementation and evaluation. Advances in health sciences education, 13(5), pp.709-722.
155. El Saadawi, G.M., Tseytlin, E., Legowski, E., Jukic, D., Castine, M., Fine, J., Gormley, R. and Crowley, R.S., 2008. A natural language intelligent tutoring system for training pathologists: Implementation and evaluation. *Advances in health sciences education*, *13*(5), pp.709-722.
156. Elkaseh, A.M., Wong, K.W. and Fung, C.C., 2016. Perceived ease of use and perceived usefulness of social media for e-learning in Libyan higher education: A structural equation modeling analysis. International Journal of Information and Education Technology, 6(3), p.192.
157. Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. Psychological bulletin,136(1), 103.
158. Elyazgi, M., Nilashi, M., Ibrahim, O., Rayhan, A. and Elyazgi, S., 2016. Evaluating the Factors Influencing E-book Technology Acceptance among School Children Using TOPSIS Technique. Journal of Soft Computing and Decision Support Systems, 3(2), pp.11-25.
159. Eme-Uche Uche. 2006. Constraints To Teacher Education in Nigeria: A study of the Nigeria Certificate in Education. Facilities, 862(98.85), p.10.
160. Ertmer, P.A. and Newby, T.J., 2013. Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. Performance Improvement Quarterly, 26(2), pp.43-71.

161. Ertmer, P.A., 1999. Addressing first-and second-order barriers to change: Strategies for technology integration. Educational technology research and development, 47(4), pp.47-61.
162. Ertmer, P.A., Ottenbreit-Leftwich, A.T. and Tondeur, J., 2014. Teachers' beliefs and uses of technology to support 21st-century teaching and learning. International handbook of research on teacher beliefs, 403.
163. Estes, J.S., 2016. Teacher Preparation Programs and Learner-Centered, Technology-Integrated Instruction. Handbook of Research on Learner-Centered Pedagogy in Teacher Education and Professional Development, p.85.
164. Etikan, I., Musa, S.A. and Alkassim, R.S., 2016. Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1), pp.1-4.
165. Etuk, E.D. and Bello, D.O., (2015) CHALLENGES AND PROSPECTS OF MATHEMATICS EDUCATION IN NIGERIA. Journal of Assertiveness: ISSN, 2276, p.9684.
166. Fathema, N., Shannon, D. and Ross, M., 2015. Expanding the technology acceptance model (TAM) to examine faculty use of learning management systems (LMSs) in higher education institutions. Journal of Online Learning & Teaching, 11(2).
167. Federal Republic of Nigeria (2004) National Policy on education (4th Ed) agos: Federal Government Press.
168. Feierabend, S., & Rathgeb, T. (2006). KIM-Studie 2005 Kinder und Medien Computer und Internet. Basisuntersuchung zum Medienumgang.
169. Fennema, E. and Sherman, J.A., 1976. *Fennema-Sherman mathematics attitudes scale: Instruments designed to measure attitudes toward the learning of mathematics by females and males*. American Psychological Association.
170. Fennema, E., & Sherman, J. (1976). Fennema-Sherman Mathematics Attitudes Scales. JSAS Catalog of Selected Documents in Psychology, 6(1), 31
171. Fishbein, M. and Ajzen, I., 2011. Predicting and changing behavior: The reasoned action approach. Taylor & Francis.
172. FitzGibbon, A., Oldham, E., & Johnston, K. (2008). Are Irish student-teachers prepared to be agents of change in using IT in education?. In K. McFerrin et al. (Eds.), Proceedings of Society for Information Technology and Teacher Education International Conference 2008 (pp. 1397-1404). Chesapeake, VA: AACE.
173. Flanagan, B., Nestel, D., & Joseph, M. (2004). Making patient safety the focus: crisis resource management in the undergraduate curriculum. Medical education, 38(1), 56-66.
174. Fox, Christine M., and Jeanne H. Brockmyer. "The development of the game Engagement Questionnaire: A measure of engagement in video game playing: Response to reviews." Interacting with Computers (2013): iwt003.
175. Gabbiadini, A., Riva, P., Andrighetto, L., Volpato, C. and Bushman, B.J., 2016. Acting like a tough guy: Violent-sexist video games, identification with game characters, masculine beliefs, & empathy for female violence victims. PLoS one, 11(4), p.e0152121.
176. Games, L., 1990. The secret of monkey island. Plataforma: PC.
177. Garba, C.H. and Hamman-Tukur, A., 2015. Relationship between Mathematics Anxiety and Mathematics Achievement of Junior Secondary School Students in Maiduguri Metropolis, Borno State, Nigeria. *Journal of Educational Foundations*, *5*(1), pp.5-14.

178. Garneli, V., Giannakos, M. and Chorianopoulos, K., 2017. Serious games as a malleable learning medium: The effects of narrative, gameplay, and making on students' performance and attitudes. British Journal of Educational Technology, 48(3), pp.842-859
179. Garris, Rosemary, Robert Ahlers, and James E. Driskell. "Games, motivation, and learning: A research and practice model." Simulation & gaming 33.4 (2002): 441-467.
180. Garrity, M.K., Jones, K., VanderZwan, K.J., de la Rocha, A.B. and Epstein, I., 2014. Integrative review of blogging: implications for nursing education. Journal of Nursing Education.
181. Gee, J.P., 2003. What video games have to teach us about learning and literacy. Computers in Entertainment (CIE), 1(1), pp.20-20.
182. Gee, J.P., 2014. What video games have to teach us about learning and literacy. Macmillan.
183. Ghosh, S., Zafar, M.B., Bhattacharya, P., Sharma, N., Ganguly, N. and Gummadi, K., 2013, October. On sampling the wisdom of crowds: Random vs. expert sampling of the twitter stream. In Proceedings of the 22nd ACM international conference on Conference on information & knowledge management (pp. 1739-1744). ACM.
184. Girard, C., Ecalle, J. and Magnan, A., 2013. Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. Journal of Computer Assisted Learning, 29(3), pp.207-219.
185. Girard, C., Ecalle, J. and Magnan, A., 2013. Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. Journal of Computer Assisted Learning, 29(3), pp.207-219.
186. Glatthorn, A.A., Boschee, F., Whitehead, B.M. and Boschee, B.F., 2018. Curriculum leadership: Strategies for development and implementation. SAGE publications.
187. Global Games Market Report 2017 https://newzoo.com/insights/articles/the-global-games-market-will-reach-108-9-billion-in-2017-with-mobile-taking-42/
188. Graesser, A.C., 2017. Reflections on Serious Games. In Instructional Techniques to Facilitate Learning and Motivation of Serious Games (pp. 199-212). Springer International Publishing.
189. Graesser, Arthur, Patrick Chipman, Frank Leeming, and Suzanne Biedenbach. "Deep learning and emotion in serious games." Serious games: Mechanisms and effects (2009): 81-100.
190. Granic, I., Lobel, A. and Engels, R.C., 2014. The benefits of playing video games. American Psychologist, 69(1), p.66.
191. Granic, I., Lobel, A. and Engels, R.C., 2014. The benefits of playing video games. American Psychologist, 69(1), p.66.
192. Gravemeijer, K., Stephan, M., Julie, C., Lin, F.L. and Ohtani, M., 2017. What Mathematics Education May Prepare Students for the Society of the Future?. *International Journal of Science and Mathematics Education*, *15*(1), pp.105-123.
193. Greenfield, P.M., 2014. Mind and media: The effects of television, video games, and computers. Psychology Press.
194. Greitemeyer, T., Traut-Mattausch, E. and Osswald, S., 2012. How to ameliorate negative effects of violent video games on cooperation: Play it cooperatively in a team. Computers in Human Behavior, 28(4), pp.1465-1470.

195. Grimley, Michael, Richard Green, Trond Nilsen, David Thompson, and Russell Tomes. "Using computer games for instruction: The student experience." Active Learning in Higher Education 12, no. 1 (2011): 45-56.
196. Gros, B., 2007. Digital games in education: The design of games-based learning environments. Journal of research on technology in education, 40(1), pp.23-38.
197. Grüsser, S. M., Thalemann, R., & Griffiths, M. D. (2006). Excessive computer game playing: evidence for addiction and aggression?. CyberPsychology & Behavior, 10(2), 290-292.
198. Gugerell, K., & Zuidema, C. (2017). Gaming for the energy transition. Experimenting and learning in co-designing a serious game prototype. Journal of Cleaner Production, 169, 105–116.
199. Gurpinar, E., Kulac, E., Tetik, C., Akdogan, I. and Mamakli, S., 2013. Do learning approaches of medical students affect their satisfaction with problem-based learning?. Advances in physiology education, 37(1), pp.85-88.
200. Hakulinen, L., Auvinen, T., & Korhonen, A. (2015). The effect of achievement badges on students' behavior: An empirical study in a university-level computer science course. International Journal of Emerging Technologies in Learning (IJET), 10(1), 18–29.
201. Hamari, J. and Nousiainen, T., 2015, January. Why do teachers use game-based learning technologies? The role of individual and institutional ICT readiness. In System Sciences (HICSS), 2015 48th Hawaii International Conference on (pp. 682-691). IEEE.
202. Hamari, J., Shernoff, D.J., Rowe, E., Coller, B., Asbell-Clarke, J. and Edwards, T., 2016. Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. Computers in Human Behavior, 54, pp.170-179.
203. Hammond, M., 2014. Introducing ICT in schools in England: Rationale and consequences. British Journal of Educational Technology, 45(2), pp.191-201.
204. Harlen, W. (2017). The teaching of science in primary schools. David Fulton Publishers.
205. Harrison, C., Tomás, C. and Crook, C., 2014. An e-maturity analysis explains intention–behavior disjunctions in technology adoption in UK schools. Computers in Human Behavior, 34, pp.345-351.
206. Hartmann, T., & Klimmt, C. (2006). Gender and computer games: Exploring females' dislikes. Journal of Computer-Mediated Communication, 11(4), 910-931.
207. Harviainen, J.T., Lainema, T. and Saarinen, E., 2014. Player-reported impediments to game-based learning. Transactions of the Digital Games Research Association, 1(2).
208. Hassan, S. and Shu'aibu, B., 2015. PERCEIVED TECHNOLOGY USE IN CLASSROOM INSRUCTIONS BY TECHNICAL TEACHERS IN NORTH-EAST NIGERIA. ATBU Journal of Science, Technology and Education, 3(2), pp.132-138.
209. Hepp, P., Hinostroza, E., Laval, E. and Rehbein, L., 2004. Technology in schools: Education, ICT and the knowledge society (pp. 30-47). World Bank, Distance & Open Learning and ICT in Education Thematic Group, Human Development Network, Education.
210. Hewitt, P.G. (2002). Conceptual physics with practicing physics workbook.. NY: Benjamin Cummings.
211. Hoffmann, L. (2002). Promoting girls' interest and achievement in physics classes for beginners. Learning and Instruction, 12, 447–465.

212. Hollingdale, J. and Greitemeyer, T., 2014. The effect of online violent video games on levels of aggression. PLoS one, 9(11), p.e111790.
213. Homer, B.D., Hayward, E.O., Frye, J. and Plass, J.L., 2012. Gender and player characteristics in video game play of preadolescents. Computers in Human Behavior, 28(5), pp.1782-1789.
214. Hookham, G., Nesbitt, K. and Kay-Lambkin, F., 2016, February. Comparing usability and engagement between a serious game and a traditional online program. In Proceedings of the Australasian Computer Science Week Multiconference (p. 44). ACM.
215. Hsia, J.W., Chang, C.C. and Tseng, A.H., 2014. Effects of individuals' locus of control and computer self-efficacy on their e-learning acceptance in high-tech companies. Behaviour & Information Technology, 33(1), pp.51-64.
216. Hsu, S.H., Wen, M.H., Wu, M.C. (2007) Exploring design features for enhancing players challenge in strategy games. Cyberpsychology & Behaviour 10 (3), 393-397
217. Hsu, T.C., 2017. Learning English with augmented reality: Do learning styles matter?. Computers & Education, 106, pp.137-149.
218. Hu, P.J.H., Clark, T.H. and Ma, W.W., 2003. Examining technology acceptance by school teachers: a longitudinal study. Information & management, 41(2), pp.227-241.
219. Hu, X. and Yelland, N., 2017. An investigation of preservice early childhood teachers' adoption of ICT in a teaching practicum context in Hong Kong. Journal of Early Childhood Teacher Education, 38(3), pp.259-274.
220. Huang, Y.M., 2016. The factors that predispose students to continuously use cloud services: Social and technological perspectives. Computers & Education, 97, pp.86-96.
221. Hung, D. & Chen, D. (2002). Two kinds of scaffolding: The dialectical process within the authenticity-generalizability (A-G) continuum. Education Technology & Society, 5(4), 148-153.
222. Hwang, G. J., Wu, P. H., & Chen, C. C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. Computers & Education, 59(4), 1246-1256.
223. Hwang, G.J., Lai, C.L. and Wang, S.Y., 2015. Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies. Journal of Computers in Education, 2(4), pp.449-473.
224. Idowu, O.O., 2016. An Investigation of Mathematics Performance of High School Students in Lagos state, Nigeria: External Factors. Urban Education Research and Policy Annuals, 4(1).
225. Ifenthaler, D. and Schweinbenz, V., 2013. The acceptance of Tablet-PCs in classroom instruction: The teachers' perspectives. Computers in Human Behavior, 29(3), pp.525-534.
226. Igbokwe, C. O. (2015). Recent curriculum reforms at the basic education level in Nigeria aimed at catching them young to create change. American Journal of Educational Research, 3(1), 31–37.
227. Isiyaku, D.D., Ayub, M.A.F. and AbdulKadir, S., 2018. Antecedents to teachers' perceptions of the usefulness of ICTs for business education classroom instructions in Nigerian tertiary institutions. Asia Pacific Education Review, pp.1-16.
228. Ivory, J. D. (2006). Still a man's game: Gender representation in online reviews of video games. Mass Communication & Society, 9(1), 103-114.

229. Jackson, K., Cobb, P., Wilson, J., Webster, M., Dunlap, C., & Appelgate, M. (2015). Investigating the development of mathematics leaders' capacity to support teachers' learning on a large scale. ZDM, 47(1), 93–104.
230. Jahnke, I. and Kumar, S., 2014. Digital didactical designs: Teachers' integration of iPads for learning-centered processes. Journal of Digital Learning in Teacher Education, 30(3), pp.81-88.
231. Jansz, J. (2005). The emotional appeal of violent video games for adolescent males. Communication Theory, 15(3), 219-241.
232. Jarmon, L., Traphagan, T., & Mayrath, M. (2008). Understanding project-based learning in Second Life with a pedagogy, training, and assessment trio. Educational Media International, 45(3), 157-176.
233. Jennett, C., Cox, A.L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T. and Walton, A., 2008. Measuring and defining the experience of immersion in games. International journal of human-computer studies, 66(9), pp.641-661.
234. Jennett, Charlene, Anna L. Cox, Paul Cairns, Samira Dhoparee, Andrew Epps, Tim Tijs, and Alison Walton. "Measuring and defining the experience of immersion in games." International journal of human-computer studies 66, no. 9 (2008): 641-661.
235. Jin, J. and Bridges, S.M., 2014. Educational technologies in problem-based learning in health sciences education: a systematic review. Journal of medical internet research, 16(12), p.e251.
236. John, S.P., 2015. The integration of information technology in higher education: A study of faculty's attitude towards IT adoption in the teaching process. Contaduría y Administración, 60, pp.230-252.
237. Jones A. 2017. The best games of 2017: Life is Strange: Before the Storm. Available: https://www.pcgamesn.com/life-is-strange-before-the-storm/the-best-games-of-2017-life-is-strange-before-the-storm [Accessed 15/08/2017]
238. Kamba, M.A., 2008. Problems, challenges and benefits of implementing e-learning in Nigerian universities: An empirical study. International Journal of Emerging Technologies in Learning (iJET), 4(1), pp.66-69.
239. Kankaanranta, M., Koivula, M., Laakso, M.L. and Mustola, M., 2017. Digital Games in Early Childhood: Broadening Definitions of Learning, Literacy, and Play. In Serious Games and Edutainment Applications (pp. 349-367). Springer International Publishing.
240. Kapp, K. M. (2012). The gamification of learning and instruction: game-based methods and strategies for training and education. John Wiley & Sons.
241. Karue, N. and Amukowa, W., 2013. Analysis of factors that lead to poor performance in Kenya certificate of secondary examination in Embu District in Kenya. *The international journal of social sciences (TIJOSS)*, *13*(1).
242. Kato, P. M. (2010). Video games in health care: Closing the gap. Review of General Psychology, 14(2), 113.
243. Kelle, S., Klemke, R. and Specht, M., 2013. Effects of game design patterns on basic life support training content. Educational Technology & Society, 16(1), pp.275-285.
244. Keller, J. M. (2009). Motivational design for learning and performance: The ARCS model approach. Springer Science & Business Media.
245. Keller, J.M., 1987. Development and use of the ARCS model of instructional design. Journal of instructional development, 10(3), pp.2-10.
246. Kemp, J., & Livingstone, D. (2006, August). Putting a Second Life "metaverse" skin on learning management systems. In Proceedings of the Second Life

education workshop at the Second Life community convention (Vol. 20). CA, San Francisco: The University of Paisley.
247. Kennedy-Clark, S., 2011. Pre-service teachers' perspectives on using scenario-based virtual worlds in science education. Computers & Education, 57(4), pp.2224-2235.
248. Kenney-Benson, G., Pomerantz, E., Ryan, A., & Patrick, H. (2006). Sex differences in math performance: The role of children's approach to schoolwork. Developmental Psychology, 42, 11–26.
249. Kerawalla, Lucinda, and Charles Crook. "From promises to practices: The fate of educational software in the home." Technology, Pedagogy and Education 14, no. 1 (2005): 107-125.
250. Kerawalla, Lucinda, and Charles Crook. "From promises to practices: The fate of educational software in the home." Technology, Pedagogy and Education 14, no. 1 (2004): 107-124.
251. Ketelhut, D.J. and Schifter, C.C., 2011. Teachers and game-based learning: Improving understanding of how to increase efficacy of adoption. Computers & Education, 56(2), pp.539-546.
252. Khan, A., Ahmad, F.H. and Malik, M.M., 2017. Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. Education and Information Technologies, 22(6), pp.2767-2804.
253. Khan, H.U., Artail, H.A., Malik, Z. and Niazi, M., 2014, August. Information technology adoption, possible challenges, and framework of supply chain management: a case study of a leading gulf economy. In Engineering Technology and Technopreneuship (ICE2T), 2014 4th International Conference on (pp. 1-5). IEEE.
254. Khenissi, M.A., Essalmi, F., Jemni, M., Graf, S. and Chen, N.S., 2016. Relationship between learning styles and genres of games. Computers & Education, 101, pp.1-14.
255. Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. The Internet and higher education, 8(1), 13-24.
256. King, W.R. and He, J., 2006. A meta-analysis of the technology acceptance model. Information & management, 43(6), pp.740-755.
257. Kirby, P. (2004). A guide to actively involving young people in research. Involve. Accessed April, 30, 2015.
258. Kirriemuir, J. and McFarlane, A., 2004. Literature review in games and learning.
259. Kislenko, K., Grevholm, B. and Lepik, M., 2007. Mathematics is important but boring: students' beliefs and attitudes towards mathematics. In Nordic Conference on Mathematics Education: 02/09/2005-06/09/2005 (pp. 349-360). Tapir Academic Press.
260. Klarkowski, M., Johnson, D., Wyeth, P., McEwan, M., Phillips, C. and Smith, S., 2016, May. Operationalising and evaluating sub-optimal and optimal play experiences through challenge-skill manipulation. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (pp. 4483-4494). ACM.
261. Klimmt, C. and Hartmann, T., 2006. Effectance, self-efficacy, and the motivation to play video games. Playing video games: Motives, responses, and consequences, pp.133-145.
262. Koehler, M.J., Mishra, P. and Yahya, K., 2007. Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. Computers & Education, 49(3), pp.740-762.

263. Koivisto, J.M., Niemi, H., Multisilta, J. and Eriksson, E., 2017. Nursing students' experiential learning processes using an online 3D simulation game. Education and Information Technologies, 22(1), pp.383-398.
264. Kongmee, I., Strachan, R., Pickard, A. and Montgomery, C., 2012. A case study of using online communities and virtual environment in massively multiplayer role playing games (MMORPGs) as a learning and teaching tool for second language learners. International Journal of Virtual and Personal Learning Environments (IJVPLE), 3(4), pp.1-15.
265. Kriek, J. and Stols, G., 2010. Teachers' beliefs and their intention to use interactive simulations in their classrooms. South African Journal of Education, 30(3), pp.0-0.
266. Krueger, R.A. and Casey, M.A., 2000. Overview of focus groups. Focus groups: a practical guide for applied research, pp.3-19.
267. Kwache, P.Z., 2007. The imperatives of information and communication technology for teachers in Nigeria higher education. MERLOT Journal of Online learning and teaching, 3(4), pp.359-399.
268. Laerd. (n.d.). Purposive sampling | Lærd Dissertation. Retrieved May 2, 2018, from http://dissertation.laerd.com/purposive-sampling.php
269. Lane, S., 2016. Promoting Collaborative Learning among Students. American Journal of Educational Research, 4(8), pp.602-607.
270. Lateef, F., 2010. Simulation-based learning: Just like the real thing. Journal of Emergencies, Trauma and Shock, 3(4), p.348.
271. Lawrence, J.E. and Tar, U.A., 2018. Factors that influence teachers' adoption and integration of ICT in teaching/learning process. Educational Media International, 55(1), pp.79-105.
272. Lazarides, R., Rohowski, S., Ohlemann, S., & Ittel, A. (2015). The role of classroom characteristics for students' motivation and career exploration. Educational Psychology, 1-17.
273. Lee, D.Y. and Lehto, M.R., 2013. User acceptance of YouTube for procedural learning: An extension of the Technology Acceptance Model. Computers & Education, 61, pp.193-208.
274. Lee, E. and Hannafin, M.J., 2016. A design framework for enhancing engagement in student-centered learning: Own it, learn it, and share it. Educational Technology Research and Development, 64(4), pp.707-734.
275. Lee, Y. and Lee, J., 2014. Enhancing pre-service teachers' self-efficacy beliefs for technology integration through lesson planning practice. Computers & Education, 73, pp.121-128.
276. Leemkuil, H., de Jong, T., de Hoog, R., & Christoph, N. (March, 2003). KM QUEST: A collaborative Internet-based simulation game. Simulation & Gaming, 31(1), 89-111.
277. Lekalakala-Mokgele, E., 2010. Facilitation in problem-based learning: Experiencing the locus of control. Nurse Education Today, 30(7), pp.638-642.
278. Lemmens, J.S. and Hendriks, S.J., 2016. Addictive online games: Examining the relationship between game genres and internet gaming disorder. Cyberpsychology, Behavior, and Social Networking, 19(4), pp.270-276.
279. Lepper, M.R. and Henderlong, J., 2000. Turning" play" into" work" and" work" into" play": 25 years of research on intrinsic versus extrinsic motivation.
280. Li, N., & Kirkup, G. (2007). Gender and cultural differences in internet use: A study of China and the UK. Computers & Education, 48 (2), 301.

281. Lin, H. and Wang, H., 2014. Avatar creation in virtual worlds: Behaviors and motivations. Computers in Human Behavior, 34, pp.213-218.
282. Lin, K.M. (2011), "E-learning continuance intention: moderating effects of user e-learning experience", Computers & Education, Vol. 56 No. 2, pp. 515-526.
283. Liu, S.H., 2011. Factors related to pedagogical beliefs of teachers and technology integration. Computers & Education, 56(4), pp.1012-1022.
284. Lomas, D., Patel, K., Forlizzi, J.L. and Koedinger, K.R., 2013, April. Optimizing challenge in an educational game using large-scale design experiments. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 89-98). ACM.
285. Lu, J., Meng, S. and Tam, V., 2014. Learning Chinese characters via mobile technology in a primary school classroom. Educational Media International, 51(3), pp.166-184.
286. Lucas, K., & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. Communication Research, 31(5), 499-523.
287. Lunce, L. M. (2006). Simulations: Bringing the benefits of situated learning to the traditional classroom. Journal of Applied Educational Technology, 3(1), 37-45.
288. Lynch, T., Tompkins, J.E., van Driel, I.I. and Fritz, N., 2016. Sexy, strong, and secondary: A content analysis of female characters in video games across 31 years. Journal of Communication, 66(4), pp.564-584.
289. Lyons, E.J., 2015. Cultivating engagement and enjoyment in exergames using feedback, challenge, and rewards. Games for health journal, 4(1), pp.12-18.
290. Ma, J., Tucker, C.S., Okudan Kremer, G.E. and Jackson, K.L., 2017. Exposure to Digital and Hands-on Delivery Modes in Engineering Design Education and Their Impact on Task Completion Efficiency. Journal of Integrated Design and Process Science, (Preprint), pp.1-18.
291. Macnab, D.S. and Payne, F., 2003. Beliefs, attitudes and practices in mathematics teaching: Perceptions of Scottish primary school student teachers. Journal of Education for teaching, 29(1), pp.55-68.
292. Mahmoudi, H., Koushafar, M., Saribagloo, J.A. and Pashavi, G., 2015. The effect of computer games on speed, attention and consistency of learning mathematics among students. Procedia-Social and Behavioral Sciences, 176, pp.419-424.
293. Makki, T.W., O'Neal, L.J., Cotten, S.R. and Rikard, R.V., 2018. When first-order barriers are high: A comparison of second-and third-order barriers to classroom computing integration. Computers & Education.
294. Malegiannaki, I. and Daradoumis, T., 2017. Analyzing the educational design, use and effect of spatial games for cultural heritage: A literature review. Computers & Education, 108, pp.1-10.
295. Maliki, A. E., Ngban, A. N., & Ibu, J. E. (2009). Analysis of students performance in junior secondary school mathematics examination in Bayelsa State of Nigeria. Student Communication Science, 3(2), 131-134.
296. Malone, Thomas W. "What makes things fun to learn? A study of intrinsically motivating computer games." Pipeline 6, no. 2(1981): 40.
297. Manches, A. and Plowman, L., 2017. Computing education in children's early years: A call for debate. British Journal of Educational Technology, 48(1), pp.191-201.
298. Mansfield, S. (2006). Keeping a critically reflexive research journal. University of Dundee, UK.

299. Marangunić, N. and Granić, A., 2015. Technology acceptance model: a literature review from 1986 to 2013. Universal Access in the Information Society, 14(1), pp.81-95.
300. Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). STEM: country comparisons: international comparisons of science, technology, engineering and mathematics (STEM) education. Final report. Australian Council of Learned Academies.
301. Martinovic, Dragana, Gerald H. Burgess, Chantal M. Pomerleau, and Cristina Marin. "Computer games that exercise cognitive skills: What makes them engaging for children?." Computers in Human Behavior 60 (2016): 451-462.
302. Martinovic, Dragana, Gerald H. Burgess, Chantal M. Pomerleau, and Cristina Marin. "Computer games that exercise cognitive skills: What makes them engaging for children?." Computers in Human Behavior 60 (2016): 441-462.
303. Marut, M.J. (2002). Numerical analysis Unpublished lecture notes in Mathematics. .Faculty of Natural Sciences, University of Jos, Jos, Nigeria.
304. Mathieu Loiseau, Elise Lavou´e, Jean-Charles Marty, S´ebastien George. Raising awareness on Archaeology: A Multiplayer Game-Based Approach with Mixed Reality. 7th European Conference on Games Based Learning (ECGBL 2013), Oct 2013, Porto, Portugal. pp.336-343, 2013.
305. Matthew, I.A., 2013. Provision of secondary education in Nigeria: Challenges and way forward. *Journal of African Studies and Development*, *5*(1), pp.1-9.
306. Maxwell, C.E. and Maxwell, E.M., 2014. Gender Differences in Digital Literacy Among Undergraduate Students of Faculty of Education, Kogi State University: Implications For E-Resources & Library Use. Advances in Social Sciences Research Journal, 1(7), pp.96-108.
307. Mayer, V. (2003). Living telenovelas/telenovelizing life: Mexican American girls' identities and transnational telenovelas. Journal of Communication, 53(3), 479-495.
308. Mbah, L.U (2015). The ideal mathematics teacher in the new millennium.A seminar paper presentation. Plateau Private School, Jos,10th June
309. Mbugua, Z.K., Kibet, K., Muthaa, G.M. and Nkonke, G.R., 2012. Factors contributing to students' poor performance in mathematics at Kenya certificate of secondary education in Kenya: A case of Baringo county, Kenya. American International Journal of Contemporary Research, 2(6), pp.87-91.
310. McCambridge, J., Witton, J. and Elbourne, D.R., 2014. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. Journal of clinical epidemiology, 67(3), pp.267-277.
311. McKernan, B., Martey, R.M., Stromer-Galley, J., Kenski, K., Clegg, B.A., Folkestad, J.E., Rhodes, M.G., Shaw, A., Saulnier, E.T. and Strzalkowski, T., 2015. We don't need no stinkin'badges: The impact of reward features and feeling rewarded in educational games. Computers in Human Behavior, 45, pp.299-306.
312. Mehm, F., Göbel, S. and Steinmetz, R., 2013. An authoring tool for educational adventure games: concept, game models and authoring processes. International Journal of Game-Based Learning (IJGBL), 3(1), pp.63-79.
313. Meluso, A., Zheng, M., Spires, H. A., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. Computers & Education, 59(2), 497-504.
314. Mennecke, B., Roche, E. M., Bray, D. A., Konsynski, B., Lester, J., Rowe, M., & Townsend, A. M. (2007, December). Second Life and other virtual worlds: A

roadmap for research. In 28th International Conference on Information Systems (ICIS).
315. Merhi, O., Faugloire, E., Flanagan, M., & Stoffregen, T. A. (2007). Motion sickness, console video games, and head-mounted displays. Human Factors: The Journal of the Human Factors and Ergonomics Society, 49(5), 920-934.
316. Mirzajani, H., Mahmud, R., Fauzi Mohd Ayub, A. and Wong, S.L., 2016. Teachers' acceptance of ICT and its integration in the classroom. Quality Assurance in Education, 24(1), pp.26-40.
317. Mishra, D., Akman, I. and Mishra, A., 2014. Theory of reasoned action application for green information technology acceptance. Computers in human behavior, 36, pp.29-40.
318. Mohamed, L., & Waheed, H. (2011). Secondary students' attitude towards mathematics in a selected school of Maldives. International Journal of Humanities and Social Science, 1(15), 277–281.
319. Moser, S., 2016. Linking Virtual and Real-life Environments: Scrutinizing Ubiquitous Learning Scenarios. Digital Tools for Seamless Learning, p.214.
320. Mun, Y.Y. and Hwang, Y., 2003. Predicting the use of web-based information systems: self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model. International journal of human-computer studies, 59(4), pp.431-449.
321. Mundy J. 2017. Technobabylon review - A Gripping Point-And-Click Sci-Fi. Available:http://www.pocketgamer.co.uk/r/iPad/Technobabylon/review.asp?c=75046
322. Murphy, C., Scantlebury, K. and Milne, C., 2015. Using Vygotsky's zone of proximal development to propose and test an explanatory model for conceptualising coteaching in pre-service science teacher education. Asia-Pacific Journal of Teacher Education, 43(4), pp.281-295.
323. Nair, I. and Das, V.M., 2012. Using Technology Acceptance Model to assess teachers' attitude towards use of technology as teaching tool: A SEM Approach. METHODOLOGY, 42(2).
324. Nair, I. and Mukunda Das, V., 2012. Using Technology Acceptance Model to assess teachers' attitude towards use of technology as teaching tool: a SEM Approach. International Journal of Computer Applications, 42(2), pp.1-6.
325. Ndujihe C. 2018. https://www.vanguardngr.com/2018/04/education-free-fall/
326. Nerdc. (2018). NERDC in brief. NERDC
327. Newman, J., 2013. Videogames. Routledge.
328. Ng, E.M., Shroff, R.H. and Lim, C.P., 2013. Applying a Modified Technology Acceptance Model to Qualitatively Analyse the Factors Affecting E-Portfolio Implementation for Student Teachers' in Field Experience Placements. Issues in Informing Science & Information Technology, 10, pp.355-365.
329. Nikolic, D., Lee, S., Messner, J.I. and Anumba, C., 2010. The virtual construction simulator: Evaluating an educational simulation application for teaching construction management concepts.
330. Nishikawa, K.A. and Jaeger, J., 2011. A computer simulation comparing the incentive structures of dictatorships and democracies. Journal of Political Science Education, 7(2), pp.135-142.
331. Njoku, L. (2018). Nigerians are receiving expired education, says U.S. varsity VC. Retrieved September 6, 2018, from https://guardian.ng/news/nigerians-are-receiving-expired-education-says-u-s-varsity-vc/

332. Ødegaard, M., Haug, B., Mork, S.M. and Sørvik, G.O., 2014. Challenges and support when teaching science through an integrated inquiry and literacy approach. International Journal of Science Education, 36(18), pp.2997-3020.
333. Ogundele, M.O., Gyang, T.S. and Sambo, A.M., 2015. Lecturers' Digital Literacy and Academic Goals Achievement of Plateau State Tertiary Institutions, Nigeria.
334. Ojimba, D.P., 2012. Strategies for Teaching and Sustaining Mathematics as an Indispensable Tool for Technological Development in Nigeria. Medaterranean Journal of Social Sciences, 3(15), pp.74-79.
335. Okafor, C.F. and Anaduaka, U.S., 2013. Nigerian school children and mathematics phobia: How the mathematics teacher can help. American Journal of Educational Research, 1(7), pp.247-251.
336. Okafor, C.F. and Anaduaka, U.S., 2013. Nigerian school children and mathematics phobia: How the mathematics teacher can help. American Journal of Educational Research, 1(7), pp.247-251.
337. Okafor, C.F. and Anaduaka, U.S., 2013. Nigerian school children and mathematics phobia: How the mathematics teacher can help. *American Journal of Educational Research*, *1*(7), pp.247-251.
338. Olgan, R., 2015. Influences on Turkish early childhood teachers' science teaching practices and the science content covered in the early years. Early Child Development and Care, 185(6), pp.926-942.
339. Oluwatumbi, O.S. and Olubunmi, A.V., 2017. AVAILABILITY AND UTILIZATION OF INTERNET FACILITIES AMONG UNDERGRADUATE STUDENTS OF COLLEGES OF EDUCATION NIGERIA. British Journal of Education, 5(9), pp.100-107.
340. Omeje, C. (2017). Private schools dump 'outdated, irrelevant' Nigerian curriculum for UK, US versions. Retrieved September 6, 2018, from https://www.icirnigeria.org/private-schools-dump-outdated-irrelevant-nigerian-curriculum-for-uk-us-versions/
341. Orvis, K.A., Horn, D.B., Belanich, J., (2008) The roles of task difficulty and prior videogame experience on performance and motivation in instructional videogames. Computers in Human Behaviour 24 (4), 2414-2433
342. Osafrehinti, I.Q., 1986. The problem of Mthematics Education in Nigeria, any solution. Journal of STAN, 24(1), pp.274-279.
343. Osang, F.B., Ngole, J. and Tsuma, C., 2013, February. Prospects and Challenges of Mobile Learning Implementation in Nigeria. Case Study National Open University of Nigeria NOUN. In International Conference on ICT for Africa (pp. 20-23).
344. Ovide, S., & Rusli, E. M. (2014, September 15). Microsoft gets 'Minecraft' - Not the Founders. Retrieved from The Wall Street Journal: http://www.wsj.com/articles/microsoft-agrees-to-acquire-creator-of-minecraft-1410786190
345. Oyedeji O. 2016. 2017 Budget: Again, Nigeria fails to meet UN benchmark on education. Available: https://www.premiumtimesng.com/news/top-news/218097-2017-budget-nigeria-fails-meet-un-benchmark-education.html [Accessed 16/02/2017]
346. Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N. and Hoagwood, K., 2015. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Administration and Policy in Mental Health and Mental Health Services Research, 42(5), pp.533-544.

347. Palloff, R.M. and Pratt, K., 2003. *The virtual student: A profile and guide to working with online learners*. John Wiley & Sons.
348. Panoutsopoulos, Hercules, and Demetrios G. Sampson. "A Study on Exploiting Commercial Digital Games into School Context." Educational Technology & Society 14, no. 1 (2012): 14-27.
349. Pareja Roblin, N., Tondeur, J., Voogt, J., Bruggeman, B., Mathieu, G. and van Braak, J., 2018. Practical considerations informing teachers' technology integration decisions: the case of tablet PCs. Technology, Pedagogy and Education, pp.1-17.
350. Park, S.Y., 2009. An analysis of the technology acceptance model in understanding university students' behavioral intention to use e-learning. Educational technology & society, 12(3), pp.150-162.
351. Park, S.Y., Nam, M.W. and Cha, S.B., 2012. University students' behavioral intention to use mobile learning: Evaluating the technology acceptance model. British Journal of Educational Technology, 43(4), pp.592-605.
352. Parker, B. C., & Myrick, F. (2009). A critical examination of high-fidelity human patient simulation within the context of nursing pedagogy. Nurse Education Today, 29(3), 322-329.
353. Patton, M. Q. (2002). Qualitative research and evaluation methods (3rd ed.). Thousand Oaks, CA: Sage.
354. Pellegrini, A.D., 2011. The Oxford handbook of the development of play. Oxford University Press, USA.
355. Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. American Educational Research Journal, 44(4), 921–958.
356. Pepin, B., Gueudet, G., & Trouche, L. (2017). Refining teacher design capacity: Mathematics teachers' interactions with digital curriculum resources. ZDM, 49(5), 799–812.
357. Perrotta, C., Featherstone, G., Aston, H. and Houghton, E., 2013. Game-based learning: Latest evidence and future directions. NFER Research Programme: Innovation in Education. Slough: NFER.
358. Perry, S.M., Catapano, M. and Ramon, O.G., 2016. Teaching, Academic Achievement, and Attitudes toward Mathematics in the United States and Nigeria. Journal for Leadership and Instruction, 15(2), pp.5-12.
359. Peter Twining. (2010) Virtual Worlds and Education. Educational Research 52:2, pages 117-122
360. Petri, G. and von Wangenheim, C.G., 2016. How to Evaluate Educational Games: a Systematic. Journal of Universal Computer Science, 22(7), pp.992-1021.
361. Petty, G., 2004. Teaching today: A practical guide. Nelson Thornes.
362. Pickard, A., 2012. Research methods in information. Facet publishing.
363. Pietri, E.S., Moss-Racusin, C.A., Dovidio, J.F., Guha, D., Roussos, G., Brescoll, V.L. and Handelsman, J., 2017. Using Video to Increase Gender Bias Literacy Toward Women in Science. Psychology of Women Quarterly, 41(2), pp.175-196.
364. Plump, C.M. and LaRosa, J., 2017. Using Kahoot! in the classroom to create engagement and active learning: a game-based technology solution for elearning novices. Management Teaching Review, 2(2), pp.151-158.
365. Podolefsky, N.S., Moore, E.B. and Perkins, K.K., 2013. Implicit scaffolding in interactive simulations: Design strategies to support multiple educational goals. arXiv preprint arXiv:1306.6544.

366. Pombo, L., Marques, M.M., Carlos, V., Guerra, C., Lucas, M. and Loureiro, M.J., 2017, June. Augmented Reality and Mobile Learning in a Smart Urban Park: Pupils' Perceptions of the EduPARK Game. In Conference on Smart Learning Ecosystems and Regional Development (pp. 90-100). Springer, Cham.
367. Poonnawat, W., Lehmann, P. and Connolly, T., 2015, September. Teaching Business Intelligence With a Business Simulation Game. In ECGBL2015-9th European Conference on Games Based Learning: ECGBL2015 (p. 439). Academic Conferences and publishing limited.
368. Porter, W.W., Graham, C.R., Bodily, R.G. and Sandberg, D.S., 2016. A qualitative analysis of institutional drivers and barriers to blended learning adoption in higher education. The internet and Higher education, 28, pp.17-27.
369. Potosky, D. and Bobko, P., 2001. A model for predicting computer experience from attitudes toward computers. Journal of Business and Psychology, 15(3), pp.391-404.
370. Prensky, M. (2010). Playing games in School: Video Games and Simulations for Primary and Secondary Education. Atsusi "2c" Hirumi. Washington, DC: International Society for Technology in Education.
371. Prensky, Marc. "Types of learning and possible game styles." Digital Game-Based Learning (2001).
372. Prion, S. and Haerling, K.A., 2014. Making sense of methods and measurement: Pearson product-moment correlation coefficient. Clinical simulation in nursing, 10(11), pp.587-588.
373. Purcell, K., Heaps, A., Buchanan, J. and Friedrich, L., 2013. How teachers are using technology at home and in their classrooms. Washington, DC: Pew Research Center's Internet & American Life Project.
374. Qian, M. and Clark, K.R., 2016. Game-based Learning and 21st century skills: A review of recent research. Computers in Human Behavior, 63, pp.50-58.
375. Rachel Pancare (2017) How Do Bright Colors Appeal to Kids. Available https://sciencing.com/do-bright-colors-appeal-kids-5476948.html [Accessed 15/07/2017]
376. Ramasundaram, V., Grunwald, S., Mangeot, A., Comerford, N.B. and Bliss, C.M., 2005. Development of an environmental virtual field laboratory. Computers & Education, 45(1), pp.21-34.
377. Rashid, T. and Asghar, H.M., 2016. Technology use, self-directed learning, student engagement and academic performance: Examining the interrelations. Computers in Human Behavior, 63, pp.604-612.
378. Rehbein, F., Kliem, S., Baier, D., Mößle, T. and Petry, N.M., 2015. Prevalence of internet gaming disorder in German adolescents: diagnostic contribution of the nine DSM-5 criteria in a state-wide representative sample. Addiction, 110(5), pp.842-851.
379. Rehbein, F., Staudt, A., Hanslmaier, M. and Kliem, S., 2016. Video game playing in the general adult population of Germany: Can higher gaming time of males be explained by gender specific genre preferences?. Computers in Human Behavior, 55, pp.729-735.
380. Reid, P., 2014. Categories for barriers to adoption of instructional technologies. Education and Information Technologies, 19(2), pp.383-407.
381. Ren, L., Green, J. L., & Smith, W. M. (2016). Using the Fennema-Sherman Mathematics Attitude Scales with lower-primary teachers. Mathematics Education Research Journal, 28(2), 303–326.

382. Richards, J.C., 2015. The changing face of language learning: Learning beyond the classroom. RELC Journal, 46(1), pp.5-22.
383. Rieber, L.P., 1996. Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. Educational technology research and development, 44(2), pp.43-58.
384. Riemer, V. and Schrader, C., 2015. Learning with quizzes, simulations, and adventures: Students' attitudes, perceptions and intentions to learn with different types of serious games. Computers & Education, 88, pp.160-168.
385. Riordan BC and Scarf D. Crafting minds and communities with Minecraft [version 1; referees: 1 not approved]. F1000Research 2016, 5:2339
386. Rossman, G.B. and Rallis, S.F., 2011. Learning in the field: An introduction to qualitative research. Sage.
387. Sa'ad, T.U., Adamu, A. and Sadiq, A.M., 2014. The causes of poor performance in mathematics among public senior secondary school students in Azare Metropolis of Bauchi State, Nigeria. *IOSR-Journal of Research and Method in Education*, *4*, pp.32-40.
388. Saba, A., 2009. Benefits of technology integration in education.
389. Sachs, J. and Leung, S.O., 2007. Shortened versions of Fennema-Sherman mathematic attitude scales employing trace information. Psychologia, 50(3), pp.224-235.
390. Salen, K., Tekinbaş, K. S., & Zimmerman, E. (2004). Rules of play: Game design fundamentals. MIT press.
391. Salinas, Á., Nussbaum, M., Herrera, O., Solarte, M. and Aldunate, R., 2017. Factors affecting the adoption of information and communication technologies in teaching. Education and Information Technologies, 22(5), pp.2175-2196.
392. Samson, M. K., & Charles, M. M. (2018). CHALLENGES FACING SECONDARY SCHOOL PRINCIPALS IN THE IMPLEMENTATION OF THE NATIONAL CURRICULUM STATEMENT IN CAPRICORN DISTRICT OF THE LIMPOPO PROVINCE. British Journal of Multidisciplinary and Advanced Studies, 2(1), 60–70.
393. Sánchez-Prieto, J.C., Olmos-Migueláñez, S. and García-Peñalvo, F.J., 2016. Informal tools in formal contexts: Development of a model to assess the acceptance of mobile technologies among teachers. Computers in Human Behavior, 55, pp.519-528.
394. Sánchez-Prieto, J.C., Olmos-Migueláñez, S. and García-Peñalvo, F.J., 2017. MLearning and pre-service teachers: An assessment of the behavioral intention using an expanded TAM model. Computers in Human Behavior, 72, pp.644-654.
395. Sang, G., Valcke, M., Van Braak, J. and Tondeur, J., 2010. Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology. Computers & Education, 54(1), pp.103-112.
396. Sawang, S., O'Connor, P.J. and Ali, M., 2017. IEngage: Using technology to enhance students' engagement in a large classroom. Journal of Learning Design, 10(1), pp.11-19.
397. Schäfer, A., Holz, J., Leonhardt, T., Schroeder, U., Brauner, P. and Ziefle, M., 2013. From boring to scoring–a collaborative serious game for learning and practicing mathematical logic for computer science education. Computer Science Education, 23(2), pp.87-111.
398. Schafer, T., Tsacle, P., Ingerson, E., Mogilefsky, B. and Chan, P., 1996. The Grim Fandango puzzle document. Lucas Arts Confidential.

399. Scharkow, M., Festl, R., Vogelgesang, J. and Quandt, T., 2015. Beyond the “core-gamer”: Genre preferences and gratifications in computer games. Computers in Human Behavior, 44, pp.293-298
400. Schcolnik, M., Kol, S. and Abarbanel, J., 2016. Constructivism in theory and in practice. In English Teaching Forum (Vol. 44, No. 4, pp. 12-20). US Department of State. Bureau of Educational and Cultural Affairs, Office of English Language Programs, SA-5, 2200 C Street NW 4th Floor, Washington, DC 20037.
401. Schenke, K., Ruzek, E., Lam, A.C., Karabenick, S.A. and Eccles, J.S., 2017. Heterogeneity of student perceptions of the classroom climate: a latent profile approach. Learning Environments Research, 20(3), pp.289-306.
402. Scherer, R., Tondeur, J., Siddiq, F. and Baran, E., 2018. The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches. Computers in Human Behavior, 80, pp.67-80.
403. Schifter, C., 2008. Infusing computers into classrooms: Continuous practice improvement. Hershey, PA: IGI Global.
404. Schneider, E. F. (2004). Death with a Story. Human communication research, 30(3), 361-375.
405. Schunk, D.H., 2003. Self-efficacy for reading and writing: Influence of modeling, goal setting, and self-evaluation. Reading &Writing Quarterly, 19(2), pp.159-172.
406. Scrimin, S., Moscardino, U., Altoè, G. and Mason, L., 2018. Attentional Bias for Academic Stressors and Classroom Climate Predict Adolescents’ Grades and Socioemotional Functioning. Journal of Research on Adolescence, 28(1), pp.245-258.
407. Shavelson, R.J., 1988. Statistical reasoning for the behavioral sciences.
408. Sherry, J. L. (2001). The effects of violent video games on aggression. Human communication research, 27(3), 409-431.
409. Sherry, J.L., 2013. The challenge of audience reception: A developmental model for educational game engagement. New directions for child and adolescent development, 2013(139), pp.11-20.
410. Shinnick, M. A., Woo, M., & Evangelista, L. S. (2012). Predictors of knowledge gains using simulation in the education of prelicensure nursing students.Journal of Professional Nursing, 28(1), 41-47.
411. Shirley, M.L. and Irving, K.E., 2015. Connected classroom technology facilitates multiple components of formative assessment practice. Journal of Science Education and Technology, 24(1), pp.56-68.
412. Shute, Valerie J., Matthew Ventura, Malcolm Bauer, and Diego Zapata-Rivera. "Melding the power of serious games and embedded assessment to monitor and foster learning." Serious games: Mechanisms and effects 2 (2009): 295-321.
413. Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. Personnel Psychology,64(2), 489-528.
414. Southgate, E., Budd, J. and Smith, S., 2017. Press Play for Learning: A Framework to Guide Serious Computer Game Use in the Classroom. Australian Journal of Teacher Education, 42(7), p.1.
415. Soutter, A.R.B. and Hitchens, M., 2016. The relationship between character identification and flow state within video games. Computers in Human Behavior, 55, pp.1030-1038.
416. Spelke, E. S. (2005). Sex differences in intrinsic aptitude for mathematics and science? A critical review. American Psychologist, 60, 950–958.

417. Squire, K. (2011) Video Games and Learnng: Teaching and Participatory culture in the digital age. New York, NY: Teachers College Press.
418. Squire, K. and Barab, S., 2004, June. Replaying history: Engaging urban underserved students in learning world history through computer simulation games. In Proceedings of the 6th international conference on Learning sciences (pp. 505-512). International Society of the Learning Sciences.
419. Stabback, P. (2016). What Makes a Quality Curriculum? Current Critical Issues in Curriculum and Learning (2): 8-12.
420. Statista (2017) Accessed 10/04/2018 https://www.statista.com/statistics/274434/time-spent-gaming-weekly-among-children-in-the-uk-by-age/
421. Stoeger, H., Duan, X., Schirner, S., Greindl, T., & Ziegler, A. (2013). The effectiveness of a one-year online mentoring program for girls in STEM.Computers & Education, 69, 408-418.
422. Stoffregen, T. A., Faugloire, E., Yoshida, K., Flanagan, M. B., & Merhi, O. (2008). Motion sickness and postural sway in console video games. Human Factors: The Journal of the Human Factors and Ergonomics Society, 50(2), 322-331.
423. Strachan, R. and Liyanage, L., 2015. Active Student Engagement: The Heart of Effective Learning. In Global Innovation of Teaching and Learning in Higher Education (pp. 255-274). Springer International Publishing.
424. Strauss, A. and Corbin, J., 1998. Basics of qualitative research techniques. Sage publications.
425. Su, C.H. and Cheng, C.H., 2015. A mobile gamification learning system for improving the learning motivation and achievements. Journal of Computer Assisted Learning, 31(3), pp.268-286.
426. Sule, B., Hussaini, M.M., Bashir, U.S. and Garba, A.,(2016) Mathematics Phobia among Senior Secondary School Students: Implication for Manpower Development in Science Education in Nigeria
427. Sule, S.S., 2016. EFFECTS OF ASSIGNMENT AND CLASS SIZE ON SECONDARY SCHOOL STUDENTS'ACHIEVEMENT IN MATHEMATICS. ATBU Journal of Science, Technology and Education, 4(2), pp.9-16.
428. Šumak, B. and Šorgo, A., 2016. The acceptance and use of interactive whiteboards among teachers: Differences in UTAUT determinants between pre-and post-adopters. Computers in Human Behavior, 64, pp.602-620.
429. ŠUmak, B., HeričKo, M. and PušNik, M., 2011. A meta-analysis of e-learning technology acceptance: The role of user types and e-learning technology types. Computers in Human Behavior, 27(6), pp.2067-2077.
430. Suratno, J., 2016. The Development of Students Worksheet Using Geogebra Assisted Problem-Based Learning and its Effect on Ability of Methematical Discovery of Junior High Students. *Implementation and Education of Methematics and Science: Proceeding of 3thInternational Coference on Research. Yogyakarta*.
431. Sweetser, Penelope, and Peta Wyeth. "GameFlow: a model for evaluating player enjoyment in games." Computers in Entertainment (CIE) 3, no. 3 (2004): 3-3.
432. Sweigart, L., & Hodson-Carlton, K. (2013). Improving student interview skills: the virtual avatar as client. Nurse educator, 38(1), 11-15.
433. Taber, K. (1992) Girls' interactions with teachers in mixed physics classes: results of classroom observation, International Journal of Science Education, 14(2): 163-180.
434. Tang, S. and Hanneghan, M., 2014. Designing educational games: a pedagogical approach. Gamification for Human Factors Integration: Social,

Education, and Psychological Issues: Social, Education, and Psychological Issues, 181.

435. Tao, Y. H., Cheng, C. J., & Sun, S. Y. (2009). What influences college students to continue using business simulation games? The Taiwan experience. Computers & Education, 53(3), 929-939.

436. Tarhini, A., Hone, K. and Liu, X., 2014. Measuring the moderating effect of gender and age on e-learning acceptance in England: A structural equation modeling approach for an extended technology acceptance model. Journal of Educational Computing Research, 51(2), pp.163-184.

437. Tassi P. 2016. Here Are The Five Best-Selling Video Games Of All Time. Available: http://www.forbes.com/sites/insertcoin/2016/07/08/here-are-the-five-best-selling-video-games-of-all-time/#e0746672deea [Accessed 12/10/2016]

438. Teo, T. and Ursavas, O.F., 2012. Technology acceptance of pre-service teachers in Turkey: A cross-cultural model validation study. International Journal of Instructional Media, 39(3), pp.187-196.

439. Teo, T. and van Schaik, P., 2012. Understanding the intention to use technology by preservice teachers: An empirical test of competing theoretical models. International Journal of Human-Computer Interaction, 28(3), pp.178-188.

440. Teo, T., 2010. Examining the influence of subjective norm and facilitating conditions on the intention to use technology among pre-service teachers: a structural equation modeling of an extended technology acceptance model. Asia Pacific Education Review, 11(2), pp.253-262.

441. Teo, T., 2011. Factors influencing teachers’ intention to use technology: Model development and test. Computers & Education, 57(4), pp.2432-2440.

442. Teo, T., Milutinović, V. and Zhou, M., 2016. Modelling Serbian pre-service teachers' attitudes towards computer use: A SEM and MIMIC approach. Computers & Education, 94, pp.77-88.

443. Thompson, R.L., Higgins, C.A. and Howell, J.M., 1991. Personal computing: toward a conceptual model of utilization. MIS quarterly, pp.125-143.

444. Tobias, S., Fletcher, J.D., Dai, D.Y. and Wind, A.P., 2011. Review of research on computer games. Computer games and instruction, 127, p.222.

445. Tolks, D., Schäfer, C., Raupach, T., Kruse, L., Sarikas, A., Gerhardt-Szép, S., Kllauer, G., Lemos, M., Fischer, M.R., Eichner, B. and Sostmann, K., 2016. An introduction to the inverted/flipped classroom model in education and advanced training in medicine and in the healthcare professions. GMS journal for medical education, 33(3).

446. Tondeur, J., Hermans, R., van Braak, J. and Valcke, M., 2008. Exploring the link between teachers’ educational belief profiles and different types of computer use in the classroom. Computers in Human Behavior, 24(6), pp.2541-2553.

447. Torrente, J., Del Blanco, Á., Marchiori, E.J., Moreno-Ger, P. and Fernández-Manjón, B., 2010, April. < e-Adventure>: Introducing educational games in the learning process. In Education Engineering (EDUCON), 2010 IEEE (pp. 1121-1126). IEEE.

448. Trefry, G., 2010. Casual game design. Designing Play for the Gamer in All of Us, 1.

449. Trepte, S. and Reinecke, L., 2010. Avatar creation and video game enjoyment. Journal of Media Psychology.

450. Tsafe, A.K. and Yusha’u, M.A., 2014. The Instrumentality of Mathematics Education in Employment Generation and Sustainability in Nigeria. In Proceedings of

the 51st Annual Conference of the Mathematical Association of Nigeria (MAN) held at the University of Ilorin, Ilorin between August 31st–September 5th.
451. Tsai, M.J. and Pai, H.T., 2012. Exploring students' cognitive process in game-based learning environment by eye tracking. WorldComp12, pp.211-214.
452. Tshabalala, T. and Ncube, A.C., 2014. Teachers' perceptions on challenges faced by rural secondary schools in the implementation of the technical and vocational education and training policy in Nkayi district. *International Research Journal of Teacher Education*, *1*(2), pp.9-15.
453. Turner, M., Kitchenham, B., Brereton, P., Charters, S., Budgen, D., 2010: Does the technology acceptance model predict actual use? A systematic literature review. Inf. Softw. Technol. 52, pp.463–479.
454. Twining, P., 2010. Virtual worlds and education.
455. Ugwuona, C.N., 2016. 2013 ASUU Strike Discourses in Nigeria: A Critical Discourse Analysis. *Mediterranean Journal of Social Sciences*, *7*(2), p.435.
456. Umameh, M. A. (2011). M. Umameh, "Survey of students' poor performance in mathematics," Lagos: Longman, 2011.
457. Umar, H. and El-yakub, S.U., 2017. UNIVERSAL BASIC EDUCATION IN NIGERIA: A REVIEW OF APPROACHES TO IMPROVE ITS QUALITY FOR NATIONAL DEVELOPMENT AND PRODUCTIVITY. *ATBU Journal of Science, Technology and Education*, *4*(4), pp.116-122.
458. UNESCO (2016) http://uis.unesco.org/en/document/world-needs-almost-69-million-new-teachers-reach-2030-education-goals
459. UNESCO. (n.d.). Curriculum. Retrieved June 10, 2018, from http://www.unesco.org/new/en/education/themes/strengthening-education-systems/quality-framework/core-resources/curriculum/
460. Vaismoradi M, Turunen H,Bondas T 2013. Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. Nurs Health Sci 15: 398–405.
461. Van der Wal, M.M., De Kraker, J., Kroeze, C., Kirschner, P.A. and Valkering, P., 2016. Can computer models be used for social learning? A serious game in water management. Environmental Modelling & Software, 75, pp.119-132.
462. Vanderlinde, R., Aesaert, K. and Van Braak, J., 2014. Institutionalised ICT use in primary education: A multilevel analysis. Computers & Education, 72, pp.1-10.
463. Venkatesh, V. and Davis, F.D., 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management science, 46(2), pp.186-204.
464. Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D., 2003. User acceptance of information technology: Toward a unified view. MIS quarterly, pp.425-478.
465. Vogel, D. Guo, M., Zhou, P., Tian, S., & Zhang, J. (2008). In search of Second Life nirvana. Issues in Informing Science and Information Technology, 5(2008), 11-28.
466. Vogt, M.A. and Schaffner, B.H., 2016. Evaluating interactive technology for an evolving case study on learning and satisfaction of graduate nursing students. Nurse Education in Practice, 19, pp.79-83.
467. Vygotsky, L.S., 1978. Mind in society: The development of higher psychological functions. Harvard, Cambridge, MA.
468. Wang, C.S., Jeng, Y.L. and Huang, Y.M., 2017. What influences teachers to continue using cloud services? The role of facilitating conditions and social influence. The Electronic Library, 35(3).

469. Wang, L.C. and Chen, M.P., 2010. The effects of game strategy and preference-matching on flow experience and programming performance in game-based learning. Innovations in Education and Teaching International, 47(1), pp.39-42.
470. Warburton, S., García, M. P., & Russell, D. (2009). 3D design and collaboration in massively multi-user virtual environments (MUVEs). Russell, D.(2009) Cases on collaboration in virtual learning environments: Processes and interactions, 27-41.
471. Ward, L. and Parr, J.M., 2010. Revisiting and reframing use: Implications for the integration of ICT. Computers & Education, 54(1), pp.113-122.
472. Warren T. 2016. Minecraft Sales Top 100 million. Available: http://www.theverge.com/2016/6/2/11838036/minecraft-sales-100-million [Accessed 24/07/2016]
473. Wass, R. and Golding, C., 2014. Sharpening a tool for teaching: the zone of proximal development. Teaching in Higher Education, 19(6), pp.671-684.
474. Weaver, A. (2011). High-fidelity patient simulation in nursing education: An integrative review. Nursing Education Perspectives, 32(1), 37-40.
475. Wentzel, K. R., Battle, A., Russell, S. L., & Looney, L. B. (2010). Social supports from teachers and peers as predictors of academic and social motivation. Contemporary Educational Psychology, 35(3), 193-202.
476. Whitton, N.J., 2007. An investigation into the potential of collaborative computer game-based learning in higher education(Doctoral dissertation, Edinburgh Napier University)
477. Wiklund, M., 2006, July. The Game Genre Factor in Computer Games Based Learning. In the proceedings of the 8: th International Conference on Computer Games, AI and Mobile Systems, CGAMES (pp. 24-27).
478. Wilson, G., 2016. Teachers' Challenges and Job Performance under the Universal Basic Education Scheme in Rivers State, Nigeria (2007-2015). *Covenant University Journal of Politics and International Affairs*, *4*(1).
479. Wirth, W., Hartmann, T., Böcking, S., Vorderer, P., Klimmt, C., Schramm, H., Saari, T., Laarni, J., Ravaja, N., Gouveia, F.R. and Biocca, F., 2007. A process model of the formation of spatial presence experiences. Media psychology, 9(3), pp.493-525.
480. Wirth, Werner, Tilo Hartmann, Saskia Böcking, Peter Vorderer, Christoph Klimmt, Holger Schramm, Timo Saari et al. "A process model of the formation of spatial presence experiences." Media psychology 9, no. 3 (2007): 493-424.
481. Wolf, M.J., 2001. The medium of the video game. University of Texas Press.
482. Wong, G.K., 2015. Understanding technology acceptance in pre-service teachers of primary mathematics in Hong Kong. Australasian Journal of Educational Technology, 31(6).
483. Wright, J. C., Huston, A. C., Vandewater, E. A., Bickham, D. S., Scantlin, R. M., Kotler, J. A., ... & Finkelstein, J. (2001). American children's use of electronic media in 1997: A national survey. Journal of Applied Developmental Psychology, 22(1), 31-47.
484. Wrzesien, Maja, and Mariano Alcañiz Raya. "Learning in serious virtual worlds: Evaluation of learning effectiveness and appeal to students in the E-Junior project." Computers & Education 55, no. 1 (2010): 178-187.
485. Wu, L. and Chen, J.L., 2005. An extension of trust and TAM model with TPB in the initial adoption of on-line tax: an empirical study. International Journal of Human-Computer Studies, 62(6), pp.784-808.

486. Wu, W.H., Chiou, W.B., Kao, H.Y., Hu, C.H.A. and Huang, S.H., 2012. Re-exploring game-assisted learning research: The perspective of learning theoretical bases. Computers & Education, 59(4), pp.1153-1161.
487. Yang, Y.T.C., 2012. Building virtual cities, inspiring intelligent citizens: Digital games for developing students' problem solving and learning motivation. Computers & Education, 59(2), pp.365-377.
488. Yau, H.K. and Cheng, A.L.F., 2012. Gender difference of confidence in using technology for learning. *Journal of Technology Studies*, *38*(2), pp.74-79.
489. Yemi, T. M and Adeshina, A. N. G. (2013). Factors Influencing Effective Learning of Mathematics at Senior Secondary Schools within Gombe Metropolis, Gombe State Nigeria. Journal of Education and Practice (Online) www.iiste.org. 4 (25). 61-67. 2013.
490. Yoon, S., Anderson, E., Lin, J. and Elinich, K., 2017. How augmented reality enables conceptual understanding of challenging science content. Journal of Educational Technology & Society, 20(1), p.156.
491. Young, M.F., Slota, S., Cutter, A.B., Jalette, G., Mullin, G., Lai, B., Simeoni, Z., Tran, M. and Yukhymenko, M., 2012. Our princess is in another castle a review of trends in serious gaming for education. Review of educational research, 82(1), pp.61-89.
492. Ypsilanti, A., Vivas, A.B., Räisänen, T., Viitala, M., Ijäs, T. and Ropes, D., 2014. Are serious video games something more than a game? A review on the effectiveness of serious games to facilitate intergenerational learning. Education and Information Technologies, 19(3), pp.515-529.
493. Yusoff, A., Crowder, R. and Gilbert, L., 2010, March. Validation of serious games attributes using the technology acceptance model. In Games and Virtual Worlds for Serious Applications (VS-GAMES), 2010 Second International Conference on (pp. 45-51). IEEE.
494. Yusuf, M. O., & Balogun, M. R. (2011). Student-teachers' competence and attitude towards Information and communication technology: A case study in a Nigerian University. Contemporary Educational Technology, 2(1), 18–36.
495. Zimmerman, B.J. and Labuhn, A.S., 2012. Self-regulation of learning: Process approaches to personal development.