FACULTY OF HEALTH, SOCIAL CARE AND EDUCATION

STEALTH ASSESSMENT AND COMPUTER GAME LEARNING: COULD THIS BENEFIT THE CHILDREN OF TOMORROW?

A THESIS IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF ANGLIA RUSKIN UNIVERSITY FOR THE DEGREE OF MASTER OF PHILOSOPHY

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(ii) Abstract

The purpose of this case study was to analyse computer games' role in assessment and seek an understanding of their role to enhance the level of achievement in schools. Research indicates that achievement levels in mathematics have declined in British schools over recent decades, however, children are being tested more than ever. This research focused on stealth assessment and game-based learning in mathematics, with a further aim to uncover if this is a practical option for assessing achievement and more effective than current methods. Additionally, it examined if computer games could keep children engaged with mathematics and what information teachers can use from game assessments to progress future learning.

This study used mixed-methods of research, as both qualitative and quantitative research methods were used. The research was carried out in a primary school setting, with participants from a year 5 class and two teachers. An experimental group played the computer game and took part in their regular mathematics lessons, whereas a control group only participated in the mathematics lessons. Observations were used to determine the engagement and motivation levels during the participant's mathematics lessons and whilst playing the game. Teacher interviews were conducted at the start and end of the week to seek their views on the computer game and stealth assessment. The participants also completed a pre and post-test to see if their achievement had changed over the one-week period.

The post-test results showed the experimental group had made greater achievement gains over the week. The observations revealed that the engagement and motivation levels of the experimental group were very high when playing the game, and actually reached higher levels in the mathematics lessons than the control group. However, the teacher revealed that the computer game did not provide enough information to progress the participants' future learning.

The evidence suggests that the computer game had some impact in the experimental groups enhanced achievement levels. Despite this, the teacher stated that the game did not provide enough information and could not be used to progress the learning. Therefore, it is not possible to say at this time whether stealth assessment is a practical method for assessing mathematics. However, this study has shown that computer games can increase achievement levels and increase the engagement and motivation towards mathematics.

Keywords: Stealth assessment, Game-based learning, Mathematics learning, Engagement, Motivation, Achievement

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(v) Abbreviation List

AfL – Assessment for Learning

DfE – Department for Education

FSM – Free School Meals

Ofqual - The Office of Qualifications and Examinations Regulation

PIRLS – Progress in International Reading Literacy Study

PISA – Programme of International Assessment

SEN – Special Educational Needs

TIMSS – Trends in International Mathematics and Science Study

Intvr – Interviewer

Resp – Response from Teacher

Copyright Declaration

I hereby declare that this thesis has been composed by myself and the work of this thesis is a record of my own work. All sources of information have been specifically acknowledged.

Jonathan Pool

Chapter 1 - Introduction

1.1 Introduction

The aim of this case study is to analyse computer games' role in assessment and seek an understanding of their role to enhance the level of achievement in schools. The research will focus around stealth assessment and computer game learning in mathematics, with a further aim to gather evidence to see if this method is a practical option for assessing achievement and more effective than current assessment methods. Furthermore, I want to see if computer games can keep children engaged with the subject matter, whether this differs to other methods of learning, and what data teachers can use from these game assessments to progress future learning. In particular, the study will look at testing in primary and secondary schools, however my research will be carried out in a primary school setting. There is a considerable amount of debate and controversy surrounding summative assessment methods in schools (Kelly, 2009; Erskine, 2014; Coughlan, 2015). There are indications throughout this study that suggest summative assessments have negative outcomes for a high number of children. Some professionals have also previously indicated that our current methods of assessing children are causing high levels of stress and fail to provide information on the full range of educational outcomes needed in a society of rapid social and technological change (Harlen 2003; Marsh,2016). Despite many changes to educational policy, the government still see rigorous testing as the only way to improve standards of achievement. This has led me to start searching for alternative methods that have the potential to better support children's learning and achievement.

My interest in assessment developed during my undergraduate years, when I was asked to write an essay about a key memory from my time at school. The memory was based around my experiences with mathematics and the assessment of this subject from primary school through to the end of my secondary education. I had always been reasonably good at mathematics throughout my primary education and remember studying relentlessly in my last year before the SATS exams. On entering secondary school, I was placed into a mixed ability form group, however it wasn't until the second year of school that I was judged on my ability. The mathematics sets were numbered from 'one' being the highest, to 'six' being the lowest. Set three was to be my number and I was happy with this decision, as the lessons were always a good challenge. The teacher that year would always have inventive and creative methods of teaching and regularly gave you feedback on how to improve and 'level-up' your work. However, a change of teacher in year nine also led to a change of pace in the lessons, with less feedback and support being given out to the class. My enjoyment of mathematics was diminishing and had left me becoming uninterested and bored.

The GCSE years were just around the corner and with year ten approaching fast, the school made the final changes to mathematics sets to determine which level of assessment pupils would take at the end of year eleven. The top three sets would sit the higher-level exam, with the bottom three sets taking the lower level exam. My level of work and motivation for mathematics had continued to decline that year, due to the uninspiring focus placed on the GCSE's and direct instruction of lessons. This led to my teacher making the decision to move me down to a lower ability set, leaving me feeling frustrated and further demotivated. This meant I would be taking the lower level exam with the highest achievable grade being a 'C'. A number of my friends were in the lower sets and had very little motivation, because they thought they were unable to achieve the highest grades. Research into set ability groups discovered that many children became progressively dissatisfied with mathematics and negatively affected their GCSE results (Boaler, 2000).

I remember those final two years of school very well, because I worked above and beyond to succeed. However, it was far from a stress-free experience. All those years of learning mathematics had come down to one assessment, which also came with the immense pressure of achieving the desirable 'C' grade. This memory opened my eyes to the pressure and stress assessments can cause, the impact they can have on motivation to learn, and how a whole educational journey can be decided in one end of year assessment.

This reflection process inspired me to find out more about the summative approach and whether there were viable alternatives to assessing children's knowledge. I decided to write my undergraduate major project on: Alternative approaches to assessing achievement in primary and secondary education. The project explored a number of limitations to summative assessments, whilst reviewing three potential alternative assessment approaches. There was also a comparative analysis of assessment attitudes in other higher achieving countries. The alternative methods in focus were formative assessment, stealth assessment using computer games and project-based assessment which used portfolios, investigative learning tasks and self-assessment. Each approach had different advantages, however based on the evidence collected in the literature, stealth assessment was the method that I thought had the most potential to benefit children and schools with assessing achievement. It was discovered that using this method could potentially enhance children's learning within the classroom, whilst providing teachers with data on their learning and misunderstandings that could then be used in a formative way to progress future learning. This learning experience inspired me to want to continue researching this topic. I wanted to carry out my own research to see whether stealth assessment and computer game learning had the ability to enhance achievement, give the teacher knowledge on children's competencies and keep children engaged with the learning.

This study will begin by looking at relevant literature, by firstly exploring the historical development of schooling and assessment in English schools. This section will be discussing the early developments in Victorian England, which will be followed by the tripartite education system and how assessment was used as a tool to direct a child's educational path. It will then examine the comprehensive schooling system and the National Curriculum, taking a look at how the curriculum content has narrowed over time to focus more on core subjects and assessing children's knowledge in these areas. Lastly, it will take a look at the types of school's children can now attend, how these schools have emerged since the introduction of the National Curriculum and whether the quality of teaching is consistent across all schools.

The research in this study will have a focus on mathematics computer games, so it will be important to explore and understand the history behind mathematics education in British schools. I will be discussing some key developments in mathematics education over the last few hundred years and how it has now become known as a core subject. It is equally important to discuss why the government have positioned it above many other subjects and why children are so heavily assessed in this area of the curriculum. Furthermore, it will discuss the international focus surrounding mathematics education, analysing whether this is affecting policy changes and changing the way mathematics is taught around the world. I think this section is imperative to set things in context and show how mathematics education changes throughout history, with the latest changes being influenced by technological advancements.

The next section will take a look at the limitations of summative assessment in our education system. It will cover how assessment has become the focus of international league tables, with governments raising the profile of subjects such as mathematics above all other curriculum subjects. There is a lot of international focus around methods of teaching that promote critical thinking. Therefore, it will be important to analyse whether current methods that promote critical thinking are being affected by assessments. The GCSE assessments are seen as incredibly important for children in secondary education. However, I will focus on whether the tiered exam structure currently in place for many British schools is gatekeeping sections of the school population. Social disadvantage in education is also a well discussed topic, so it will be necessary to look into how current assessment practice affects children from different backgrounds and whether there are any reliability issues.

This will lead onto computer game learning and stealth assessment, focusing on how this technology has opened the door for new and different resources to be considered, for use in the classroom and assessment in particular. I will look into the different perceptions of computer games; the potential barriers surrounding them and also review any evidence that may show how learning could be enhanced by playing computer games. It is important to look into why these games may become useful resources for supporting the curriculum and their potential value as tools for assessment. There will also be a discussion on how stealth assessment is being used to support children's social development. Furthermore, if stealth assessment is able to promote formative assessment approaches in the classroom, examining the benefits this may have for children, teachers and schools.

The international focus around assessment has also led me to explore the differing attitudes towards assessment. This section will cover a comparative analysis of assessment in Britain and Finland. It will focus on how Finland has developed an alternative method of assessing their children and how these compares to the British attitudes towards assessment. Furthermore, I want to discover whether either of these two countries are incorporating game-based learning into their classrooms.

Finally, the literature review will discuss current trends in motivation for assessment, looking at the different types of motivation, whether current methods actually have an impact and if there are new trends that aim to engage and motivate children. Additionally, this chapter will take a look at whether school assessments damage children's motivation to attend university and their future careers.

Whilst there is quite a lot of research into the effects of game-based learning on children, there is very little exploring how effective computer games can be for assessing children's achievement in mathematics. In addition, whether children's engagement and academic motivation levels towards mathematics are higher when computer games are used, compared with the more traditional methods of learning. Therefore, the purpose of my study is to explore the effects of a mathematics computer game on achievement, engagement and academic motivation levels in a primary school. The case study will aim to investigate computer games' role in assessment and seek an understanding of their role to improve the achievement levels in schools. I want to carry out my own study to see if stealth assessment using a mathematics computer game is a practical way of assessing children's achievement, and if it could be more effective than current methods of assessment. Furthermore, can the computer game keep children engaged and motivated with mathematics and if this differs to other methods used in the classroom. Lastly, if teachers can use the data collected from a computer game to progress the children's future learning in the classroom.

The methodology section will explain my research questions in more depth, whilst also giving a detailed explanation on the computer game chosen for the study. In order for me to answer these questions, I chose to conduct a study over a one-week period with a class of year 5 children in a local primary school setting. As the study I will be carrying out is using a small sample of participants, a decision was made to carry out multiple data collection methods in order for me to gain a larger amount of data. The methods chosen were observations, pre and post-tests, teacher interviews, as well as using the data collected from the computer game. There will also a discussion on the ethics and safety aspects considered throughout the process, as well as any limitations occurred during the research process.

The final sections of this case study will be the results, analysis and discussion. The results section will present all of the data collected in this study. This will be followed up with an analysis and discussion of the findings, linking this to relevant literature, whilst also trying to discover if stealth assessment and computer game learning can benefit the children of tomorrow.

1.2 Stealth Assessment

Stealth assessment uses evidence-centred design (ECD) assessment frameworks, which are placed into the fabric of a gaming environment (Shute & Ventura, 2013). Whilst children interact with the game, they are constantly presented with complex problem-solving tasks, which draw upon their creative skills, knowledge and understanding of the topics that teachers are looking to assess (Shute & Ventura, 2013). The evidence needed to assess acquired knowledge is provided by the children's actions within the game.

1.3 Computer games and learning

The definition of games is not easy, because of the different types of games available. The Futurelab handbook for gaming states the term 'game' refers to the following:

Digital games – as used by the Digital Games Research Association to represent all games that have a digital technology base.

Video games – is a term used by industry bodies such as Interactive Software Federation of Europe (ISFE) for portable games consoles and television-based consoles.

Computer games – are those that are played directly on a PC.

Online games – these include large multi-player online role-playing games and casual games.

Mobile games – these are played on a handheld device, which include mobile phones, mobile consoles and tablet computers

Ulicsak & Williamson (2010) state that these types of games can be subdivided even further into three categories. These are educational games, leisure games and educational leisure games. Educational games are designed with explicit educational goals that aim to support processes of learning. Leisure games do not have learning as an explicit goal; however it must be pointed out that any game could be used to learn something. Educational leisure games are described as games such as The Sims, the Roller Coaster Tycoon series and city building games. These types of games aid teaching of specific areas, however, are designed for leisure use (Ulicsak & Williamson, 2010). However, this study will be looking at the use of educational computer games and their use for stealth assessment purposes.

Chapter 2 – Literature Review

2.1 Introduction

To understand why this research is being conducted, it is suitable to provide a summary of significant viewpoints within the relevant literature. I want to find out if stealth assessment and computer game learning in mathematics can benefit the children of tomorrow. Therefore, I wanted to investigate how the culture of mathematics and in particular assessment has developed over time, to establish whether or not new methods could be incorporated into our education system. This section will focus on the development of British education, in particular mathematics and assessment. It will explore the summative assessment method used in British schools and also compare these to another higher achieving nation that focuses far less on assessment. There will be a strong focus on computer game learning and stealth assessment, as well as seeing whether motivation is impacted by current methods used in schools. Any abbreviations in this chapter can be found in the abbreviation list.

2.2.1 The development of British education and assessment

It is important to understand what motivated authorities to develop education systems focused around assessment, which is why this study must firstly examine the historical developments of education in Britain. This study needs to have a historical analysis to see how the national culture has developed in which assessment, and in particular the core subjects have become the main focus in our schools. The education system in this country has changed significantly over the last couple of centuries. However, there are records of schools being traced back to the end of the sixth century, with one of the earliest schools being established in Canterbury in 598 (Gillard, 2010). It was not until the industrial revolution in Victorian Britain where education started to develop significantly.

2.2.2 Victorian education developments

More recent changes to schooling developed during the industrial revolution, where there was a need for mass education due to the construction of factories for the substantial production of goods and the increased specialisation of labour (Gillard, 2010). Long (2006) states that the very early stages of schooling in the Victorian era were heavily influenced by social class. Picard (2009) states that in an increasingly complicated industrial world, the chances for illiterate children to succeed in life were slim. However, Britain was developing quickly, and a number of day schools started to emerge, in the form of Ragged Schools, Parish Schools and Church Schools. Ragged schools originated in the Sunday School founded in 1780 in Gloucester, teaching children to read so they could read the Bible, which at the time was the one text that was easily available (Picard 2009). Parish schools, also described as Parish workhouses, provided education for the children in their care. However, Birch (2008) states that these schools were often poorly observed and often forced children to attend other schools.

Bartlett & Burton (2012) state that most education in the early 1800's was split into two forms, with the church providing basic education to the poor working-class children and the public schools providing education for those of privilege. These 'poor' schools were designed to principally train large numbers of working-class children (Bartlett & Burton, 2012). Picard (2009) states that these schools adopted the Lancaster system whereby the smartest pupils taught others what they had learnt, each of whom would pass it on to the next group of children. It is said that whilst the brighter children taught their fellow pupils, the teacher's responsibility was to assess the children's work (Bartlett & Burton). Despite this, Long (2006) argues that no matter what access children had to education, family background exerted a large influence on the probability of attendance. Gillard (2010) states that in 1816, 875,000 of England's 1.5 million children attended a school of some kind, however it is important to note that their average duration of school attendance was just one year. This is compared to 1861 where an estimated 2.5 million children out of 2.75 million received some type of education (see Appendix 1). However, Bartlett & Burton (2012) state that education was very mixed in quality, with most children leaving school before the age of 11 years old. Despite the vast difference in quality, Gillard (2010) argues that there were similarities to modern day education, with a move towards a focus on standards of achievement. Authorities were now pressurising all types of schools to improve standards. However, the Revised Code of 1862 permitted schools to claim grants for children, if they attained one of six standards in reading, writing and arithmetic examinations. These early assessments are said to resemble contemporary National Curriculum attainment targets of today (Bartlett & Burton, 2012).

The upper classes did not send their children to these poorer schools, because they could afford prestigious fee paying preparatory and public schools. The quality of learning at public schools was vastly different to all other education in Britain. Picard (2009) states that only the British could call their most prestigious, exclusive and fee-paying education establishments 'public'. During early educational developments, Britain had allowed a divided school system to grow in line with its class structure (Gillard, 2010). However, Roach (1991) states that the public schools in Britain have had a long association with the ruling classes, historically educating upper class boys and preparing them for public service or entry to prestigious universities such as Oxford and Cambridge. Early signs of a structured and government influenced curriculum was also becoming evident in these schools. The Clarendon Report of 1864 recommended that the public-school system should be divided further, creating a separate class of public schools, tightening the reigns over government, management and the curriculum of nine highly regarded schools – Eton, Charterhouse, Harrow, Merchant Taylors', Rugby, Shrewsbury, St Paul's, Westminster and Winchester. (Gillard, 2010). Although there had been many conversations about curriculum changes in schools before this report, these schools were informed that their curriculum should consist of classics, mathematics, two natural sciences, geography, history, a modern language, drawing and music (Gillard, 2010).

Education changed rapidly throughout the nineteenth and twentieth centuries, with the Elementary Education Act 1891 introducing free education and making education compulsory for all children up to the age of fourteen (Gillard, 2010). Long (2006) is critical of this move, stating that despite education becoming available to all, the variation of quality was enormous. However, Long (2006) states that despite the vast variations of education a child could receive, these early schooling systems are widely regarded as a major contributor in moving Britain forward and becoming a leading economic force.

2.2.3 Tripartite education system

The 1944 Education Act is considered to be a defining moment in British education (Blatchford, 2014). Gillard (2010) supports this claim, stating this development has led to us now accepting free primary and secondary education as a national birth right. Education would become nationally funded, whilst also permitting secondary education to all, which previously excluded most working-class children (Smith, 2007). There was also a defined split between primary and secondary education at the age of eleven, with children progressing through a tripartite hierarchical system of grammar, secondary modern and technical schools (Smith, 2007). The aim of this development was to guarantee that entry to these various schools was based on merit alone, giving children from poorer backgrounds an educational opportunity they could not previously obtain (Harris & Rose, 2013). Barber (2014) supports this claim stating it opened the way for a more closely-knit society, reflecting on social solidarity of wartime Britain. However, Pring et al., (1996) is critical, stating this system divided society further with grammar school children able to progress onto higher education, whereas opportunities for those entering secondary modern and technical schools were severely limited.

The tripartite schooling system used assessment as a key tool in determining the type of secondary education a child would receive. Children would take the 11-plus exam, with higher attaining children continuing on to grammar schools and lower attaining children progressing to either technical or secondary modern schools. Smith (2007) states this test was different to modern day high stakes summative assessments, because it only tested to see which school most suited the child. Devine (2004) is critical of these assessments, stating it was the government's attempt to establish formal equality of educational opportunity, however it clearly failed to create a more open society. Harris et al., (2013) is equally critical, stating middle class families had the cultural and economic capital to coach their children to pass the test. The literature suggests that this test was not an accurate measure of innate ability. However, some research contradicts this theory, with the London School of Economics proving that the 11-plus assessment did benefit some lower income families, because brighter children were able to gain a better education in the grammar schools (Boliver & Swift, 2011). Despite this, there were concerns over the reliability of the 11-plus assessment, which led to the growth of the comprehensive schooling structure (Pring & Walford, 1996).

2.2.4 Comprehensive education

Britain was slowly moving away from the tripartite education system throughout the 1970's and 80's. It was being replaced by a modernised comprehensive system, which highlighted the importance of secondary education in children's lives (Bartlett & Burton, 2012). Comprehensive schools aimed to provide equal educational opportunities for all children, whilst also trying to break down the social barriers created by the previous system (Pring & Walford, 1996). However, Bennett et al., (1991) states that education in England at this time, was not providing equal opportunities to all. Research suggests there was a clear lack of central and local control over the curriculum, as well as traditions of teacher autonomy in schools, led to teaching in primary schools becoming extremely diverse (Bennett & Desforges, 1991). Furthermore, teachers were in charge of allocating curriculum time, the mode of teaching and all taught a different curriculum which was dependant on their own particular expectations.

The Plowden Report 1967 (cited in Gillard, 2010) argued that education should follow a measured progression from a relatively open curriculum in the earlier years of schooling to more subject differentiated after the age of 12. It also stated the curriculum should promote individual discovery and first-hand experience rather than just the motion of storing facts and acquiring knowledge. This closely links to Piaget's theory of development, whereby he thought that children have a natural urge to investigate and discover, which enables them to become more efficient at solving problems and construct knowledge for themselves (Piaget, 2001, Pound, 2012, Cohen, 2013). Furthermore, Alexander (2009) states that Plowden recommended classroom instruction to be a mixture of individual, group and class work. However, research from Bassey in 1977 (cited in Bennet & Desforges, 1991) contradicts these recommendations, revealing that most classrooms were dominated by teacher-led whole class work, with only two hours per-week devoted to children working individually on topics they had chosen. Furthermore, it was found that most teachers restricted pupils' movement and talking time in the classroom, expecting them to work in silence most of the time (Bennett & Desforges, 1991). This research was supported by Her Majesty's Inspectorate in 1978, which inspected a random national sample of 500 schools, finding that only 5% of teachers was using Plowden's recommended 'progressive' methods, with three quarters preferring a didactic approach (Alexander, 2009). This literature shows that despite educational research into the best methods of teaching children, teachers were often found to be using teacher-led class work and often failed to recognise the progressive educational methods. A system that was intended to offer an equal education for all, was actually still dictated largely by teachers and all children were receiving a very different education diet.

This system was to encounter major educational reform in 1988, with the Education Reform Act introducing both structural and curricula changes (Gillard, 2010). Gerrard (2015) argues that the rise of neo-liberal ideologies led to a market led educational system. Strain (2008) supports this claim by stating that the changes aimed to create a market whereby schools competed for pupils. However, Chitty et al., (2009) argues that the government introducing local markets was their attempt of reinstating the selection of pupils, under the radar. Robinson (2010) is critical of this move and does not understand why education was reformed around the economy, when it is impossible to know how the economy will develop in the future. Despite these significant changes, the comprehensive system was considered by many to be far superior to any previous educational system (Pritchard, 1996)

2.2.5 The National Curriculum

The National Curriculum was introduced in 1988, splitting primary and secondary education into phases and prescribing what should be taught be taught at each of these phases. Children would now move through key stages of learning, completing assessments at the end of each stage (Bartlett & Burton, 2012). Lord Baker (cited in Woodward, 2008) who was Secretary of State for Education at the time, stated that introducing the National Curriculum was necessary to ensure the quality of education to increase nationwide and improve achievement levels at all ages. However, Kelly (2009) is critical of this view, arguing that these changes moved Britain into an assessment led era of reform, with the government using assessment to take control of the curriculum. Robinson (2010) compares current schools to those of the Victorian era, stating that despite major reform schools still operate with a production line mentality using school bells, teaching separate subjects and grouping children by age.

The National Curriculum prescribes the teaching of a number of subjects, however English, mathematics and science are considered core subjects and are highly regarded throughout primary and secondary education (DfE, 2015). Lipsitt (2008) argues that the existing curriculum has narrowed dramatically as a result of standardised testing in schools. Research from the Cambridge Primary Review supports this claim, arguing that national assessments are narrowing the curriculum, thus limiting learning opportunities for children (Alexander, 2010). Additionally, with the curriculum focusing more on the core subjects, evidence suggests innovation and creativity within schools has declined (Lipsitt, 2008). More recent arguments claim the curriculum has not developed in line with technological advancements, with children learning the same facts their parents learnt, leading to alienated groups of children (Robinson, 2010). Lord Baker (cited in Peters, 2017) has recently changed his views on the National

Curriculum, stating that in the next few decades millions of jobs will disappear, with new ones taking their place, however in order to have these new jobs children have to have a range of skills, not just academic subjects. Nevertheless, the Department for Education (DfE) (2010) believe the core subjects are the building blocks of education and increasing levels of achievement in these subjects is essential for our country to compete in the global economy. Ward & Busby (2015) are critical of this approach, stating that if education is built on an economy model, then schools will begin to fail in creating interested and interesting people. Ofsted's latest review highlights that primary schools are prioritising reading, writing, spelling and grammar, and are at risk of narrowing the curriculum (Ofsted, 2016). Furthermore, recent reports suggest disadvantaged children in secondary schools are also being shut out of foundation subjects such as history, geography, the arts and modern languages, to focus on improving their achievement in the core subjects (Adams, 2017). Amanda Spielman, the head of Ofsted (cited in Adams, 2017) states "social mobility could be at risk if some pupils were given restricted options and schools watered down their curriculum to concentrate on exam results". Evidence in the literature suggests assessment seems to be controlling the curriculum that schools teach, with teachers increasing time spent learning the core subjects, in an attempt to gain higher scores in national tests.

2.2.6 Different types of schools

The type of school children can attend has changed considerably since the National Curriculum was introduced. The aim of the National Curriculum was to raise standards and to ensure all children are given the same standard of education (Gillard, 2010). A couple of recent additions to the list of schools are the academies, multi-academy trusts and free schools. These were introduced by the coalition government in 2010, as a way of giving schools the flexibility to raise standards internally (DfE, 2015). Moreover, none of these schools are required to follow the National Curriculum, but they are measured by the same criteria as other schools. For example, Progress 8 was introduced in 2016 to measure pupils of similar attainment levels from the end of primary school to the end of secondary school (DfE, 2016).

Furthermore, the Department for Education argue that it also encourages schools to offer a broad and balanced curriculum (DfE, 2016). Morris (2012) argues that the government have used curriculum freedom in academies to tempt more schools to follow suit, rather than leading a genuine national debate about the future needs of children in all schools. The described process of deregulation of allowing schools to set their own curriculum outside of the National Curriculum makes the educational process one that can also be turned into a market. Marketization of the education sector allows businesses to buy a stake in academies, which can be seen as one of the main reasons behind the government backing this development for economic gain (Mansell & Boffey, 2016). The Department for Education (2014) reveal that school sponsors have an obligation to improve each school's performance. Mansell & Boffey (2016) are critical of this, arguing that schools are enticed into becoming multi-academy trusts, because there is a greater amount of financial backing available from sponsors, than under local authority control. However, there have been recent high-profile cases of this method failing to support schools, leaving large numbers of schools and children in a state of limbo. Perraudin (2017) states the government have encouraged many schools to join multi-academy trusts, promoting them as a support system for schools. However, DfE figures reveal that 40,000 children in 64 academy schools are at present waiting to find new sponsors, after being abandoned by, or stripped from, the trust that originally managed them (Perraudin, 2017). The literature exposes the fact that schools are changing their status for economic purposes, rather than educational purposes. Further statistics from YouGov show that 1 in 5 teachers think that changing their school to academy status will not improve their children's overall achievement in assessments (Dahlgreen, 2016).

At present, all maintained schools require their teachers to have qualified teacher status, however academies and free schools can hire untrained teaching professionals. The conservative government say this development allows schools to hire 'brilliant' individuals that will help improve standards at a faster rate (DfE, 2012). Petty (2012) supports this claim, stating that any person who excels at the interview stage should be given a job whether qualified or not. Others argue that schools are only hiring un-qualified teachers as a way of saving money (Shepherd, 2013). However, statistics reveal 59% of 2,300 teachers said their unqualified colleagues were teaching lessons, assessing children's progress and preparing them for assessments (Shepherd, 2013). The NASUWT Teachers Union (2016) state that since 2015, there has been a 22% increase in the number of unqualified staff employed by schools. It is argued that this places the ability of the education system, to raise standards at significant risk (NASUWT, 2016). This completely contradicts the Department for Education's aim for education, which is to raise standards and ensure that all children are given the same standard of education. If our schools have unqualified teachers working alongside qualified peers, standards of teaching are going to vary which may affect levels of achievement in key stage assessments. This literature shows that the latest developments and reform to the current system is resembling that of the 1900's, with vast differences in the quality of teaching within many different types of schools. It is also important to highlight that despite the different types of schools, each of them is required to take the same summative assessments, which could be a reason for the imbalance of achievement.

2.3 Mathematics education

The research carried out in this study will be focusing on a mathematics computer game. Therefore, it is important to examine how mathematics has developed in schools and whether it is possible for assessments using computer games might be used in the future. The section will explore some of key developments to mathematics education in Britain and how it has advanced to its current form in the National Curriculum. There will be a discussion on how the subject of mathematics has become one that is rigorously assessed and compared internationally and if our children are keeping up with other top-performing nations.

2.3.1 A brief summary of key developments to mathematics education in Britain

It is said that mathematics is nearly as old as humanity itself and has evolved over time from simple counting, calculation, measurement, the study of shapes and motions of physical objects to the complex and abstract discipline in today's society (Howson, 2008). Smith (2004, p.11) states that "mathematics provides a powerful universal language and intellectual toolkit for abstraction, generalisation and synthesis". However, mathematical advances have been brought about by early civilisations such as Mesopotamia, Ancient Egypt and developments of Ancient Greece (Hodgkin, 2005). This study cannot give a comprehensive history of mathematics education but will instead concentrate on the more recent history of mathematics education in Britain. The earliest schools in Britain on record belonged to the Church, with a curriculum that aimed to distribute Christianity across the country (Howson, 2008). However, Hodgkin (2005) states that it is difficult to pin-point the exact time when mathematics was first taught. Gillard (2011) states that St. Augustine, who arrived in Britain in A.D. 597, began the process of setting up grammar schools and song schools. St. Augustine's concept of education came from the Roman and Hellenistic schools, which included seven liberal arts of grammar, logic, arithmetic, geometry, astronomy, music and rhetoric (Gillard, 2011). However, one theory is that Theodore, the Archbishop of Canterbury in the seventh century, taught arithmetic to groups of disciples for the purposes of calculations regarding Easter (Hodgkin, 2005). This early use of Mathematics was also used in the year A.D. 776 in York by the schoolmaster Alcuin, who continued to centre mathematics teaching around the church calendar.

It was not until the 1600 – 1700's, where Universities such as Cambridge and Oxford were making serious developments in mathematics, but the subject was only accessible to privileged elite (Gillard, 2011). It took the industrial revolution in the late 18th century for the government to see a purpose of providing a national education system, that involved more than teaching just low-level reading skills to the masses (Gillard, 2011). Also, with a more industrialised society the country required people to become numerate as well as literate, to maintain a strong economic position ahead of countries, such as Germany and the United States (Bartlett and Burton, 2012). The Revised Code of 1862 laid down conditions for schools to ensure children were reaching one of six standards in arithmetic, in order to receive school funding (Bartlett and Burton, 2012). However, it was the Elementary Education Act of 1870 which really opened up basic mathematics to the working classes, which had previously been a subject taught to the middle and upper classes of society (Hodgkin, 2005). Bartlett and Burton (2012) state that this act gave all children the opportunity to learn basic arithmetic as it became a compulsory school subject. Despite this, Gillard (2011) states it wasn't until 1880 when it became compulsory for children aged between five and ten to attend school. This literature shows how mathematics was slowly developing in society, from being something that was regarded as a subject only for those of privilege, to a nationally required skill in order for Britain to stay competitive with the rest of the world.

The elementary system was fairly established by 1902, when the Balfour Education Act legislated for the development of grammar and secondary schools, as well as creating a free place system for a small number of poorer able children (Bartlett and Burton, 2012). Moreover, secondary schools at this time were still fee-paying and populated by the middle classes (Bartlett and Burton, 2012). Gillard (2011) states that these secondary schools often borrowed the private school's academic curriculum, which included mathematics. However, by 1944, only 10% of children had a secondary school place, with many children staying at elementary school until the age of 14 (Bartlett and Burton, 2012). Mathematics became more dominant in the curriculum after the 1944 Education Act. The act increased the compulsory education age to 5 – 15 and split schools into primary, secondary and further education categories (Bartlett and Burton, 2012). According to Gillard (2011), the tripartite system that was introduced in this act, became the first measure by which primary schools were judged, as children were now tested by the 11-plus exam. Furthermore, this new system put pressure on primary schools, forcing them to emphasize teaching literacy and numeracy in order to ensure good results in the 11-plus examinations (Gillard, 2011). Howson (2008) supports this view, stating that pressure on schools was high, and success in the 11-plus exam showed which schools were effective primary educators. As previously mentioned in section 2.2.3, children who achieved high scores in this exam would progress to the grammar schools, with lower scores heading onto the secondary modern schools. Howson (2008) describes how mathematics education in the secondary modern schools was becoming problematic.

A new curriculum had to be developed fairly quickly. In addition, there was a serious shortage of highly qualified mathematics teachers in these schools, with many opting to teach in grammar school system (Howson, 2008). This is concerning, because in 1961 there was 53.8% of children in secondary modern schools, compared to 22.1% in grammar schools (Howson, 2008). Smith (2007) states that many areas had a limited number of academic places in the grammar schools. For example, in Rutland only 15% of children were deemed to be suitable for grammar schools, compared to 30% in Croydon. This could be a reason why the number of children in grammar schools in 1961 was so low, because some areas only saw a small percentage of children as suitable for that type of education. The literature shows that despite many decades passing since mathematics was first made available to all children, there was still a great divide in the school system and in the quality of mathematics teaching, with authorities still selecting those they thought would fit the grammar school mould. This meant that a large proportion of children would not be taught the same standard of mathematics of those in the grammar school system.

Mathematics in schools developed even further during the 1980's, with the comprehensive education system and the introduction of the National Curriculum. Margaret Thatcher's Conservative government were now taking control over what would be taught in schools, with mathematics being classed as a core subject, alongside English and science (Gillard, 2011). Children were now expected to reach attainment targets in mathematics at the end of each key stage, with GCSE mathematics assessments taking place at the end their secondary education (Bartlett and Burton, 2012). Lippsett (2008) argues that the changes made in 1988, had given education a more coherent structure, but the curriculum was too prescriptive and narrowed classroom learning to focus more on core subjects, such as English, mathematics and science.

Mathematics assessments, otherwise known as SATS were introduced into primary education in 1995, with children being tested at the end of Key Stage 1 and Key Stage 2 (Bartlett and Burton, 2012). However, concerns were growing in 1995 over the standards of mathematics in primary schools, after the first national Key stage 2 assessments (DfE, 2010). Furthermore, DfE (2010) stated that time spent learning mathematics varied considerably across schools, with many not integrating the subject effectively into everyday learning. In 1997, the newly appointed Labour government introduced the National Numeracy Pilot, which later became the National Numeracy Strategy (DfE, 2010). This strategy also chose to use the word ‘numeracy’ synonymously with ‘mathematics’, thus everything in the primary mathematics curriculum became numeracy and that is how it has stayed until the present day (Haylock, 2014). Furthermore, it suggested that all primary schools must teach numeracy for at least one hour per day, consisting of direct whole-class teaching and that schools must have a framework to secure the planning of progression (Gillard, 2011). Appendix 4 shows the percentage of primary school children achieving level 4 and 5 over a fifteen-year period. There is a clear increase in the number of children reaching level 4, but very little movement of the number of children reaching level 5. Ofsted (2010) were critical of the National Strategies, stating that in a third of primary schools and more than half of secondary schools had not rooted out the weaknesses in basic teacher skills. Furthermore, Ofsted (2010) recommended at the time, that schools should prepare for a transition towards a new system, which would see an end of the National Strategies. However, Shepherd (2010) reported that some teachers found the National Numeracy Strategy useful, as it helped them to focus on improving standards in their classrooms.

Children in schools of today learn a lot more about mathematics than those educated in previous systems, whereby only basic arithmetic skills were taught. Teachers in the current education system have to ensure children develop skills and knowledge in counting, place value, number systems, the structures of the four basic number operations, mental strategies, written methods for calculations, fractions, ratios, rounding, properties of numbers, calculations with decimals, percentages, proportionality, algebraic thinking, measurements, geometry and statistics (DfE, 2015). Additionally, children are taught to apply their mathematics to both routine and non-routine problems, which includes breaking down complex problems into a number of simpler steps (DfE, 2014). However, the Department for Education (2014, p5.1) states “Teachers should use every relevant subject to develop pupils’ mathematical fluency”. Moreover, the government believe that if children can develop confidence and skills in numeracy, they will experience success right across the curriculum (DfE, 2014). DfE (2015) also mentions that the reason why teachers should develop their children’s mathematical skills in all subjects, is that this helps them appreciate and understand the importance of mathematics. Despite this, Haylock (2014) states that evidence shows many primary teachers experience feelings of panic and anxiety when faced with unfamiliar mathematical tasks in the National Curriculum. Further research also suggests that teachers own anxieties about mathematics can often be passed on to the children they teach (Haylock, 2014).

This raises some questions whether the mathematics curriculum of today is fit for purpose, whether teachers are struggling with government pressure of ensuring all children are developing key mathematical skills, and whether teachers own anxieties are affecting children’s achievement in the subject. Hanson (2014) thinks that the current mathematics curriculum is placing too much pressure on children to learn these skills from a young age. Furthermore, the government’s actions of ignoring key research into mathematics teaching, has the potential to seriously damage children’s learning, breaching Section 78 of the

Education Act 2002, which requires that the National Curriculum promotes the mental development of children (Hanson, 2014).

There have also been developments into how mathematics is taught in secondary education. Schools are now having to set children on ability in mathematics and a number of other subjects (Gillard, 2011). In 1997, Ofsted suggested that organising children into set groups of ability would significantly improve standards (Sukhnandan and Lee, 1998). This was supported by the Labour government in 1997, with the White Paper Excellence in Schools stating, “Unless a school can demonstrate that it is getting better than expected results through a different approach, we do make the presumption that setting should be the norm in secondary schools.” (cited in Boaler et al., 2000). Research by Boaler (2000) contradicts this theory, with evidence revealing that achievement levels of lower ability children in a set classroom are in fact lower, than those of similar ability in a mixed ability classroom. Bloom (2017) supports this view, stating that research has shown for a long time that even whilst small achievement gains are made by higher-achieving children using this method, the impact on lower-attaining groups is negative. Furthermore, in a study of GCSE mathematics results, it was also discovered that children in set ability groups became progressively dissatisfied with learning and that many of the children who were negatively affected were the most able (Boaler, 2000). Bloom (2017) states that schools are still harming lower-ability children’s chances of success in mathematics by continuing to set by ability. Cook (2014) states that as of 2014, 94% of British secondary school children were grouped by ability for mathematics. Despite this, the government claims that standards in mathematics are slowly increasing when compared to other countries around the world, although statistics reveal that the UK is gradually falling behind (DfE, 2010, OECD, 2015).

2.3.2 International assessment of mathematics

In the last few decades, mathematics achievement in schools has been assessed internationally, closely scrutinised by governments which has led to frequent changes to policy

(Ward, 2018). One of the latest examples of a change to policy in mathematics, is the government introducing East Asian-style teaching methods (Ward, 2018). This is most likely because the countries in East Asia, are the highest achieving in the international mathematics assessments. However, the first sign of an international comparative study of educational achievement in mathematics, came in 1961 by The First International Mathematics Study (FIMS) (Loveless, 2007). Loveless (2007) states that mathematics was chosen as the subject of the first international study of children's achievement for a number of reasons. The first reason being how important mathematics had become to education and society. Furthermore, countries around the world were becoming concerned with improving technology and science, and these are based in a fundamental way on the learning of mathematics. Additionally, studies into the teaching of mathematics and the curriculum, suggested that most countries were using similar approaches, so it was feasible that an international test could be constructed and be acceptable to fit with most countries curricula (Loveless, 2007). In more recent times, the first international assessment of mathematics was conducted by TIMSS (the Trends in International Mathematics and Science Study) in 1995, which was soon followed by the PISA (Programme for International Student Assessment). The TIMSS assessments test children's mathematical knowledge every four years at Key Stage 2 and Key Stage 3 level (TIMSS, 2016). On the other hand, the PISA assessments aim to evaluate education systems worldwide by testing the mathematical knowledge of children at KS4 level, every three years (OECD, 2018). When examining the TIMSS mathematics results in 2015, England's Key Stage 2 results revealed a score of 546 (Appendix 5), a slight increase of four points since the previous test in 2011 and gave them a position of 10th in the international rankings (TIMSS, 2015). The Key Stage 3 results show another increase with a score of 518, which was up by 11 points compared with the previous assessment, however, England's international ranking slipped from 10th to 11th place (TIMSS, 2015). Furthermore, Northern Ireland finished 6th in the Key Stage 2 assessments. School standards minister, Nick Gibb (cited in Adams & Weale, 2016) stated that these results show how our children are more engaged and confident in mathematics compared with some of the highest achieving countries. However, when examining the PISA test scores in mathematics at Key Stage 4 level (Appendix 6), the United Kingdom scored 492. This score was down two points compared to the previous assessment, meaning the UK had fallen from 26th to 27th in the international league tables and was the lowest position since the tests were first introduced.

These assessment results clearly show that standards are decreasing as children progress through the education system. Adams & Weale (2016) argue that teachers in the UK have much lower job satisfaction when compared with other countries and that a shortage of experienced mathematics teachers is having an impact on children’s attainment. However, further questions need to be raised about the reliability of these international mathematics assessments. Adams and Weale (2016) state that the results of the TIMSS assessments can be misleading, because each time these tests are taken, there are a different set of countries included. Sands (2017) states that in the case of the PISA assessments, the OECD only select a small sample of children to represent the full population of each countries education system. Furthermore, it is argued that the reliability of these mathematics tests should be questioned even further, with Argentina and China being allowed to take a sample of scores from their most educated cities or regions. Garner (2017) shares a similar view on the reliability, stating that China which topped the rankings, had only entered its best-performing schools in Shanghai for the tests. In addition, Finland, who also ranked in the higher echelons of the PISA league table, entered children that were on average a year older than those assessed in other countries, like France and Italy (Garner, 2017). If our government is using this data to make changes to policy and mathematics education in the UK, it is worrying, because it appears these assessments are far from being a reliable source.

2.4 Summative assessment in British schools

This section will explore the summative assessment method used in British education. The limitations to this approach will be examined, looking at the potential problems it causes both teachers and children. Additionally, I want to see if critical thinking and methods of teaching are affected by these assessments. There will also be further discussion on the international focus around summative assessments, which expands on the previous section discussed in 2.3.2. Finally, this section will look at the GCSE tiered exam structures, as well as the current achievement levels of socially disadvantaged children are affected by current approaches.

2.4.1 The limitations of current assessment methods used in schools

Summative assessments have become the most important method of tracking educational outcomes and summarising what children know or can do at certain times (Harlen, 2003). However, the effectiveness of testing in schools is often a controversial issue. The TGAT Report in 1988 recommended that assessment in the National Curriculum should include different forms such as formative, diagnostic, summative and evaluative (DfES, 1988). It stated that the basis of a national assessment system should be formative but designed to indicate areas needing more detailed assessment of the child. Further recommendations were that assessment should only be summative at the end of secondary education, because before that point it is unnecessary and possibly damaging to children (DfES, 1988). Gillard (2010) describes a political decision was made, that all key stages of education should be assessed using the summative method. Kelly (2009) is critical of this decision, stating there can be no justification for summative assessment methods in primary or early secondary education, other than the desire to focus on the evaluative function of assessment, with schools judged against national benchmarks through the publication of league tables. Pollard (2014) is equally critical, arguing that the judgements assessment creates on school quality puts immense pressure on teachers to perform well. Erskine (2014) supports this view, stating that current testing methods are a major problem, because they are the only measure determining the success of children, teaching staff and schools. Additionally, this approach may reveal weaker areas of a child's learning but cannot explain the reasons why. This theory is supported by Kelly (2009), arguing that formal testing only assesses levels of teaching and learning, and it is not effective in assessing educational progress. However, it is said that good summative testing is important, with the intention that well-designed tests should be reliable, valid and fit for purpose, to ensure student attainment is accurately assessed (Butt, 2010). According to Le Cordeur (2014), assessment is an integral part of education, not just for monitoring learners' performance, but is also a vital instrument to improve teaching in schools. This statement is supported by the DfE (2013), who state that current assessment methods are crucial for effective teaching, external school-level accountability and national benchmarking. Despite this, Asthana (2018) states that children in British schools are some of the most over-assessed in the modern world. The award-winning teacher, Nancy Atwell, argues that testing damages standards and decimates morale among teachers (Coughlan, 2015).

It is important to recognise that the literature in favour of the summative assessment approach only discusses the benefits to teaching practice, whilst failing to identify any benefits this may have on children. The Nuffield Foundation (2003) state that when the results of assessments are used to pass judgments on schools and teachers, they also affect the methods in which children are taught.

2.4.2 Critical thinking and methods of teaching

Critical thinking is regarded as an essential requirement for responsible human activity, allowing people to make autonomous decisions and question beliefs that are not based on solid evidence (Gelerstein, et al., 2016). However, it is said that summative assessment is leading children down a path of absorbing facts to memorise, limiting time in the curriculum for activities that promote critical thinking skills (The Nuffield Foundation, 2003). Mayo (2012) shares this view, stating that children are now being rewarded for memorisation in tests, more so than using their imagination, creativity and critical understanding of the world. Hennessy (2004) states that typical classroom teaching does not do much for critical thinking, with schools preferring to focus on mastering facts and techniques in the core subjects in order improve assessment results. The Nuffield Foundation (2003) argue that summative assessments are encouraging methods of teaching that promote superficial learning, rather than deep conceptual understanding. Morse (2012) argues that critical thinking is key for advancing children's cognitive ability, reflective ability and increasing their levels of achievement in school. Henry Giroux is a key theorist of critical pedagogy and argues that it is vital for maintaining democracy by developing children into engaged members of society (Giroux 2001, Giroux 2011). Moreover, to develop these children into those who question practices, policies and people, and affirm the value of diverse knowledge and opinions (Giroux 2001, Giroux 2011). Giroux also suggests that high stakes assessments have limited a teacher's autonomy and devalued the teaching of critical thinking (Steinberg & Kirylo, 2013). Current teaching practices can also be linked to Freire's banking model, whereby students are empty vessels into which the teacher deposits knowledge (Freire, 1972). Additionally, the depositing of knowledge into the passive student excludes them from active participation in developing first-hand knowledge, resulting with them becoming dependant on other's (Freire, 1972). The DfE (2010) state that the National Curriculum provides rich and varied contexts which should enable children to think creatively and critically to solve problems. However, Ab Kadir (2017) disputes this claim, stating that teachers who are tasked with teaching critical thinking and developing critical thinkers, are not prepared for it due to mandated educational policies. Furthermore, Andrews (2009) argues that assessment has led curriculum reform, causing an increasingly narrowed and prescriptive curriculum that rarely permits children to articulate their ideas and think critically. This section of the literature suggests that assessment is restricting teaching methods that aim to promote higher order thinking skills, which is said to be damaging children's ability to think critically and become autonomous learners.

2.4.3 International focus on assessment

In recent years, there has been a lot of focus surrounding the levels of achievement in schools internationally. Children's achievement in schools is now being measured internationally, with governments competing to be the highest achieving nation. Achievement is measured globally through the Programme of International Assessment (PISA), Progress in International

Reading Literacy Study (PIRLS) and Trends in International Mathematics and Science Study (TIMSS) (PISA, 2016 & IEA, 2017). Gurney-Read, (2016) states that these international assessments are becoming a major point of comparison for governments. The PISA assessments were launched in 2000, with students from 72 countries being tested in reading, mathematics and Science (OECD, 2015). This international focus on core subjects has seen their profile rise above all other curriculum subjects, increasing pressure on teachers and children to achieve the highest results. Kelly (2009) is critical of this and believes that for children to become highly education, the school curriculum must view all subjects with equal importance. Lloyd (2014) states that most international governments agree that a highly educated country will be successful in world markets. This is further proof that education is moving in the direction of becoming commodified under the neoliberal ideologies of our government. Garner (2017) states that the government hangs on every word that comes out of tests like PIRLS, TIMSS and PISA rankings. Robinson & Aronica (2015) support this view, arguing that the British government use these international assessment results to justify educational reforms. Wilby (2014) is critical of the assessments, stating that leading educationalists see them as damaging, leading the government to make short team fixes to move up the international leader board. However, the director of the Organisation for Economic Cooperation and Development (OECD), Andreas Schleicher argues the tests help schools and governments to learn from higher achieving nations (OECD, 2016). Despite this, there are serious questions about the reliability of these test results (see section 2.3.2). The literature discussed here shows that international summative assessments are raising the profile of the core subjects even further, which is limiting children's learning time in other curriculum areas. Additionally, they are placing added pressure on schools to raise standards and there are clear issues over the reliability of the results produced in these assessments.

2.4.4 Tiered assessments in secondary education

When analysing literature surrounding secondary school GCSE's, it appears that further limitations can be found in the tiered exam system. The GCSE qualifications are of high importance to children in secondary education, because higher achievement, especially in the core subjects, enables access to further education and better career opportunities. Harlen (2003) thinks that testing the core subjects can have strong effects on the lives and careers of young people. However, some children in secondary schools are being denied the opportunity to achieve the highest grades in these subjects, due to a tiered exam structure. A report in 2004 stated that there was great concern over tiered exams in mathematics, as this system prevented many children from being able to achieve a C grade (Smith, 2004). The Department for Education (2013, p.6) argue that “in order for British pupils to compete internationally, we need to make sure that the level of challenge is set correctly”. The Office of Qualifications and Examinations Regulation (Ofqual) state that the current assessment structure helps target different levels of achievement, so children find the process challenging but also suitable (Ofqual, 2013). Recent reform to GCSE’s changed the grading system from letters to a number format, with foundation level assessments being graded from G-C and the higher-level assessments E-A. Oates (2013) supports this exam structure, stating that children take exams suited to their ability. However, Ofqual (2013) state that most schools will steer middle ability children in the direction of the foundation assessment, because the C grade is easier to achieve. Nillson (2013) supports this claim, arguing that schools are gaming the system to increase the number of C grades achieved. This literature reveals that the tiered high stakes assessment structure is failing, as it is encouraging schools to gatekeep children’s’ achievement, in order to increase the numbers of C grades and therefore improving their place in the league tables. Furthermore, it can also have major effects on children’s aspirations, limits their progression throughout life and it fails to close the gap of achievement within our education system.

2.4.5 The effects of social disadvantage on assessments

Historically, the upper classes in British society have performed better in school assessments, compared to children from poorer working-class families. Recent studies reveal that social class remains the strongest predictor of academic success (Bloom, 2016). This suggests that current assessments are not an appropriate method for judging children's academic achievement, as there are significant differences in outcomes between children at opposite ends of the social ladder.

The cultural, economic and social capital of families is often seen as a major factor effecting children's' level of achievement. This can be seen previously in section 2.2.3, which discussed the tripartite system and how middle-class parents used their experiences and knowledge to prepare children for the 11+ exam (Harris & Rose, 2013). Edgerton et al., (2014) state that middle class parents have a greater involvement and understanding of their children's learning compared to working class parents. Ciabattari (2010) states that historically, working class parents do not have the same level of knowledge and social experience as middle-class parents and generally rely on the teacher to direct their child's learning. This can be linked to Pierre Bourdieu's theory which states that cultural capital involves familiarity with the dominant culture and, particularly the ability to understand and use 'educated' language (Bourdieu & Passeron , 1990). Moreover, the possession of cultural capital varies with social class, however, the education system assumes the possession of cultural capital. So, it becomes difficult for lower-class children to succeed in the education system (Bourdieu & Passeron , 1990). Furthermore, Bourdieu argues that social inequalities are legitimated by the educational credentials held by people in the dominant positions in society (Bourdieu & Passeron, 1990). Sullivan (2002) argues this means that the education system plays a key role in maintaining the status quo. Edgerton et al., (2014) suggests that families will pass on their educational values based on their own experiences of education. Hill and Cole (2004) argue that this advantage middle class children possess, has further increased the achievement gap in assessments. However, the DfE (2015) state that the National Curriculum ensures that there are no barriers to children's achievement.

Bernstein's sociolinguistic theory of language suggests that children from middle class backgrounds have the ability to use elaborated code to convey ideas (Berstein, 2003). This benefits these children, because they are more able to express ideas and facts in assessments. Additionally, Benstein (2003) states that although children from working class families may still be able to express themselves orally on the same level as the middle-class children, their ability to express ideas and facts in written form will not be of the same standard. This outcome means children who are not proficient in the linguistic skills required in schools are defined as failures or lacking intelligence, simply by virtue of the way they relate to the world (Bernstein, 2003). This is supported by Bloom (2016), who argues that the language required in assessments is suited for middle class children. Moreover, it is also argued that standardised tests measure middle class knowledge, which is ‘owned’ by those in power, therefore oppressing those from poorer backgrounds (Kohn & McConaghy, 2000). In addition, Bloom (2016) states this is evident in the KS2 reading assessment, which tests children’s vocabulary knowledge, instead of their reading ability. This literature reveals that middle-class children have a superior foundation knowledge of vocabulary and language, which will give them a greater advantage in assessments.

There is statistical evidence to support this theory that summative assessment favour children from the higher social classes. Taylor (2006) reveals a study of 400,000 children, which states that whatever background a child comes from, they almost certainly do better in assessments when in middle class schools. In affluent areas of London, children achieving five or more A-C GCSE’s was 95%. However, when this is compared to socially deprived areas in the Midlands, children achieving the same results was a mere 24% (Taylor, 2006). The latest government statistics support this further, with the highest scoring ethnic group for achieving five or more GCSE’s being Chinese children with 74%. When this is compared with black and white children, they score 53% and 56% respectively (DfE, 2015). However, when analysing the same ethnic groups that are eligible for free school meals (FSM), a key indicator of social disadvantage, the outcomes are even lower. Figures show a decline in all three groups with the Chinese children scoring 57%, black children scoring 46% and white children scoring 30% (DfE, 2015).

The success of children in high stakes assessments can affect their aspirations for future careers. Research reveals that children from middle class families are more likely to progress onto higher education courses and enter professional occupations (Bolton, 2010). This contradicts the government's theory that our education system allows all to achieve. Bartlett and Burton (2012) discuss that out of one hundred groups of parents from professional careers, 66% of their children acquired a degree and went on to work in professional occupations. Compare this to children from working class families with 7% of children acquiring a degree. It could be argued that this evidence reveals the results of summative assessments are affecting children's aspirations.

2.5 Computer game learning & stealth assessment

This section will explore literature on computer-game learning and stealth assessment, to see what value it has to children's learning. In addition, to see if it has the potential to be used more often by schools to enhance the curriculum and teaching. This section will also discuss the reasons for and against the use of computer games, looking at the potential benefits to children, teachers and society. Furthermore, there will be an analysis of the potential barriers when using computer games in the classroom. Finally, it will discuss the literature related to stealth assessment, looking at whether this could benefit children's overall development and enhance teacher's formative assessment in the classroom.

2.5.1 Computer game learning

The UK games industry is continuously growing, and it was valued at £4.33 billion in 2016, up 1.2% from 2015 (Hebblethwaite, 2017). Additionally, the amount of time children play computer games continues to increase year on year (Escobar-Chaves & Anderson, 2008). When video games first appeared on the market, their design was not for educating people in mathematics, literacy or aspects of ancient history. Loo (2017) states the entertaining nature of video games caused them to develop a negative reputation for rotting children's brains or distracting them from school work. McVeigh (2001) reported on a controversial study in 2001, sharing this negative perspective, that computer games are stunting the developing minds of children and creating a dumbed-down generation. Walker (2016) is equally critical, arguing that the time spent, and addictiveness of games has resulted in children losing touch with reality. Despite this, there has been a vast amount of research that proves playing computer games is actually beneficial to children's development. Digital gaming has shown to be positively related to a number of cognitive skills, such as problem solving and critical thinking (Webb, et al., 2013). Research in Australia analysed data from 12,000 secondary school pupils, discovering that those who played computer games achieved higher scores in the science, mathematics and reading PISA assessments (Gibbs, 2016). Wouters et al., (2013) argues that when pupils play computer games for more than a single session, it leads to more beneficial learning outcomes than conventional learning methods. Furthermore, Wouters et al., (2013) states that in comparison to traditional learning approaches in the classroom, the benefits of playing a computer game may only pay off after pupils have had multiple sessions, in order for them to get used to the game. This is supported by Clark et al., (2016) who states that when playing computer games over multiple sessions, it can lead to significantly better learning when compared to playing for a single session. Furthermore, a recent study from Columbia University showed that high digital gaming usage by children aged between 6-11 years old, greatly increased their critical thinking and overall school competence (Gibbs, 2016). Research by Daphne Bavelier (2012) a cognitive research specialist, supports this view, arguing that gaming when consumed responsibly in small doses can have powerful impacts on children, enhancing brain plasticity, learning, attention and vision.

2.5.2 Why should computer games be considered for use in schools?

A recent study has indicated that computer games, even violent ones, can help children develop essential intellectual and emotional skills that support academic achievement (Granic, et al., 2014). Computer games are now being used in ways that educate and inform children on many different levels. Anderson (2012) argues that games can provide schools and children with many exciting teaching and learning opportunities. Loo (2017) states that teachers around the world are gradually recognising the benefits of game-based learning in their curricula. However, there are some that still believe education authorities are reluctant to allow computer games to transform the curriculum. Psotka (2013) states that technology such as computer games is pushing fundamental change in education, but education is not willing to make the changes to adopt it. Furthermore, Psotka (2013) states that schools 30 years ago found it easy to incorporate computers, as this technology did little more than turn pages of text or provide simple drill and practise mathematical problems. However, many schools and teachers are waiting for definitive evidence that computer game environments are more effective than traditional teaching methods (Psotka, 2013). Robinson (2010) thinks the standardisation of teaching in Britain favours direct instruction of factual information over methods that promote creativity and learning by doing. However, Smale (2013) states that computer games allow players to learn by doing things, with content knowledge easier to learn than direct instruction methods, because learners are immersed in activities and experiences that use these facts for plans, goals, and other purposes. Piaget believed that knowledge comes from personal experience and that learning should be supported by action (Piaget 2001). Moreover, children need to experiment actively with materials and experience things in the real world to develop thought (Piaget, 2001, Pound, 2012, Cohen, 2013). Smale (2011) thinks that if a child can play as a scientist, historian or city planner in a computer game, performing tasks that mimic real world jobs, then they have the opportunity to learn by doing.

Computer games have the ability to be used right across the curriculum and can be used to help children learn specific aspects of subjects. Anderson (2012) states there are so many examples of how computer games can be used by teachers to enhance classroom learning. The highly popular game Angry Birds can be used in mathematics to teach children about angles and trajectory (Anderson, 2012). Furthermore, BBC News (2017) gives an example of how one school have used Minecraft for cross curricular purposes, teaching children about mathematical concepts including perimeter, area, basic coding and linking it to aspects of history. Children used the game to construct a Bronze Age city, which also taught them about how ancient structures were built and how people lived during this period of time. Gould (2012) states that learning doesn’t always come from playing the game itself, but it can become the context for learning. An example of this could be Guitar Hero, which does not necessarily have much educational value. However, Gould (2012) states it can be played to inspire children to learn about and create a music project, with children designing CD cases or learning about how to market a band. Nevertheless, Stuart (2011) states that the government are slowly acknowledging the value of computer games, but their outdated concepts of technology and learning is part of a lingering belief that computers should be used merely for information retrieval and reward systems within a traditional education system.

Schools are often under extreme pressure to create learning environments where all learning types are catered for. It can also be difficult for teachers and schools to provide every child with individualised learning plans. However, Plass et al., (2012) states that computer games have the ability to adjust gameplay based on children’s past actions and decisions. Furthermore, a game experience can be tailored to a child’s preference or performance (Plass et al., 2012). With some educational games, if a child solves a problem correctly it is possible for the game to adjust the difficulty to become more challenging (Loo, 2017). Additionally, if they struggle with a concept, it can either present the same concept in a different context or change the difficulty until the child has demonstrated a mastery of that skill (Loo, 2017). Plass et al., (2012) argues that if games have a balance of enjoyment with appropriate levels of challenge, they have the ability to keep children in their own unique engaging and challenging zone for learning.

As technology develops over time and society becomes more advanced, certain jobs are going to disappear and be replaced by new ones. Loo (2017) states that computer games can become a powerful tool for schools, because they allow children to become familiar and interested with technology from an early age. Furthermore, games have the ability to teach children basic technical skills that will help in later life (Granic, et al., 2014). Lord Baker (cited in Peters, 2017) argues that the current education system is not fit for purpose and that schools need to be training children for the jobs of tomorrow, providing them with a range of skills, not just academic subjects. This is interesting, because Lord Baker was the education secretary that first introduced the National Curriculum under Margaret Thatcher's conservative government. Furthermore, Lord Baker (cited in Peters, 2017) states that children need to have good team work and problem-solving skills to succeed in modern society. Loo (2017) argues that computer games have the ability to develop children's reasoning, memory, perception and problem-solving skills, all of which are important for a number of technical careers. Watson et al., (2016) agrees, stating that computer games are well suited for educating children in preparation for working in today's knowledge economy. This literature suggests that in order for our society to move forward with technological advancements and evolving professions, we need to be providing children with the tools from an early age which equip them with skills for the careers of the future.

2.5.3 Potential barriers to computer game learning

Despite the many benefits previously mentioned, there may also be certain barriers to overcome. Watson et al., (2016) states there are still some people in education that maintain the firm stance that computer games are not suitable for the school setting and should not have a place in any classroom. However, Sandford et al., (2006) argues that the numbers of educators who are already using games in their teaching practice are growing steadily. It must be pointed out that there are numerous barriers to incorporating computer games into everyday classroom practice, however mounting research in this field is suggesting that there are great benefits to children's cognitive, social, emotional well-being when using games for educational purposes (Anderson, 2012, Plass et al., 2012, Granic et al., 2014, Shute et al., 2016, Watson et al., 2016).

Two potential barriers to overcome are time and the cost of equipment. Some computer games require time for both teachers and students to learn, which may be perceived as better spent on traditional methods of learning (Smale, 2011). However, Watson et al., (2011) argues that time should not be an issue, because today's pupils have the ability to figure out gaming problems very easily. Furthermore, Marsh (2007) supports this view, stating that once children and teachers become familiar with computer-based programmes, it can in fact save time, with teachers able to gain immediate information of their pupil's learning. Williamson (2009) states that the dominant barriers are logistical, with the high cost of software and a lack of licensing agreements meaning most game titles are restricted to being played on one PC. Additional barriers also surround this issue, with the possibility of needing technical support staff to help within the classroom, which carries an extra cost of training or employing new staff (Smale, 2011). Sandford et al., supports this view stating that there are a variety of technical hurdles to overcome when using games in the classroom, such as the setting up process and also the copyright protection features of some games. Moreover, Sandford et al., (2006) argues that technical support staff are vital to ensure teachers overcome these difficulties. Smale (2011) states that schools also need to consider the cost associated with game materials and supplies. The National Association of Head Teachers (cited in Ferguson, 2016) states that due to inadequate government funding, schools are asking parents to contribute funds for new technological equipment. Therefore, unless the government increases the education budget for schools, it will be impossible to implement educational technology that supports computer-game learning in all classrooms. This literature suggests that schools will need technical support staff to not only support teachers with introducing game-based learning, but also to overcome technical issues that may arise during gameplay. The financial difficulties some schools face under the current government may influence budget discussions on the idea of using computer-game learning, because the additional costs of equipment, training and employing technical support staff may not be worthwhile.

There are further barriers relating to the teachers themselves, with some feeling a lack of experience or their inadequate skills of playing games prevents them from fully adopting computer games into the classroom (Watson & Yang, 2016). Furthermore, some adult perceptions of computer games can also affect their use within the classroom. Watson & Yang (2016) describe how negative views of computer games amongst parents and teachers can often see this method of learning shelved for more traditional practices. A study in 2006 looking at teaching with games, found that there was a generational divide, with 72% of teachers never playing computer games (Sandford, et al., 2006). However, it was discovered that 67% of younger teachers aged between 25- 34, with less than 5 years teaching experience, wanted to use computer games within their classrooms (Sandford, et al., 2006). Additionally, the study also revealed that teachers' lack of experience playing computer games should not be an issue, and that the meaningful use of game-based learning depended much more on their curriculum knowledge, their working context and the effective use of their existing teaching skills (Sandford, et al., 2006). However, a further study in 2009 of 1,600 teachers in British schools found that a little under half of them believed that playing computer games can lead young people to develop antisocial behaviours (Williamson, 2009). To overcome the barriers mentioned, it will be important to change the attitudes of teachers and school leaders to realise computer games' full potential. This still seems a delicate barrier to overcome, because despite research showing some benefits, teachers still have certain reservations about children playing computer games. Watson et al., (2011) states that male and female teachers generally have different barriers when considering game-based learning. Research discovered that male teachers regarded the main challenge to be implementing game-based learning effectively, with female teachers finding challenges arise when using the technology and obtaining games as the main barriers (Watson et al., 2011). Stuart (2011) argues that the government and educators need to realise learning is no longer a linear commodity, and traditional skills that rely on repetition and memorisation are becoming outdated in a time of instant information retrieval. Stuart (2011) also states that computer games can teach us all how children will need to learn in the digital age; as active agents, using numerous simultaneous interactive resources. Once this has been achieved, educators will be more likely to make adjustments to budgets and to their curriculum planning to incorporate game-based learning into their classrooms. Furthermore, schools will require additional funding from the government to allow for this method to be adopted nationwide in every classroom.

2.5.4 Stealth Assessment

As discussed previously, traditional summative assessments are often too simplified and do not provide information on a child's full understanding. Kelly (2009) argues that new approaches to assessment are needed, and that the tasks we use to assess children should reveal how they go about solving a problem. Shute et al., (2013) shares a similar view, that schools need assessments that measure what students actually can do with the knowledge and skills they have already obtained. Digital games could be the answer, as they are able to provide children with meaningful assessment environments by giving them problems to solve which require the application of different skills. Smale (2011) states that some of the most promising uses for computer games for teaching and learning are new opportunities they provide for assessment. Stealth assessment is a method of testing that uses computer games to invisibly capture gameplay data. Interaction with the game leads to children being continuously challenged with complex tasks, which draw upon their problem solving, creative skills, understanding and knowledge of specific topics the teacher is aiming to assess (Shute & Ventura, 2013). The teacher then gains evidence of the child's knowledge from how they interact within the gaming environment. Kaya (2010) states that when children know they are being tested, test anxiety can often drag down performance. However, stealth assessment can be used to avoid test anxiety and administered without children knowing. Furthermore, it gives teachers information on a child's competencies, which can be used formatively for future planning and learner development (Shute & Ventura, 2013). Game-based learning has been highlighted as a powerful method for keeping children motivated and engaged in school (Shute & Ventura, 2013). Therefore, games are now being recognised as the future of learning in schools, and an alternative way of testing children's achievement (Shute & Ventura, 2013).

Shute et al., (2016) argues that the dynamic nature of stealth assessment allows schools to measure children's learning continually, with the teacher able to change the level of difficulty based on each child's outcome and provide them with vital information that can be used for future learning within the classroom. DeRosier et al., (2012) supports the use of stealth assessment, as it takes up minimal time and training of teachers, allowing them more time to act on results to enhance future learning. However, Kaya (2010) states that a large proportion of educators believe that computer games should only be used to supplement classroom learning, but not as tools for assessing children's learning. Plass et al., (2012) has a contrasting view, stating that computer games should be used to bridge the gap between learning in school and learning at home. With many educational computer games now having embedded assessment software, teachers have the opportunity to stealth assess and track children's progress playing these games for homework. Furthermore, by not restricting learning opportunities to time spent in the classroom, games can continue children's learning outside of school on devices such as laptops, tablets or even mobile phones.

The British government state that summative assessments help drive improvement in children (DfE, 2014). However, Harlen (2003) is critical of this view, stating current assessments fail to provide information on the full range of educational outcomes needed in today's society. Kelly (2009) supports this view, stating that current assessments fail to promote higher-order thinking. Kaya (2010) states that schools are being encouraged to pay more attention to improving children's higher-order thinking, due to the increasing recognition that these skills are needed to be competitive in the global market place. Despite the government acknowledging these skills are needed, their current assessment methods do not assist with the development of these skills. Shute et al., (2016) argues that well-designed digital games offer a practical alternative to assessing children's achievement, whilst also assist with developing problem solving and higher-order thinking skills that are needed in the 21st century. Webb et al., (2013) supports this view, stating stealth assessment will play a major part in transforming future assessment practices in schools that supports the needs of the learner and educational authorities. According to OECD (2014) there needs to be a shift towards supporting problem solving skills in school curricula and assessment, in order to tackle real-life problems. Therefore, the use of stealth assessment, which develops good problem-solving skills, is important for children to successfully navigate through school and their future careers. Further research in the United States revealed that stealth assessment through digital gaming enhanced children's cognitive outcomes, whilst enabling teachers to grasp the strengths and weaknesses of their children (Shute, et al., 2016). However, a limitation to this research was that it was only conducted on a small sample of pupils.

2.5.5 Stealth assessment and social development

Stealth assessment has also been used to test children's social development. Research by DeRosier et al., (2012) used a game called Zoo-U to test children's social skills. Children were presented with a series of social problems that needed to be solved. Results showed that levels of test related stress were much lower, student engagement increased by 96% and it highlighted which children needed extra social support. DeRosier et al., (2012) states that children with poor social skills are more likely to suffer from stress, anxiety and experience educational underachievement. However, research does reveal that children with stronger social skills have higher academic outcomes and improved resilience against stressful life events such as high stakes assessments (DeRosier, et al., 2012). This research using a game-based programme to stealth assess proved that this method can reduce stress and increase engagement with the learning (DeRosier, et al., 2012). It also allows teachers to identify children that are struggling socially, meaning interventions can be introduced to support children and enhance future learning (DeRosier, et al., 2012). Vygotsky's theories support this method, as he objected to measuring achievement through intelligence tests, believing that observing children how they go about certain tasks could reveal more about their understanding and development (Vygotsky & Kozulin, 1986, Mooney, 2013). Additionally, it can also be linked to his theory of scaffolding which relies on observations of what children can do and planning learning around their capabilities (Vygotsky & Kozulin, 1986, Mooney, 2013). Moreover, in order to scaffold well for children, teachers need to be keen observers. These observations need to inform where children are in the learning process and where they are capable of going, given their individual needs and the social context that surrounds them (Vygotsky & Kozulin, 1986, Mooney, 2013).

Further research was conducted in the UK in 2009, looking at what teachers gained from game-based learning activities. Interviews with the teachers revealed that social interactions and relationships were enhanced from using computer games (Williamson, 2009). Many teachers felt social interactions were an aspect often overlooked when using game-based learning in the classroom. However, interactions between children and between children and their teachers were shown to have strengthened (Williamson, 2009). Williamson (2009) states that this was because the children were able to take increased personal and collaborative ownership of tasks, with their teachers also granting them greater responsibility and recognition.

2.5.6 Stealth assessment promoting formative assessment methods

Stealth assessment, as previously discussed can have many positive outcomes on children's learning and assists teachers to better understand their children's knowledge on specific areas of the curriculum. However, it also promotes other forms of assessment such as formative assessment, which is argued can greatly enhance learning and achievement (Black & William, 1998, Marsh, 2007). Formative assessment, also known as Assessment for Learning (AfL) is an ongoing process conducted both formally and informally, by which evidence about a child's learning is collected and used to guide learning and future curricula planning (Department for Children, Schools & Families, 2008). This approach involves the teacher providing useful feedback on classroom work, highlighting specific errors and offering suggestions for improvement (Grover, 2014). Furthermore, it encourages children to focus their attention thoughtfully on tasks, compared to simply getting the correct answer (Grover, 2014). Kennedy et al., (2008) states that an assessment activity can help learning, if it provides information to be used as feedback by teachers and children to adapt the learning in which they are engaged. Furthermore, these assessments become formative when the evidence is used to adapt the curricula to meet the children's learning needs (Black & William, 1998). When stealth assessment is carried out through the use of computer games, children's knowledge is constantly being tested through interactions with the game, producing data on their learning. This data can then be used formatively by the teacher to progress their learning further or make adjustments to future learning activities. Therefore, stealth assessment could become a valuable tool to the formative process, as it quickly and efficiently collects evidence needed for teachers to provide feedback on a child's learning.

The value and effectiveness of formative assessment has gained a lot of attention within the past couple of decades, more so since the departure of 'levels', which benchmarked children's progression (Box et al., 2015). The government has given schools more freedom over how they asses their children, even stating that "we need more assessment, but of a different kind" (DfE, 2015). Therefore, this opens the door for teachers to adopt new methods that promote more formative assessment such as stealth assessment. Despite this, Butt (2010) argues that teachers often feel constrained by external tests, resulting in them being less likely to give alternative methods a greater role in directing children's learning. Harris (2013) states formative approaches can benefit all abilities, with low achievers it shifts their attitude on assessment to something that can help them learn, with high achievers profiting with a more challenging curriculum and focusing on their progress rather than grades. Marsh (2016) supports this view stating it empowers children to realise their own learning needs, giving them control over future learning targets. Public Health England (2015) argue that any form of assessment that involves children in decisions that impact them, will benefit their wellbeing and emotional health. Despite this, Box et al., (2015) states that methods of assessment such as formative and stealth assessment can be affected by head teachers, who pressurise teachers into concentrating on obtaining high academic results. However, Black et al., (1998) shares a contrasting view, stating that the culture of rewards and grades have focused children on gaining the best marks, rather than improving their own learning. Furthermore, like previously mentioned, it is important for head teachers to realise the benefits technology can have on assessment and raising achievement, which will hopefully change attitudes and reduce the risk of them narrowing the curriculum to improve test results.

Research into the benefits of formative assessment was carried out over a four-year period in three schools. It revealed positive outcomes, as teachers were able to make better sense of children's thinking, which allowed them to respond with more detailed feedback, and resulted in higher student achievement. Furthermore, it benefitted teacher development, because teachers were reflecting more on their teaching methods (Furtak, et al., 2016). It also improved teaching in the classrooms with varying social and economic backgrounds (Furtak, et al., 2016). Despite this, it is important to recognise that this research was only based on three schools and would have been more significant if more schools were involved. However, a larger study in the USA researched the impact of formative assessment with 529 teachers and 10,000 children (Curry, et al., 2016). It discovered that the use of formative assessment helped promote teacher motivation to enhance classroom instruction and meet the needs of the children (Curry, et al., 2016). Furthermore, the study also revealed an increase in children's summative assessment grades after formative assessment had been conducted. These outcomes are supported by Pollard (2014) who states that formative assessment has proven to raise standards in schools. Additional research by Marsh (2007) suggests it enhances critical thinking, problem-solving, peer assessment and communication skills. This evidence shows the importance of formative assessment in the classroom. Therefore, if methods such as stealth assessment can be used more often by teachers, it will allow for more detailed formative feedback of children's learning to be completed. Additionally, the evidence shows that more formative feedback in schools can help increase summative assessment grades whilst also enhancing children's problem solving and communication skills. This shows that different assessment methods can work together to increase achievement, which was also a recommendation in the 1988 TGAT report.

There are questions raised about the time-consuming nature of formative assessment and how teachers just do not have the time available to give detailed and meaningful feedback to all children. Butt (2010) states this may explain why teachers still value summative assessment methods compared to the time-consuming, but more educationally worthwhile, formative approaches. Marsh (2007) doesn't think is should be an issue, suggesting schools should use more computer-based programs which give children and teachers instantaneous feedback on their learning. Manning (2017) agrees, stating technology should be used to automate some of the paperwork for teachers, allowing them to give instantaneous feedback and freeing up more time for them to teach. Ofsted (2014) state that their inspections now look at how schools use assessment information to identify children needing additional support, including the most able. The literature shows that some teachers do not always value the formative methods due to the time used at collecting the data, however if methods are used that can reduce the time aspect, it could benefit teachers and children on a number of levels. This raises the question whether stealth assessment using computer games could play a pivotal role in reducing time constraints on teachers, allowing for more formative assessment to take place in the classroom and also satisfying Ofsted's requirements of identifying children which require further support.

2.6 Comparing international models of assessment

The literature has so far suggested that there are a number of limitations to summative assessment. However, it has also shown how an alternative method such as stealth assessment, could potentially be used to measure achievement more effectively and promote other forms of assessment. I will be investigating the different attitudes on assessment in England and Finland, whilst also exploring why the Finnish approach has proven to be more successful. Finland is one western country that has consistently excelled in the international PISA assessments over the years and is highly regarded around the world as a leading education nation (Lopez, 2009, OECD, 2015). Furthermore, Lopez (2009) states that their sustained success has prompted governments to consider how they have done this. A report from Ofsted in 2010 highlighted Finland's success in mathematics and investigated their methods in order to aid improvement in the United Kingdom (Ofsted, 2010). Dutton (2010) states that Finland has no national assessments like the key stage assessments seen in English education system. This comparison is important for this research because it will highlight how another higher achieving nation has introduced new methods and succeeded. Therefore, is stealth assessment and computer game learning the addition our education system needs that could change our fortunes in mathematics achievement.

2.6.1 The differences between the English and Finnish education systems

Our government's attitude on assessment firmly favours the summative approach, whereas the Finnish government have decided to take the formative approach. The English education system was once a pioneer for other developing nations, however a decline of achievement, has seen England fall behind the highest achieving nations. Shuayb et al., (2008) believes the economic downturn in the 1980's is to blame, as Margaret Thatcher's government tried to raise standards, by limiting the power of teachers within the classroom and taking full control over the failing education system. Brehony (2005) is critical of this decision, stating that education shifted from being child-centred, to a system based on the needs of the economy and society. However, despite achievement rates falling regularly, the current conservative government still argue that the only way to raise standards is to use robust summative assessments (DfE, 2013). Former education secretary, Justine Greening (cited in Davies, 2017) argues that "the government wants to build a stable assessment system that helps children learn, freeing up teachers to do what they do best: supporting children to fulfil their potential". This statement gives the impression that the government recognise the importance of formative assessment in the classroom, but with an education system that relies so much on summative data, it is hard to see how alternative methods could be introduced. This is supported by Berliner (2018) who states that alternative approaches to assessment are unlikely to be adopted by our government as they do not offer the same comparable data.

Evidence of this can be seen with the Department for Education's attempt to introduce a mix of assessment approaches for infants. Berliner (2018) reports that the trial in 2015 involved a number of assessment suppliers, each offering different approaches, with results showing the most popular method being observations of children. However, the government could not compare the assessment approaches and decided to abandon all three (Berliner, 2018). The government want to keep control over accountability and competition through league tables, which requires children to take tests that produce summative data. Kelly (2009) is critical over this attitude on testing, arguing there is still no evidence that proves summative assessment methods raise standards at all.

On the other hand, Finland has flourished in recent years using an alternative approach to the summative method. In contrast to England, Finland's social democratic society has an economy which emphasis the distribution of wealth, so that everyone's needs are met with a collective capital (Saarikoski & Saarikoski, 2012). Their socialist policies consider equality at the heart of society and in recent decades has seen them concentrate on becoming a knowledge society, which is also replicated within the Finnish education system (Sahlberg, 2015). Popa et al., (2015) states that equality is the most important word in their education system and that all political parties in Finland agree on this. Therefore, schools in Finland are all publicly funded and draws upon the same pool of university-trained educators to ensure all children receive the same level of education anywhere in the country (Popa et al., 2015). Additionally, their educational ideologies focus on loose standards and flexibility, with schools developing their own learning and intelligent accountability, which values teachers' professionalism to judge what is best for children (Sahlberg, 2007). This is a total contrast to education in England with children attending many different types of schools, an education system focused on standards and rankings and accountability of schools and teachers being high on the agenda of the government. Sahlberg (2015) describes how the Finnish education system has no rankings, comparisons or competition between schools or regions.

Lopez (2012) describes how teacher based formative assessments are used to monitor the progress of each child, with only one summative test at the end of secondary education. Sahlberg (2015) states that a major difference between their education system and other western countries, is that Finland's teachers prepare children to learn how to learn, not how to take a test. It is argued that the Finnish governments trust in teachers, to create a learner-focused curriculum based around formative assessment has led to higher achievement levels (Sahlberg, 2015). Morgan (2014) supports this view, stating that achievement is higher, because teachers are creating superior learning environments, that bases new learning around the children's needs. Moreover, in Finland many of their teachers move through the school with the same class, making strong connections with the children (Sahlberg, 2015). This allows the teachers to better understand their children's capabilities and understanding of the curriculum and further tailor the curriculum to meet their needs. Lipsett (2008) thinks that teachers in England are afraid to tailor teaching to pupils' needs, because they feel the need to stick to the government's National Curriculum. Recent reforms in Finland have also seen a reduction of subject content and is encouraging teachers to teach competences through project-based learning (Abrams, 2017). This method promotes higher-order thinking and enables children to demonstrate their depth of learning (Morse, 2012, Tan, 2013).

2.6.2 Examples of game-based learning in England and Finland

England and Finland are leading powers in technology and are now becoming main hubs for the computer and mobile gaming world. In Finland, computer games are also being incorporated into curriculum to enhance their education system further. Bird (2013) states that when Finnish traditions in education and computer games are combined, it can become a winning combination that supports individualised learning. One game that is being used is SmartKid Maths, which was voted Best Digital Educational Game in 2013 from the Finnish eLearning Centre. The game presents children with mathematics problems and using the children's actions, all answers are collected with the data being sent to the teacher for detailed learning analysis (Bird, 2013). However, it is not just Finland that is using computer games for learning purposes. Despite the different attitudes surrounding assessment, many English schools are also reaching out to games companies to help with learning mathematics. Vasagar (2012) states that the government are now looking to games companies, such as Mangahigh to explain a number of complex problems to children. One example of how Mangahigh games are assisting schools with teaching is through a game called ‘Wrecks Factor’, whereby children have to correctly factorise quadratic expressions to answer different ships distress calls to save the crew. Co-founder of Mangahigh, Marcus Du Sautoy (cited in Vasagar, 2012) states these games can help teachers spot which children are struggling, enabling them to provide additional support. Michael Gove (cited in Stuart, 2011), the former education secretary states that “it is amazing how quickly they (children) can learn” from using Mangahigh computer games. This raises some questions as to why the government are not incorporating these games into the mathematics curriculum and are not willing to provide funding to ensure they are available in every school in England, if they can help children learn at a faster rate. Despite these promising attempts to introduce more game-based learning, some are still sceptical that our education system is willing to fully adopt gaming across the curriculum (Psotka, 2013).

2.7 Current trends in motivation

This section will explore the different types of motivation and the current trends that surround the English education system. There will be a discussion on intrinsic and extrinsic motivation, analysing which one schools are promoting more. and the approaches schools are using to keep children motivated in lessons. It is vital to see how current methods might impact children’s motivation for learning and whether there are strategies in place that aim to engage and inspire learning for its own sake. Technology is becoming increasingly available, therefore there will be a discussion on how technology is being used to increase academic motivation. Additionally, if there is any form of technology that is becoming more popular in the school environment.

2.7.1 Intrinsic and extrinsic motivation

Motivation is a complicated subject, with many theories trying to explain human behaviour and thinking. Woolfolk et al., (2013) states that there are many factors that can affect motivation, with one theory that motivation relies on internal factors (intrinsic), such as needs, curiosity and personal interests. Another explanation of motivation highlights external factors (extrinsic), such as rewards, punishments, and social pressure (Glassman & Hadad, 2009). Intrinsic motivation can be defined as the natural tendency to seek out and overcome challenges as we pursue personal interests and exercise capabilities (Sansome & Harackiewicz, 2000). This is essentially, performing an activity for its own sake and the joy of doing it, rather than the desire for some external reward. Woolfolk et al., (2013) supports this view, stating that when someone is intrinsically motivated, they do not need incentives or punishments, because the task they are performing is rewarding in itself. In contrast, extrinsic motivation refers to the pursuit of an instrumental goal and is driven by external rewards such as receiving praise from a teacher, avoiding punishment or achieving a specific grade in an assessment (Reiss, 2012). Furthermore, Woolfolk et al., (2013) states that with this type of motivation, a child is not really interested in the activity for its own sake, rather they are only interested in what will be gained by doing it. However, according to Deci and Ryan's self-determination theory (cited in Reiss, 2012), intrinsic interest can be undermined by extrinsic incentives. This view is supported by Malone (1981) who states that external reinforcements in the classroom destroy the intrinsic motivation children have to engage with the learning activity. Middleton (1995) argues that when children are motivated intrinsically to perform an activity, they spend more time engaged, learn better and find more enjoyment in the activity than when they are motivated extrinsically.

In recent years, many schools have been advised to use extrinsic motivational techniques and implemented what is known as school reward systems, with teacher's rewarding children for completing tasks, good behaviour or achieving higher grades (DfE, 2014, Hepburn, 2015, DfE

2012, Robinson, 2010). These rewards are often used as a way of controlling behaviour or keeping children focused with classroom learning. Examples of such rewards are often in the form stickers, certificates, merits or prizes. This is a behavioural approach to motivation, which was pioneered by theorists such as Skinner and J. B. Watson. According to this approach, an understanding of learner motivation starts with an analysis of the rewards present in the classroom (Woolfolk, et al., 2013). However, Black et al., (1998) argues that this culture is detrimental to children's intrinsic motivation to learn. Furthermore, when a classroom culture focuses on rewards, class rankings or grades, children will always look for ways to obtain the best marks rather than improve their learning (Black & William, 1998). However, Cherry (2017) thinks that extrinsic motivation can be beneficial in some situations, for example, external rewards can tempt interest and participation in a subject in which the child has no initial interest. Robinson (2010) is critical of the curriculum, stating that children are still being taught the same subject content their parents learnt decades before, which is a reason why some children are alienated and lack motivation to learn. According to Rowlands et al., (2001), children will only respond to things that are relevant to them. Pollard (2014) states it is crucial that children are offered a curriculum that interests them to increase motivation for learning for its own sake.

Middleton (1995) reviewed ten research studies that analysed teachers lesson plans and discovered that they focused primarily on content goals, with motivation seen as a secondary focus. If teachers are not placing a greater emphasis on children's motivation in tasks, then interest levels and intrinsic motivation is likely to be at a much lower level. Butt (2010) thinks that learning for its own sake is undervalued and it is just a means to an end. Furthermore, children begin to see most of the learning and assessments, as a process of jumping barriers to progress, rather than learning for intrinsic purposes of enjoyment, interest, curiosity and intellectual advancement (Butt, 2010).

In contrast to the behavioural approaches used in many education settings, the humanistic approach to motivation emphasises the intrinsic sources of motivation as a child's needs for 'self-actualisation' or the need for 'self-determination' (Woolfolk, et al., 2013). Furthermore, Woolfolk et al., (2013, p.433) states the humanistic standpoint that "to motivate means to encourage peoples' inner resources – their sense of competence, self-esteem, autonomy and successful personal development". Maslow's hierarchy of needs theory is considered to be an influential humanistic explanation of motivation, recognising the complexity of motivation and sought to describe it in terms of a hierarchical structure (Appendix 3) with different types of needs (Glassman & Hadad, 2009). Maslow stated that people are motivated to achieve specific needs and some of these needs have a higher importance than others. Glassman et al., (2009) states that the first four lower-level needs are called deficiency needs, which are for survival, safety, belonging and self-esteem. The top-level needs are growth-needs and when these are met a person's motivation does not stop, instead it increases to pursue further fulfilment and enabling them to reach their full potential (Woolfolk, et al., 2013). However, Glassman et al., (2009) states that unfortunately advancing through this process is often disrupted by a failure to meet the lower-level needs. Marsh (2016) states that high stakes assessments are causing immense stress levels for children. Additionally, Harlen (2003) argues that the stressful nature of assessments reduces self-esteem for many children, demotivating them to succeed in other learning tasks. This area of our education system is therefore preventing many children from progressing through the self-esteem level in the hierarchy of needs, meaning it is less likely they will reach the final stage of fulfilling their potential.

The humanistic approach to motivation also highlights that autonomy is important for intrinsic motivation (Woolfolk, et al., 2013). However, Mayo (2012) argues that in most schools it is common for teachers to reward children for memorising facts. Kohn (cited in Steinberg et al., 2013) states that rewards in education create unequal power, causing children to become dependent on the teacher's judgement, instead of developing their own sense of autonomy.

This is supported by Freire's banking model, which describes the depositing of knowledge into the passive learner, excludes the child from active participation in developing first-hand knowledge, leaving them dependant on the teacher (Freire, 1972). MacDougall (2008) states that autonomous learners rely less on teachers for support, which enhances their motivation and constructive collaborative participation with learning in the classroom. This evidence in the literature suggests that school assessments and the culture of rewards are failing some children, preventing them from reaching the higher echelons of the hierarchy of needs and therefore decreasing their intrinsic motivation for learning. Black and William (1998) state that the culture needs to change to become a culture of success, which is backed by a belief that all children can achieve.

2.7.2 Technology & Academic Motivation

It was mentioned previously that many schools use rewards to motivate learners, but it was discovered this only encourages extrinsic motivation, which was said to be detrimental to children's intrinsic motivation towards learning. Therefore, many teachers are regularly searching for new ways to inspire, engage and motivate children to learn. Floyd (2009) supports this view, stating that teachers and parents are investing more time with technology, seeking new ways to harness it in order to motivate children with learning. However, some believe the problems associated with motivation arise because many curriculum topics are no longer relevant and have not changed with technological advances, causing children to lose sight with the purpose of their education (Kelly, 2009, Robinson, 2010). It is suggested that connecting academic content with children's enduring personal interests is important for developing children's intrinsic motivation with school subjects (Woolfolk et al., 2013). Furthermore, if children have their own interests incorporated into learning, they are more likely to seek new information and have positive attitudes towards learning (Woolfolk et al., 2013).

With technology becoming increasingly available in the digital age, children are using more of computers, tablets, games consoles and mobile phones, because these forms of technology interest them. Therefore, schools are searching for new ways to incorporate technology into the classroom, as a method of catching and holding children's interests with learning (Manning, 2017). Furthermore, this has seen schools in Britain spend £900m on education technology in the past year (Manning, 2017). However, Garrison & Akyol, (2009) state that with any educational development, incorporating more technology into classrooms must be an extension of existing methods and should not take control over classroom learning. Glaser (2018) is critical of schools using technology for learning purposes, stating it has brought more harm than good, with children becoming hooked and losing interest in more wholesome activities. Schleicher (2015), is equally critical, stating that OECD research shows countries that have heavily invested in technology for educational purposes have seen no significant improvements in the achievement of reading, mathematics or science. Research by Eyyam & Yaratan (2014) challenges this claim, with their study showing that educational technology actually has positive effects on children's performance in mathematics. However, Schleicher (2015) states that schools have not yet become good enough when using technology and that using 21st-Century technologies to 20th-Century teaching practices will weaken the effectiveness of teaching. Despite this, Coughlan (2015) makes a valid point that if children are unable to navigate through a complex digital landscape, they will find it increasingly difficult to participate in the economic, social and cultural life around them. Furthermore, research from Bouck et al., (2007) argues that the use of technology encourages cooperation, creativity and equips children with the tools they need to determine their futures and to contribute to society. This is supported by Lewis (2009), stating that the freedom and challenge technology gives children, enables them to enhance their creativity and problem solving, as well as encouraging the growth of intrinsic academic motivation. However, Jacobs (2013) states that in order to improve learner's academic motivation, the teacher needs to consider using technological opportunities to meet a larger learning goal or target. In other words, if teacher's use computer games for learning purposes or assessment, they would need to be used in a way that supports the children's long-term learning objectives. Black et al., (1998) argue the best way to increase intrinsic motivation is the teacher providing feedback on children's learning. This literature shows that technology such as stealth assessment using game-based learning could potentially be utilised in the classroom, because of its ability to engage children, develop their problem-solving skills and assist teachers with formative assessment.

2.7.3 Current trends of using technology to increase motivation in the classroom

2.7.3.1 Tablet computers

There are many examples of current technology being used to improve motivation and learning experiences for children. A study conducted in 2014, of 671 state and independent schools found that tablet computers are now being used in 70% of schools, with numbers increasing from 400,000 to 900,000 by 2016 (Coughlan, 2014). Additionally, it was discovered that 9% of these schools had an individual tablet device for every child. However, it must be noted this was mainly discovered in academies or independent schools, rather than state schools (Coughlan, 2014). Further evidence from the study found that head teachers noticed the use of tablets for learning helped motivate children who might otherwise be disengaged.

A further study conducted by Finnegan & Warren (2015) discovered that tablet computers were useful in motivating boys from poor backgrounds to read and learn. One example of a successful tablet app being used in the classroom is a programme called 'Kahoot' and is one of the top education apps in the UK and USA (Manning, 2017). This programme allows teachers to create learning games using questions, videos, images and diagrams to quiz children's knowledge in numerous curriculum subjects. This tablet app allows the whole class to take part at the same time, either in groups or individually and encourages peer-led discussions about the learning topic. Furthermore, the app allows teachers to assign homework, increasing children's motivation to continue their learning at home. My classroom experiences as a teaching assistant have allowed me to see tablets being used for learning purposes. A science lesson was transformed by the teacher, with children using tablet computers in small groups to create a nature documentary outside in the school grounds. However, despite some of the success stories, Liang-Vergara, (2017) believes it to be irresponsible for us to assume that all children will be motivated and self-driven by placing them in front of digital content and expecting them to succeed.

2.7.3.2 Computer Games

An increasing number of researchers and educators are also backing computer games as a promising method of teaching that can motivate children and strengthen important skills needed in the information age (Watson & Yang, 2016). Bai et al., (2012) states that computer games can be used to improve children’s mathematics learning of understanding abstract concepts. Furthermore, regular mathematics lessons with teachers explaining concepts through narratives or examples can often confuse children, leaving them lost and demotivated (Bai et al., 2012). However, when computer games are used, they can give children visual representations that help generate mental models of the mathematical concepts (Bai et al., 2012). This view is supported by leading stealth assessment researchers, Shute and Ventura (2013), who argue that learning through computer games is now regarded as one of the most powerful methods for keeping children engaged and motivated to learn. Williamson (2009) states this is most likely because computer games are now a big part of children’s present-day culture. Moreover, Williamson (2009) argues games provide an insight into children’s lives and experiences outside school, therefore should be considered as worthy academic tools in the classroom for improving motivation for learning. Malone (1981) states that there are a number of features that make learning fun and intrinsically motivating, these include informational complexity, responsiveness, challenge, and fantasy. Additionally, Malone (1981) states that computer games are clear examples of a highly motivating activity.

According to Malykhina (2014), many teachers now think that games can motivate struggling children. Furthermore, low-performing children are often disengaged with learning and activities that are happening in the classroom (Kelly, 2009). Research in the United States found that lower-performing children value technological instruction tools, because technology is able to provide instant feedback and gives instructional assistance (Leong & Alexander, 2013). Stealth assessment programmes using computer games are often able to give feedback on the children's learning, either directly to them or through information given to their teacher for formative feedback (Shute, et al., 2016). Malykhina (2014) thinks game-based learning tools could be very effective for addressing the gap of achievement and motivating lower-performing children to succeed. Despite this, McVeigh (2001) states that games cannot be viewed as the latest quick fix to our education system, because they cannot replace the expertise of the teacher. However, Gould (2012) states that anyone who doubts the use of computer games in the classroom, needs to be reminded that they are a form of play. Play has been proven by many theorists to enhance children's development in a number of different areas (Pound, 2012). Moreover, Holmes et al., (2013) state that playing different forms of games requires children to have an understanding of academic concepts, which, in turn promotes higher academic achievement.

A recent study of 445 children in the USA looked into the effects of technology on motivation, using a computer game called DimensionM (Bai et al., 2012). The games design was to enhance mathematical skills through activities which promote collaboration (Bai et al., 2012). Children were asked to take two assessments, with pre-test results revealing an achievement gap between the lower ability and higher ability children. However, after playing the computer game, the researchers found that children's performance was considerably improved and reduced the achievement gap between the two groups. Moreover, they discovered that the lower ability children's motivation to learn mathematics was greatly improved after playing the game (Bai et al., 2012). This backs up the previous research from Leong and Alexander (2013), which found that lower ability children value technological instruction tools.

It was mentioned previously that stealth assessment games are typically designed to constantly present children with challenges to overcome, which has shown to increase the development of their problem-solving skills. However, these challenges are also said to benefit them motivationally. Malone (1981, p.360) states that “challenge is captivating, because it engages a person’s self-esteem”. Therefore, if a child experiences some success in an educational environment, for example overcoming a challenging activity, this can make them feel better about themselves and more motivated to pursue further successes (Malone, 1981). However, if children experience failure with challenging activities in their education, then this generally lowers self-esteem levels and significantly decreases their interest. This could be a possible reason why there are a large number of de-motivated children in our education system, because many are experiencing failure in high-stakes summative assessments, which is reducing their interest and motivation to continue learning. If methods such as stealth assessment can capture children’s attention and increase self-esteem, then it is possible we will see more children motivated to learn for its own sake and higher achievement in summative assessments.

However, there are now computer games being designed that teach mathematics where by children learn to fail in order to learn. ST Math is a game used in the United States that teaches children about perseverance, with children presented with mathematical problems in order to move a penguin character across the screen. Liang-Vergara (2014) states the game is self-paced and self-motivating, teaching children visually and experientially, and providing them with immediate feedback which enhances problem-solving and reasoning skills. If children continue to get a puzzle wrong on a number of occasions, a yellow border will appear around the screen that enables the teacher to see which children need the additional support. The game is said to be frustrating at first, however, research has shown that children playing the game have doubled or tripled their achievement in summative assessments (Liang-Vergara, 2014). Furthermore, it is said that the frustration it causes initially, teaches the children that failure is ok, and when they finally complete a puzzle it motivates them to pass the next level

(Liang-Vergara, 2014). Additionally, the tricky nature of the game allows for children to work collaboratively, giving tips to their peers on how complete challenges, which drives the motivation to learn more about mathematics and complete further tasks. This collaborative aspect of the game links to Vygotsky's social learning theory, which states that collaboration develops language, which is the main tool for thinking and improving reasoning skills (Vygotsky & Cole, 1978). Furthermore, Vygotsky emphasised the importance of interaction with teachers and peers in advancing children's knowledge (Vygotsky & Cole, 1978, Mooney, 2013). Moreover, Liang-Vergara (2014) argues that it is almost impossible to create the same level of personalised assessment and exploration in summative paper-based tests. This example has shown the potential of stealth assessment using computer games and how it can be used to motivate children to learn more about a subject. Furthermore, teaching children about the importance of failure and perseverance in order to learn, can be useful for all future learning in the classroom.

2.7.4 Summary of literature review

The first section of this literature review discussed some of the major developments to education and the types of assessments children have been required to take from the Victorian era to the present day. Assessments in Britain were once controlled by the teachers, before the purpose shifted to determine children's educational path, and now it is currently used by the government to measure schools and pupils against a national benchmark. The government in recent decades have also made assessment summative at all levels of education in Britain. This section also discussed how the government think that the National Curriculum core subjects are the building blocks of education, despite a large proportion of the literature suggesting that the curriculum has narrowed as a result, with children now receiving a watered-down education. Furthermore, it was discussed that in the current system children are able to attend a number of different types of school, with some schools having control over what is taught, and others having to follow the National Curriculum frameworks. This literature shows that the education system has developed greatly over time, meaning that possible changes to assessment and the curriculum could happen in the future, with technology potentially being used more to benefit schools and children.

Next, I examined how mathematics has developed from being a subject that was once exclusive to the church and privileged members of society, to a subject that is now studied by all children and seen as a vital tool for progressing in today's modern society. The curriculum has changed vastly over the past one hundred years, with children now expected to meet higher standards than ever from a very early age. Mathematics education is still developing around the world, with the subject being assessed, compared and scrutinised internationally. It now appears that these international assessments are one of the main driving forces behind the government's recent policy changes to mathematics education (Garner, 2017). Moreover, if standards are dropping in mathematics and questions are being asked over the reliability of assessments, it could mean that the government may need to examine alternative assessment methods such as stealth assessment in the future. It was therefore important to examine summative assessment in more detail, looking at the possible limitations.

The literature then began to unearth many limitations to the summative assessment method in the next section. Schools, teachers and pupils are being placed under immense pressure to succeed, in a system that is regarded as one of the most assessed in the world. Furthermore, questions have been asked at how reliable the data is from these tests, with some claiming that they fail to provide a full picture of a child's learning. Critical thinking is vitally important in modern Britain; however, it is said that many schools focus on mastering facts in the core subjects as a way of improving assessment results. It was discovered that if children just absorb facts, there is less chance of them becoming autonomous learners, and thus become more dependent on the teacher for their learning. In addition, there are other factors that have raised the profile of the core subjects, with International assessments and league tables being partly responsible. These assessments measure a nations level of reading, mathematics and science, with governments using a lot of this data to make changes to education policy. Further limitations were discovered when looking at the tiered exam structure for GCSE children. The literature suggests that schools are steering middle ability children towards lower level exam papers in order to increase the chance of them achieving a ‘C’ grade. However, this is seen to be gatekeeping a large percentage of children from reaching the higher end of the achievement scale. Social class still remains the strongest predictor of academic success. The government state that the National Curriculum allows all to achieve and also removes barriers of achievement. However, the literature discovered that many middle-class children are better prepared for assessments, which are said to measure middle class knowledge. Statistics back this up further, showing that middle-class children achieve much higher grades than those from working class backgrounds. Would a different approach to assessing children’s achievement help support more children in our education system?

The next section investigated the use of stealth assessment and computer game learning. Research has shown many positive outcomes of using stealth assessment, however, according to Webb et al., (2013) there are still significant challenges that remain with the development of stealth assessment programmes. Moreover, current ideologies and school competition make it difficult to see how the government would accept this form of assessment to compare schools in national league tables. However, Shute et al., (2013) believes as technology progresses, data gained from these assessments may be aggregated into rich and valid profiles of pupils, reducing the need for a teach-stop-test model which has governed classrooms for the past few decades. Furthermore, support is growing internationally for children to be assessed on their critical thinking, teamwork and problem-solving skills, and stealth assessment could be the answer. Using computer games to assess children’s learning has identified ways of moving assessment design towards a more child-centred approach, showing positive outcomes in social, cognitive and emotional aspects. Furthermore, the literature suggests that it also strengthens pupil-teacher relationships, provides teachers with an additional tool for setting and monitoring targets, and uses children's misunderstandings for formative purposes that can enhance future curriculum planning.

One country that uses formative assessment at the heart of their education system is Finland. Therefore, the next section of the literature review explored the differences between Britain and Finland's assessment models. The literature revealed that the purpose of assessment in these countries is completely different, with Britain using assessment for political purposes of controlling the curriculum, focusing on standards and accountability. One the other hand, Finland uses assessment to diagnose the educational needs of the children in order to plan an effective curriculum. The summative stance in Britain has yet to see any major improvements of standards. However, with formative assessment at the heart of the Finnish education system, it has seen levels of achievement steadily increase. Despite the differing assessment attitudes, both countries share some similarities, with schools experimenting with computer games to support the learning of mathematics. With stealth assessment being proven to facilitate formative assessment methods, it will be interesting to see if the British government uses this approach more in the future to raise standards in the high-stakes summative assessments.

The final section explored different areas of motivation in education. The literature revealed that many aspects of the current education system are driven by extrinsic rewards, which can undermine intrinsic motivation towards learning. It was suggested motivation in schools is being affected on a number of fronts, such as an outdated curriculum, stress caused from assessments and children seeing education as hurdles to overcome in order to reach the next stage. The comparison of behaviourist and humanistic approaches revealed that summative assessments can cause children unwanted stress, which effects their self-esteem, resulting in a lack of motivation for learning or prevents them from reaching their full potential. The pressure on schools to ensure good achievement levels means they are often rewarding children for memorising facts, leaving children more dependent on the teacher and less likely to become autonomous learners. Furthermore, autonomous learners are more likely to have a higher intrinsic motivation for learning. One theory of increasing motivation is to connect academic subjects with children's personal interests, such as technology and has seen many schools invest more in this area. However, it was discovered that teachers need to use this technology in the right ways to support learning and assessment. A couple of new trends being used in the classroom are tablet computers and computer games. Games that can challenge children were found to be the best at increasing motivation towards learning. Additionally, computer games that teach children through failure were found to increase motivation and perseverance with learning. With this information in mind, stealth assessment and game-based learning could play a vital role in improving motivation, learning, and assessments in the classroom.

Chapter 3 - Methodology

3.1 Introduction

In modern society, children must be able to harness technology to learn, solve problems and get by in a world that is centred around technology (Manning, 2017). Computer games are a form of technology that are increasingly being used as a learning tool in many school classrooms. While there are a number of studies that look at the effects game-based learning has on children generally, there is only a limited amount of research conducted into how effective computer-games can be when used to stealth assess children's achievement in mathematics. Additionally, whether computer games have any effect to children's overall engagement and academic motivation towards mathematics, compared to other learning approaches in the classroom. This study was conducted over a one-week period in a primary school setting and the target audience was Year 5 pupils.

3.2 Aims and Research Questions

In light of the literature review, the purpose of this study was to explore the effects of an educational mathematics computer game on achievement, engagement and academic motivation in a primary school setting. The aim of this case study is to investigate computer games' role in assessment and seek an understanding of their role to enhance the level of achievement in schools. It will be important to gather evidence to see if stealth assessment using computer game learning in mathematics is a practical method for assessing achievement and more effective than current methods of assessment. In addition, whether computer games can keep children engaged and motivated, and if this differs to other methods of learning mathematics in the classroom. Finally, do teachers find the computer game data collected useful and if it can be used to progress future learning in the classroom.

Therefore, the following research questions directing this study were:

Research Question 1 - Does the computer game used enhance the level of achievement more than the conventional instructional approach?

The first question I had was whether the mathematics computer game would lead to greater learning benefits, compared to the regular mathematics instructional methods used in the classroom. My hypothesis was that the computer game would have a positive impact on the children's achievement. This hypothesis was supported by Bavelier (2012) findings, that gaming when consumed responsibly in small doses can have powerful impacts on children and enhance their learning. My thoughts were that the computer games' motivating properties might encourage the children to put more effort and focus into the learning, therefore seeing this group outperform the control group.

Research Question 2 - Is stealth assessment using game-based learning a practical method for assessing achievement in mathematics?

This question was to examine whether stealth assessment using computer games is a method that could potentially be considered as an alternative and more effective approach when assessing children in the classroom. With summative assessments revealing weaker areas of children's learning, they do not explain the reasons why. In addition, various prior research has revealed that stealth assessment measures what children actually can do with the knowledge and skills they have already obtained and has a number of benefits to children's development (Shute et al., 2013, DeRosier et al., 2012). With the Department for Education (2015) stating, "we need more assessment, but of a different kind". It is therefore important to see how effective stealth assessment might be within mathematics and whether it could be adopted into the National Curriculum in the future.

Research Question 3 - Does the computer game increase engagement and motivation towards mathematics learning?

I hypothesised that the children playing the game would be more engaged and motivated with the learning than the control group, because of the more colourful, playful and captivating aspects of the game. Furthermore, previous research has shown that children experience an increased level of motivation and engagement when they play educational computer games (Malone, 1981, Williamson, 2009, Bai et al., 2012, Shute & Ventura, 2013). Moreover, Shute & Ventura (2013) state that learning through the use of computer games is a powerful method for keeping children motivated and engaged.

Research Question 4 - Does the teacher find the data collected from the computer game useful and could this be used to progress the children's future learning?

The last question was whether the data obtained from the computer game was of value to the teacher and whether or not they would use this for any future classroom learning. My hypothesis was that the game would provide the teacher with some additional knowledge on the children's learning in that area of mathematics. This was supported by Shute and Ventura (2013) findings that stealth assessment using computer games gives teachers information on children's competencies, which can then be used for future planning and learner development.

It needs to be acknowledged that this research is only a small-scale classroom-based case study, involving a comparison of test scores, observations and teacher interviews. Therefore, the results collected may not provide an accurate representation to stealth assessment and game-based learning methods. It is also important for this study to consider both positive and negative consequences of playing the computer game. Therefore, when analysing the results, I will also be considering any negative effects that might be presented.

3.3 Mangahigh Computer Game – Sundae Times

Mangahigh is one of the first game-based learning websites, whereby children can learn mathematics from purpose-built games that balances both learning and having fun (Mangahigh, 2018). Furthermore, all games and activities developed by Mangahigh are linked to the National Curriculum in England and Wales, covering topics such as algebra, number, geometry, measurement, statistics and probability. These games are compatible on a number of devices, as seen on the left-hand side of figure 1, they can be played on portable handheld devices as well as computers. There are many educational mathematics games available, however, the one chosen for this study was Sundae Times as shown on the right-hand side of figure 1.

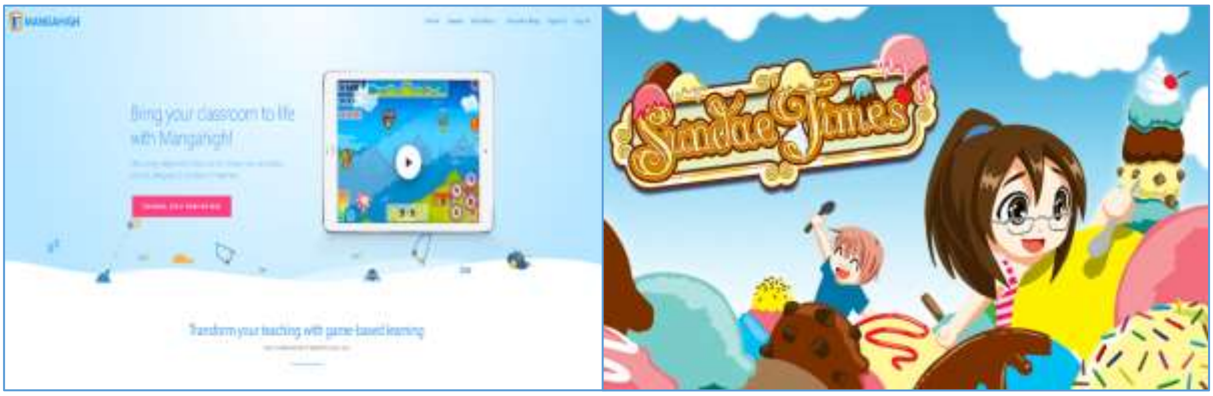


Figure 1: Mangahigh website and the Sundae Times computer game used in this study

When the children log into the game for the first time, they begin with setting up their gamer profile and asked to select an avatar, as seen in figure 2. This avatar image is then used on their profile and can be seen in all other areas of the Mangahigh website. The participants and the classroom teacher in this study were given an instruction sheet, which explained how to log in, how to set-up a profile and how to get started with the Sundae Times game (see Appendix 14). Sundae Times is a multiplication game that helps develop mental mathematic skills. The main aim of this game is for the participants to see who can answer basic multiplication facts the fastest. With each correct answer given, the game adds another scoop to the participants ice cream sundae, as seen in figure 2. In each game that is played, those playing are given 90 seconds to complete as many problems as possible, however, incorrect answers result in time penalties being applied and reducing time on the game clock.

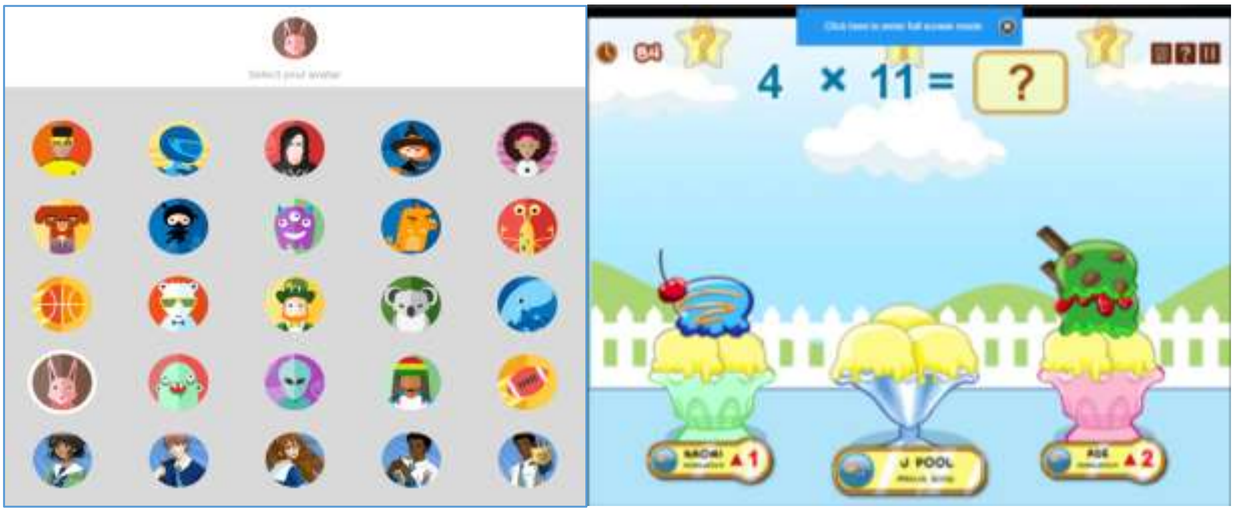


Figure 2: Gamer Avatars & Sundae Times gameplay

The game allows the participants to play from the two to fifteen times tables, however, for the purpose of this study those taking part were only instructed to play the two to twelve times tables. The participants were not given any specific instructions on which times tables to focus on and were allowed to select whichever level they wanted to play. Prior to starting the game, it gives the participant playing a choice to play individually against the computer in ‘solo play’, work together as a team against other classes in their school, or play against other players from around the world. In my study the participants were only instructed to play the solo game mode. During the game-play, those playing are presented with in-game problems to overcome in order to progress through the game, for example, removing obstacles that obstruct the certain sections of the screen. This is done by clicking various buttons or by using the computers mouse. At the end of each game, participants receive feedback on their efforts and are informed of any incorrect answers. Their performance is rated out of ten based on the problems answered, accuracy of their answers and final placing. The higher the score achieved, the more stars and points each participant accumulates. Additionally, teachers are able to set assignments and game modes for their children, with all gameplay results being recorded on the administrators account, shown below in figure 3.

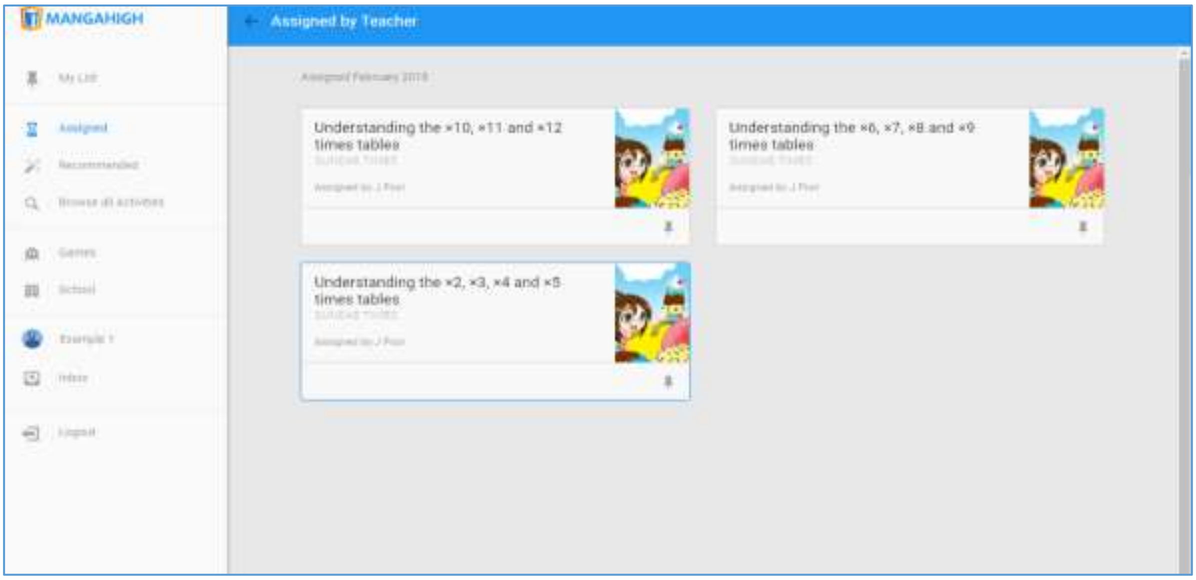


Figure 3: Teacher administration page – class assignments

3.4 Methods

The design of this study used mixed-methods of research, as both qualitative and quantitative research methods were used. Sarantakos (2013) states that there are many advantages to mixed-method research, such as a diversity of data, higher validity, more insightful understandings and more comprehensiveness of findings. As this was a case study into stealth assessment and game-based learning, it did have a number of qualitative methods of data collection, for example, teacher interviews and descriptions from observations. Opie (2010) states that qualitative data can be collected from many sources such as, open-ended questions in questionnaires, descriptions from observational research and interview transcripts. Lodico et al., (2006) states that case studies are often a common form of qualitative research. Furthermore, Yin (2013) supports the use of a case study, adding it gives strength to a research study as it can encompass experience to what has already been researched and proposed. There were also quantitative methods used for the data collection in this study. Leedy and Ormrod (2013) state that quantitative research focuses on using numerical data, which can then be compared and analysed. An observation schedule will be used to keep a count of the different interactions the children have during their mathematics learning periods. Further quantitative data will be collected from the mathematics computer game used in the study. Additionally, numerical data will be collected from the participants in a pre and post mathematic test, to determine any changes to their achievement levels throughout the study.

I decided that the most suitable research model to use would be the ‘control group’ method. Punch and Oancea (2014) describe this research method as an experiment of using two comparison groups. In addition, the researcher will manipulate an independent variable to one of the groups (experimental group), and the other group (control group) will either experience something different, or nothing at all. The aim is to say that any differences found in the outcome variable between the two groups are caused by the independent variable (Punch & Oancea, 2014). In this study, the control group experienced no changes to their daily routine.

This research involved working with a Year 5 teacher at a local primary school. The ten children were picked at random by their teacher and only selected if they had been given parental permission to take part. The teacher had notified me that based on his recent mathematic assessments, most of the class were of a similar ability, with a very small attainment gap between the highest attainer and the lowest. The teacher also informed me that the children chosen were all of a similar ability in mathematics. Once I had been given a list of names, I randomly allocated five into the ‘control group’. These children took part in the teacher’s regular mathematics lessons throughout the week. The other five children were placed in the ‘experimental group’ and played the Mangahigh computer game for 20 minutes per day, as well as taking part in the teacher’s regular mathematics lessons. The game was set-up and monitored by the teacher or teaching assistant to replicate the teaching conditions used in the school. The type of game that was chosen for this study was selected to fit with the children’s learning that term, which focused around multiplication. All teaching conditions for both groups were the same in terms of the mathematics topics taught and both groups were given the same homework tasks by the teacher, which were to be completed online. The experimental group only had access to the Mangahigh game during the selected learning periods throughout the week. The only difference between the two groups was that the experimental group used the computer game. The participants were not given any information about the purpose of the study by the teacher or researcher, because stealth assessment requires the children to be unaware that an assessment is taking place. This reduces the chances of any assessment anxiety and allows the researcher to witness their natural reactions whilst playing the computer game.

3.4.1 Data Collection

There were a number of different methods of data collection in this study. Punch and Oancea (2014) state that in order for a researcher to increase validity, they should use multiple methods of data collection. Therefore, by combining several qualitative and quantitative methods in this study, I was able to more precisely assess the effects of using stealth assessment and game-based learning on motivation and achievement levels in mathematics.

3.4.2 Pre-& Post Multiplication Tests

The two groups of participants completed a times-table test at two measuring points: the pre-test at the beginning of the school week and the post-test at the end of the one-week research period. The participants were given five minutes to complete as many answers as possible on the times table grid. This grid consisted of questions from the two to twelve times tables and had a total of 143 questions. Leedy and Ormrod (2013) state that pre and post assessments must be identical as possible to ensure test-retest reliability. Therefore, the two times table tests given to the participants in this study were identical, to ensure the data was reliable. The data collected in these tests will help compare the achievement levels between the two groups. It was important to find out the participants prior knowledge at the start of the week, in order to see whether there had been any changes to their achievement levels at the end of the research week. The tests were presented to the participants by Teacher A as a times table challenge, in order to reduce the chances of any assessment anxiety. The times table test used in this study can be seen in Appendix 7.

3.4.3 Teacher Interviews

Interviews were used for collecting qualitative data in this study. Yin (2013) states that interviews are one of the most important sources of case study evidence. There are three different types of case study interviews, however, I decided the best option for this study was to use the shorter interview method. This interview method usually takes up to 1 hour and can be conducted in an open-ended and conversational manner (Yin, 2013). My interviews were based around questions I had written prior to the research taking place and were used as prompts for discussion. Punch & Oancea (2014) describe this as a semi-structured interview, which is a guided conversation with a stream of questions presented in a fluid manner. Kvale (1983) states that qualitative research interviews, such as those used in this study, must have a purpose of collecting descriptions and perceptions of the world from the interviewee's point of view. The purpose of my interviews was to collect data from the perspective of the teachers about stealth assessment, game-based learning and their methods of assessing mathematics in the classroom. I decided to interview two teachers, each with different levels of experience and at completely different stages of their teaching careers. Additionally, for the purposes of this study they will be described as Teacher A and Teacher B. However, only the classroom teacher (Teacher A) was interviewed twice, once at the start of the week and again at the end of the week. This was done to see if there were any differences to Teacher A's perceptions as the week progressed. In addition, I wanted to get their thoughts on the data received from the computer game and whether the data presented could be used for future learning purposes. The classroom teacher (Teacher A) had 8 years of teaching experience and was a part of the senior management team within the school. Teacher B was a newly qualified teacher (NQT) in their first full year of teaching in key stage one. The thought process behind interviewing two teachers with various levels of experience, was to see if there was any variation or similarities to their perceptions around stealth assessment, game-based learning and assessment methods used in mathematics. Punch and Oancea (2014) state that for semi-structured and more open-ended interviews, one of the best methods of recording data is through the use of audio or video recording devices. Therefore, I decided to record the interviews onto an audio recording device, with the data then written up as a transcript. The questions that guided my teacher interviews can viewed in Appendix 8.

3.4.4 Participant Observations

Observations were also used in this study to collect quantitative and qualitative data. The purpose for using observations was to look at the levels of engagement and motivation towards mathematics. It was imperative to establish whether there were any differences to the engagement and motivation levels of the two groups. Furthermore, to establish whether there are any changes to engagement and motivation levels of the experimental group when playing a computer game, compared to their normal mathematics lessons. An observation schedule was developed prior to conducting the research to ensure that I could collect data that would assist me when answering the research questions. Punch and Oancea (2014) state that observations using a pre-developed observation schedule which uses predetermined categories and classification, are described as structured observations. Furthermore, highly structured approaches such as the method used in this study, often collect quantitative data (Sarantakos, 2013, Punch & Oancea, 2014). However, qualitative data was also collected from observing the participants and writing additional detailed notes on the actions witnessed. Punch and Oancea (2014) describe this as a qualitative approach, because the data is collected in a more natural open-ended way. The design of my observation schedule (Appendix 18) enabled me to collect the data in two ways. In order for quantitative data to be collected, a tally chart was used which allowed me to keep a count of the times each participant displayed a specific action. Qualitative data was collected by writing detailed descriptions of the actions witnessed for each of the participants. These observations were carried out from a distance, using the observation schedule to monitor the levels of engagement, different interactions during the mathematics lessons and when playing the

Mangahigh computer game. This method is described as naturalistic observation, whereby the observer neither manipulates nor stimulates the behaviour of the participants they are observing (Punch & Oancea, 2014). The experimental group playing the computer game are described in the results section as participants 1 to 5 and the control group as participants 6 to 10.

3.5 Ethics and Safety

The word ethics refers to what we believe to be ‘right’ and ‘wrong’, in what is classed as acceptable conduct (Comstock, 2013). Furthermore, Maurice Punch (cited in Opie, 2010, p.25) states “Ethics has to do with the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair”. The research ethics in this study was approved by passing the required criteria of the Anglia Ruskin University ethics policy and code of practice. Prior to starting the ethics approval application, it was important to complete the mandatory training to help with the ethical review process and to gain an understanding of the potential problems that could arise during this study. This involved completing the Epigium online training modules: Ethics 1 good research practice (see appendix 9) and Intellectual property in the research context (see appendix 10). This was vital for the preparation stage of the study and helped me understand the ethical considerations needed before starting the research ethics application. Moreover, it gave me an understanding of the ethical requirements needed when carrying out research within a school setting.

The ethical process then progressed to completing the ‘Stage One Research Ethics Application’ form (see appendix 11). This document helped narrow down the aims of the study, with a complex description of the research that would take place. Moreover, this process assisted with selecting the most effective methods of data collection, the procedure that was needed to ensure that reliable and valid data was collected, and that all ethical risks involved in the study were managed accordingly. Section two of this document required me to complete the ‘Research Ethics Checklist’ to highlight the level of risk involved in the study. Two of the questions that needed further discussion into how the ethical risk would be managed were:

1. Involve the co-operation of a ‘gatekeeper’ to gain access to participants?
2. Does the study involve human participants?

Firstly, I had to gain access to the participants through the co-operation with a number of gatekeepers. This involved gaining permission from the head teacher of the school, the classroom teachers and the parents of the children taking part in the study. Opie (2010) states that when higher numbers of people are asked for permission, there is more chance that ethical approval will not be granted. In order to manage this risk and gain consent from all parties involved, a research information document and consent letter was first sent to the head teacher and teachers involved. After consent was obtained from the school, a separate information document and consent letter was sent to all of the parents in the chosen class. The information documents explained the aim of the research, the nature of the research, the methods of data collection, the potential benefits and disadvantages, the ethical process followed by the researcher, how the data will be used, and gave them the right to withdraw from the study at any point. In the consent form, it was also explained that all participant information and data collected would be confidential and anonymous. These documents can be seen in appendix 12 and 13. Comstock (2013) states that informed consent was developed to protect participants and must be obtained by researchers who intend to gather information about any participants involved in a study.

However, as this study is about stealth assessment, the children taking part were not informed about the purpose, because this is a method of assessment requires the children to be unaware that they are being assessed. Opie (2010) describes this as ‘covert’ research, whereby researchers are not straightforwardly honest about what they are doing. Furthermore, the researcher does not reveal that they are researching or what they are researching. This method is often confused with deception and criticised as intrinsically unethical (Spicker, 2011). It was imperative that the children did not know about the purpose of the research being carried out. Making them aware that they were being assessed on their mathematical knowledge might have increased the chances of ‘test-related stress’. Kaya (2010) argues that when children know they are being assessed, test anxiety can often drag down performance. To manage this risk, Teacher A informed the children that I was in the classroom to observe the everyday occurrences in their learning environment. Despite this, the teacher did make the children aware that those playing the computer game could stop at any point throughout the week.

There were also other ethical considerations to consider, such as the parents giving consent, but the child not wanting to take part. The risk was managed here by the teacher treating the mathematics computer game like any other learning activity and selecting which children would take part once consent had been given. It was also important to consider that I might encounter problems should parents decide not to consent. However, this was again managed by the teacher selecting the children after they had received consent. I had to take into account that some of the children might be doing extra mathematics revision away from school, which might have affected the overall data collected between the two groups. However, I was informed by the teacher that the whole class would be completing mathematics homework online. In addition, all children would have the same homework and learning tasks to complete. This reduced the risk of the children doing extra mathematics revision and potentially affecting the overall data collected.

The research also involved interviewing teacher’s, therefore ethical considerations were also needed for this aspect of the research. Bell (2005) states that interviews should take place in a public setting. Therefore, the interviews carried out with Teacher A and Teacher B were done so in their classrooms, to ensure they felt at ease throughout the process. These were also arranged and approved by the participant beforehand, giving them the time to ask any questions about the process. It was important to consider further issues that could arise here, as the teacher or school could have withdrawn from taking part in the study at any point.

As the research in this study would involve a number of human participants in a year 5 class, specific steps were taken to manage the ethical risk involved. Firstly, the children playing the mathematics computer game would do so for 20 minutes per day, over a one-week period. This amount of time was chosen, so the children were able to play the whole game and so it did not take them away from the classroom activities for too long. After conversations with Teacher A, it was discovered that the mathematic topics covered in lessons that term would be multiplication, division, fractions and decimal placements. Therefore, a game was chosen to focus around one of those mathematic topics, which was multiplication. This decision was made to ensure that there was minimal disruption to their weekly learning outcomes. The classroom teacher (Teacher A) also confirmed this would be acceptable and that they would include this into their weekly mathematics lesson plans. Furthermore, to minimise disruption to classroom learning, Teacher A would be in control of setting up the mathematics game for those taking part. This was to ensure that the children felt at ease and so that Teacher A knew exactly what the children would be learning throughout the game. The teacher and children were given an instruction sheet on how to access and set up the game (Appendix 14). The teacher confirmed that this would cause no disruption to the children's learning as the game would be played at an appropriate time and will be under his and the teaching assistant's supervision. The teacher made sure that whilst the experimental group was playing the computer game, the control group and the remaining children were also in the computer suite carrying out ICT research tasks for their topic that term. After the 20 minutes was up, the experimental group were instructed to carry on with the same work as their classmates.

The data collected from this study was kept confidential at all stages, with the school, teacher's and children's names being kept anonymous. This meant that I made sure not to discuss any participant names or findings with anyone. Furthermore, all names were excluded from any data collection recordings. Passwords were applied to all files that contained data and any paper data collected was kept in a locked filing cabinet. The consent forms explained about the participant confidentiality, data collection procedures and how all data would be destroyed after use. Comstock (2013) states that participants should be made aware that any data collected in a study will be destroyed after it has been used. The reference number for the ethics application in this study is FHSCE-DREP-17-067 and ethical approval from the Departmental Research Ethics Panel can be seen in Appendix 15. It is important to mention that approval was given on the second attempt after feedback was given by the Ethics Panel and subsequently all of their requirements were met in full. This process gave me a much better understanding of how to comply with Anglia Ruskin University's Research ethics policy and code of practice. Furthermore, it allowed for a better preparation of the research design, procedures, data collection methods and ethical considerations involved in this type of study.

3.6 Limitations

Before proceeding to examine the results, it is important to recognise some limitations of the study or those that were encountered throughout the process.

Firstly, in my ethics application I initially stated that my research would look into stealth assessment through computer games, however, with a tight timescale I chose to look at just one game. It took a lot of time to find the most appropriate game and then gain permission from the game developers. I found it very difficult to find similar games to compare in such a short period of time. If I continue this research in the future, I will definitely look to use more than one computer game.

There are some limitations when using interviews for data collection, for example, the answers given to the researcher by the two teachers were based on their personal experience and opinion. Consequently, the data collected from the interviews can create a biased opinion on stealth assessment and game-based learning. The interviews in this study were conducted in a semi-structured method, with pre-prepared questions guiding the conversation between myself and the interviewees. Sarantakos (2013) states that there are a number of weaknesses to semi-structured interviews. Moreover, semi-structured interviews can often cause the interviewer to try and pull answers out of the person being interviewed, potentially influencing the answers (Sarantakos, 2013). McLeod (2014) states that those being interviewed can also find themselves searching for an answer to the questions presented by the interviewer and therefore might not be accurate. There were some limitations to the interviews carried out in this study. For example, both teachers were incredibly busy that particular week and it appeared that they were rushing through some of the interview questions. Sarantakos (2013) states that interviews can often be an inconvenience to those being interviewed and this may affect the accuracy and detail of their answers.

There is always the possibility of unexpected issues arising during the data collection stage of the study. These can often be avoided by carrying out a pilot study (Opie, 2010). However, for this project it was not possible to carry out a pilot study, with certain factors that prevented this from happening. The school only permitted a short window for the research to be carried out in the chosen year five class. Thus, after completing the thorough ethical application process and receiving ethical approval, there was very little time to carry out a pilot study as well as complete the planned research week. There were some unforeseen issues on the first day of observations with the experimental group playing the computer game. The school had a large number of technical issues with the aging computers, meaning that there were a limited number of working computers available. Consequently, there were not enough computers for all of the participants to play the game for the full 20-minute period. However, each of the participants did get to play the game for a minimum of 15 minutes. Ratcliffe (2017) states that many British schools experience regular technical difficulties as the computers are often old and well past their shelf life. The school did have a large number of computers, and most of these were quite old. I’m not sure a pilot study would have prevented this from happening, but it might have highlighted the fact that the school had older computers.

3.7 Summary

It was mentioned previously that in order for a researcher to increase validity, they should use several methods of data collection (Punch & Oancea, 2014). This study has used multiple data collection methods, using both qualitative and quantitative measures. This meant I was more able to accurately assess the effects of stealth assessment and computer game learning in mathematics. As a future primary school teacher, I value these results as they will be useful to inform my teaching strategies in the classroom.

Chapter 4 - Results

4.1 Introduction

In order to analyse how stealth assessment and computer game practice affects academic achievement and motivation in year 5 mathematics, I used several data collection methods. The data collected was first analysed individually, then integrated together to build greater picture of the results. As there is such a large amount of data from different methods of data collection, I will be analysing the data in a specific order. It will start with the pre and post test scores, followed by the teacher interviews, participant observations and finally the computer game data. Due to the fact that this study is based on a small sample, and because of the qualitative approach used (10 participants), statistical tests on such a small sample will not bring additional insights for the research questions asked.

4.2 Pre and post-test results

The pre-test and post-test results measured the academic achievement levels of the year 5 participants in mathematics. The pre-test was to measure their current ability in the 2 to 12 times tables. The identical post-test was to determine the level of progress made throughout the week. A total of 10 participants aged between 9 and 10 years old took part in the tests, all having five minutes to complete as many of the 143 questions on the times table grid as possible (Appendix 7). The results will compare two groups of children, with the (n=5) in the control group having no changes to their daily routine and (n=5) in the experimental group who played the mathematics computer game as well as taking part in the teacher's regular lessons.

Figure 4 reveals how the experimental group managed in the pre-test at the start of the week. All of the results were relatively low scoring; however, this table shows that they were all of a similar ability with only a 20-point difference between the highest and lowest results. The highest score was from participant 2 (P2) with 45 points, with the lowest from (P5) of 25 points.

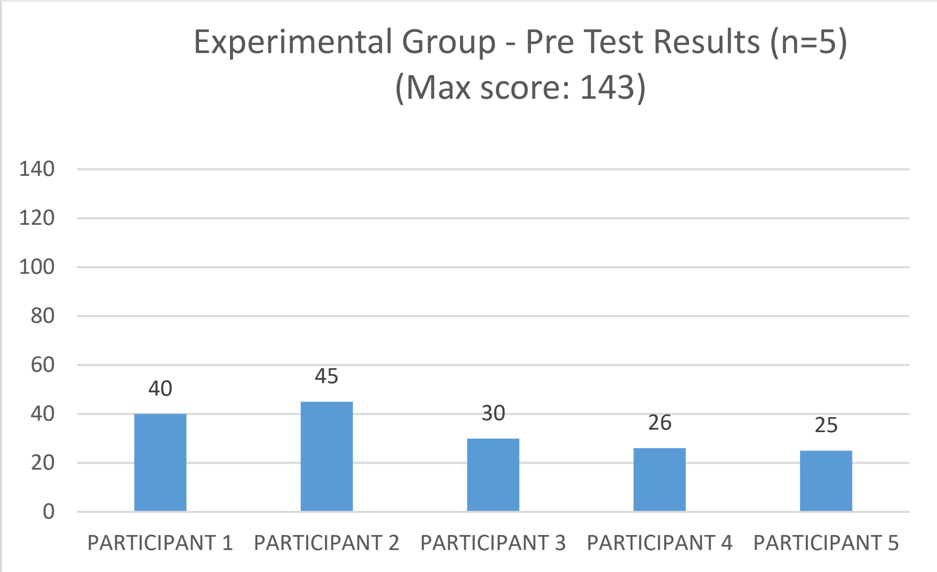


Figure 4 – Pre-test results from the experimental group

Figure 5 reveals the pre-test scores from the control group at the start of the week. The results show that 80% (n=4) of the group performed to a relatively similar level. However, participant 9 (P9) scored highest with 116 points, 51 more than the second highest (P7) and 80 more than the lowest score in the group (P6).

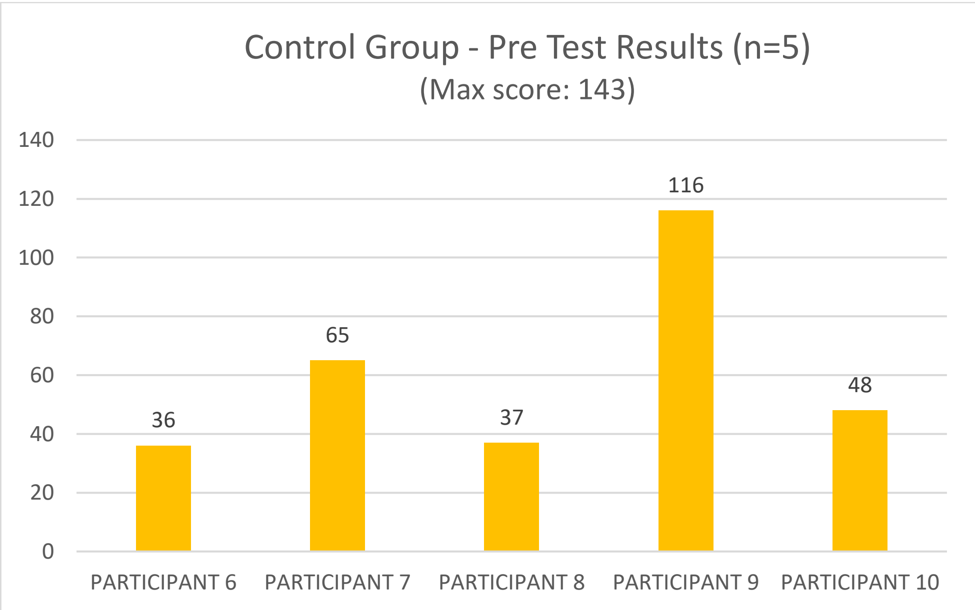


Figure 5 – Pre-test results from the control group

When you compare both groups alongside each other in Figure 6, it is quite clear that most of the participants are of a similar ability when it comes to mental mathematics. Out of the 10 participants, 80% (n=8) are within 23 points of one another, with the other 20% (n=2) scoring higher than the average. The teacher selected the 10 participants to take part in this study based on them being of a similar ability. These results show that the teacher was fairly accurate in the participant selection, with minimal differences between the two groups.

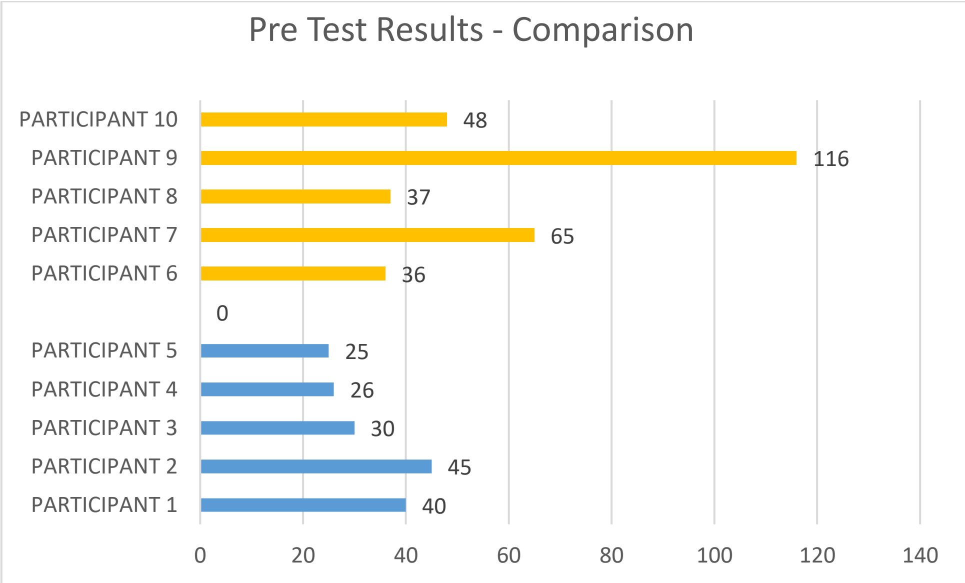


Figure 6 – A comparison of pre-test results from control and experimental groups comparison

At the end of the week, both groups were asked to re-take the times-table test for the same amount of time. The purpose of doing this was to see whether either group had made any progress over the course of the week. The experimental group had taken part in both the mathematics lessons and played 20 minutes of the computer game each day. The experimental group's results of the post-test can be seen in figure 7. The results revealed that all of the participants in this group had in fact increased their overall score. The highest score came from (P2) again with a score of 71, 5 more than the second highest (P4) and 28 more than the lowest score from (P3) with 43.

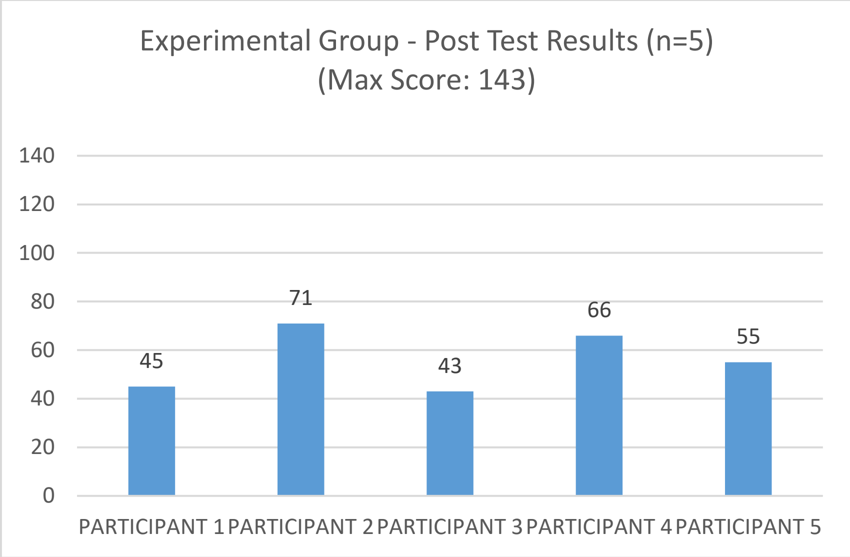


Figure 7 – Experimental group post-test results

However, when you compare the pre and post-test results of the experimental group, there are some clear changes to their achievement levels. Figure 8 shows each participant's percentage increase from the pre-test to post-test. Despite (P2) scoring the highest in each of the tests, they only made a 58% increase on their previous score. The most notable changes came from (P4) and (P5), who improved their score by 154% and 120% respectively. The smallest gains came from (P1) who only showed a 13% increase on the previous test.

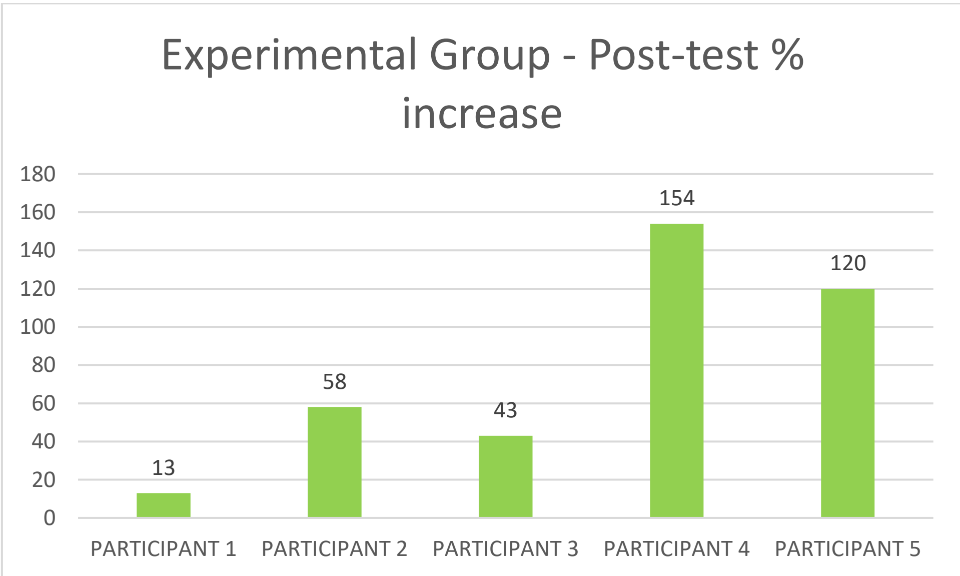


Figure 8 – Experimental group post-test percentage increase

The control group's post-test results can be seen in figure 9. These results also revealed increases to all of the participants scores. The highest score was once again from (P9) who managed to score 143, which meant 100% of the questions were answered correctly. The lowest score came from (P8) with a score of 46 correct answers. The difference between the highest scorer (P9) and the lowest score (P8) was 97 points, an increase on the pre-test difference.

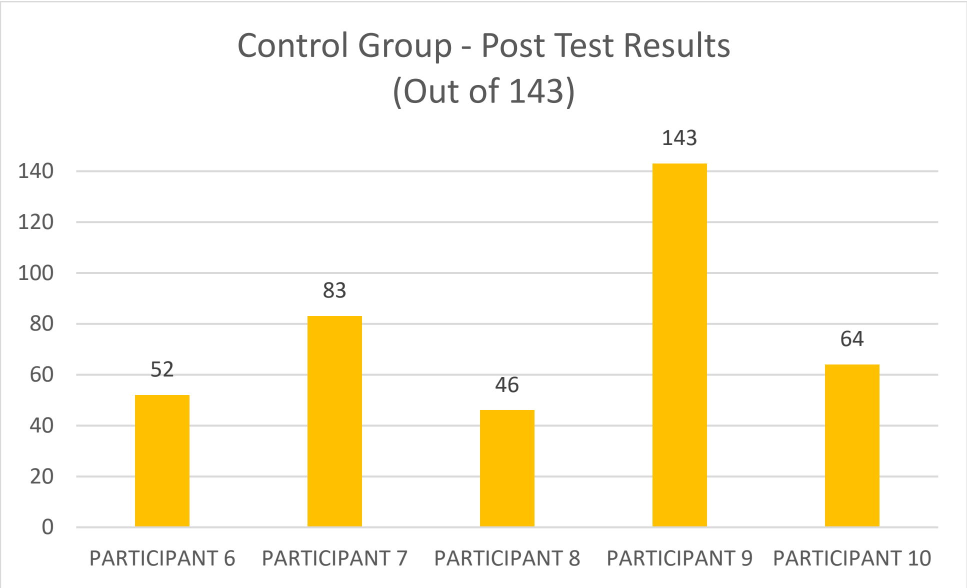


Figure 9 – Control group post-test results

It is revealed in figure 10 the percentage increase that the control group made throughout the week. The biggest increase came from (P6) who increased their score by 44%, with the next being (P10) and an increase of 33%. The smallest increase came from (P9) who made a 23% increase, however it must be highlighted that (P9) did score maximum points on the post-test. Despite this, (P8) made the lowest amount of progress in the control group, only increasing their score by 9 points.

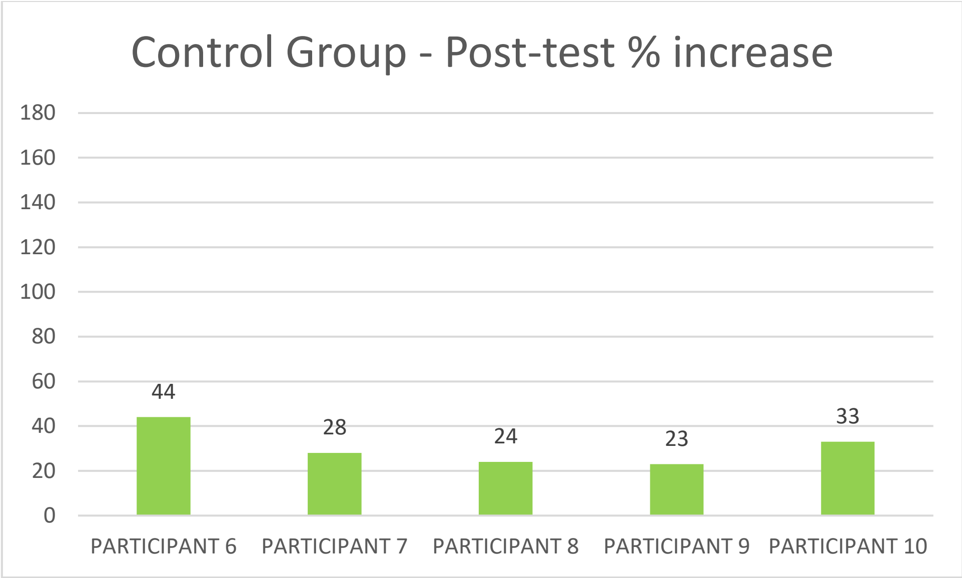


Figure 10 – Control group post-test percentage increase

When you put the two groups scores together and look at the overall increases of each group it reveals that the greatest change to achievement came in the experimental group. Figure 11a shows the difference between the pre and post-test scores for both the control group and the experimental group. This image shows that participant 4 and 5 outperformed all other participants, making the greatest improvement. However, three participants in the experimental group (P2, P4, P5), made greater improvements than 80% (n=4) of the control group. Despite this, the lowest improvement was also in the experimental group with (P1).

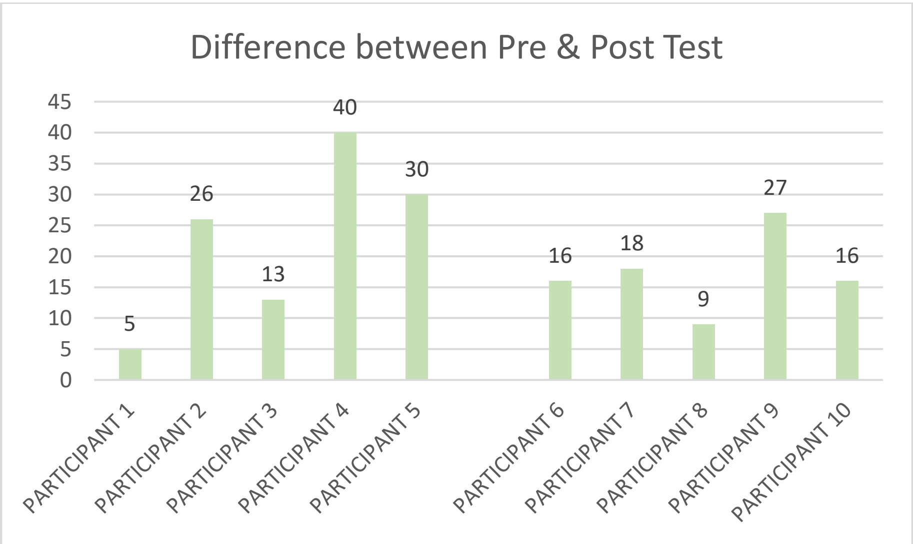


Figure 11a – Difference between pre and post-test scores

Overall the group that made the most improvement over the two tests was the experimental group, with an increase of 114 points. This was compared to the control group who made an overall increase of 86 points. When looking at the means of both groups in figure 12a, the control groups pre and post-test mean equalled 60.4 and 77.6 respectively, with an increase of 17.2. This is compared to the experimental group with the mean of pre and post-tests being 33.2 and 56 respectively, with an increase of 22.8. This shows that the average scores increased more in the experimental group. This is supported by the graphs in figure 12b, which show the experimental group having made the greatest change. The control group had the highest scoring participants (P6, P9), but the difference between the two test scores is clearly greater in the experimental groups graph.

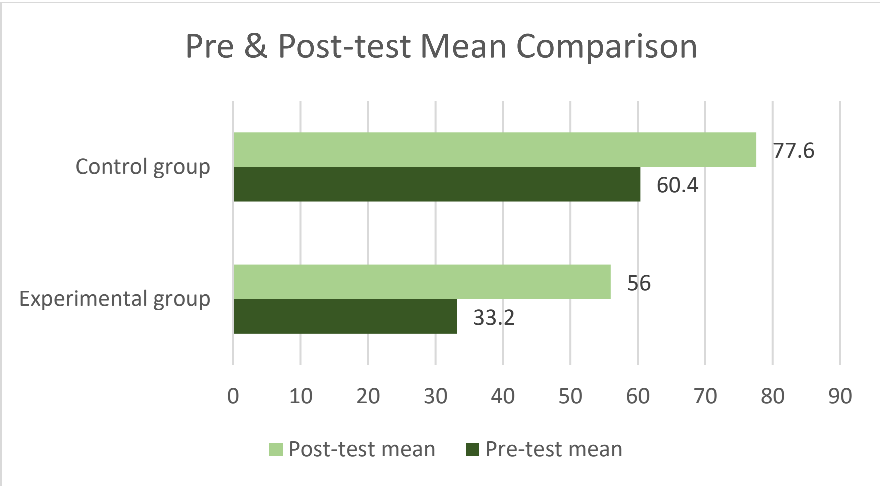
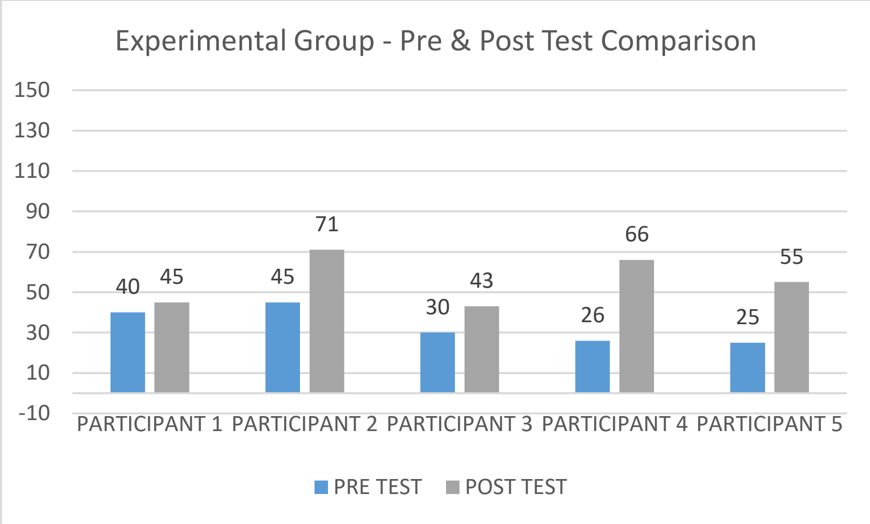


Figure 11b – Pre and post-test mean comparison



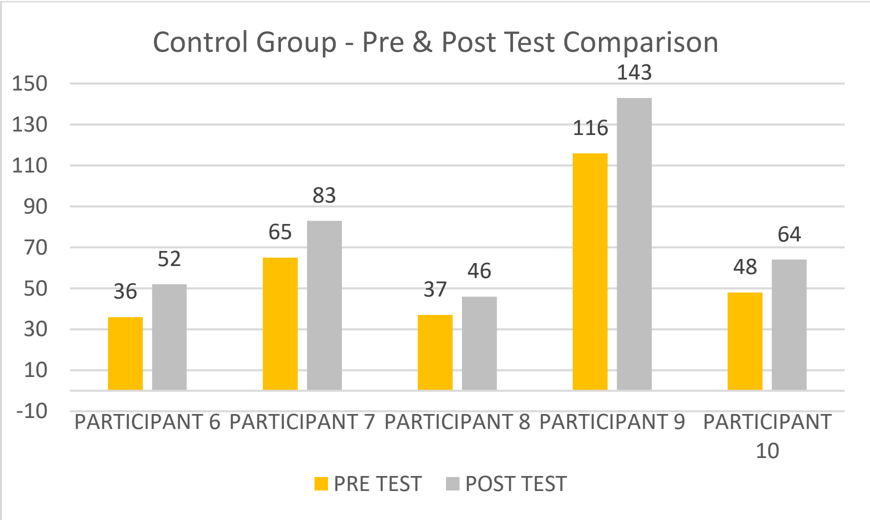


Figure 12a & 12b – Pre and post-test score comparisons

4.3 Teacher interviews results

The interviews measured the teachers' perceptions on mathematics assessment, stealth assessment and computer game learning. They were also used to see if the classroom teacher (Teacher A) found the data collected from the computer game was useful and could be progressed any future learning. The pre-research interviews were carried out by interviewing two teachers, one being an experienced year five teacher (Teacher A) and the other being with a newly qualified teacher (Teacher B) that was teaching a year one class. I then carried out a follow up interview at the end of the week with Teacher A to get their thoughts after the computer game had been played, and to see if there were any changes to their answers. The following interviews were recorded on an audio recording device. In the transcripts, the interviewer will be abbreviated to 'Intvr' and the responses from the teachers will be 'Resp'. The pre-research interview transcripts can be found in Appendix 19 and 20, with the post-research interview in Appendix 21. In this section I will summarise the key responses of both teachers.

4.3.1 Summary of pre-research interview – Teacher A

The first interview with Teacher A revealed some interesting responses. The discussion began with asking how they go about assessing mathematics. Teacher A revealed that both formative and summative assessments are used regularly to measure the children's progression throughout the year. It was discovered that this class uses a range of computer aids to support these assessments. Furthermore, it was mentioned that formative assessments were the main method used in mathematics, with the summative method only used at the end of each half term. It was also mentioned that the teacher uses the formative method of assessment right across the curriculum, as a way of revisiting the learning and assisting with their development throughout the year. It was interesting to hear Teacher A's thoughts on the summative method, that sometimes the teachers do not know how the children may react to these tests, which was seen as a problem. Teacher A expressed concerns about this method, stating that they did not want learning to be based around a test. However, Teacher A understood that this is the only way to hold schools to account at present and to see how much the children have progressed. Teacher A's thoughts on assessment methods for mathematics were also discussed. Their response highlighted that multiple assessment methods must be used together, to build a bigger picture of the children's learning. In addition, Teacher A highlighted that summative assessment does not allow teachers to spot the weaker areas of learning. The conversation also revealed that Teacher A believes that assessments in school should be more teacher-led and that the government should put more trust in teachers to know where their children's learning is currently at throughout the year.

When asked for their thoughts on stealth assessment using computer games, Teacher A was relatively positive about this method of assessment. However, it was stated that this way of assessment "needs to be productive, well planned and have a purpose to ensure it was supporting the children's learning." Teacher A had mixed thoughts on children playing computer games; however, they had no issues with them playing games as long as these were age appropriate. This led to a discussion on game-based learning. Interestingly, Teacher A was in favour of this, as long as it is targeted correctly. Furthermore, it was stated that "computer games could be embedded in the curriculum, but not used all the time and have to be relevant to the learning." The conversation continued with Teacher A stating that the school had already used mathematics computer games in the past and they often use them to compete against other classes in the school. However, when probing this information further, it was discovered that computer games were only used when it was relevant and not used as a regular learning tool.

Next, we discussed the topic of motivation and engagement levels during their mathematics lessons. Teacher A mentioned this was a tricky subject, because the methods currently used state that the whole class must progress at the same pace. It was mentioned that this causes disengagement amongst the higher achievers and the current methods of teaching mathematics are not ideal. Additionally, Teacher A expressed his concerns about current methods not fully supporting every child, stating "There is a really difficult balance with this approach at the moment and supporting every single learner. We can't differentiate quite as strongly as we use to be able to in maths." However, the interview revealed that more technology is being used to combat this disengagement and to keep the learning varied. Teacher A thought that computer games could improve engagement and motivation in mathematics, but they shouldn't be used too often and must have a purpose. This led to Teacher A being asked whether stealth assessment and computer game learning could benefit the children of tomorrow. The response was mixed, stating it could be beneficial if used correctly, but this would need to be intrinsically linked to support all areas of learning. However, Teacher A also thought that this method was quite a closed procedure and could only measure certain aspects of the children's learning. He also stated, "It must be that the children were learning and tested on what they were doing, rather than just playing a game, if you get what I mean, to support all areas of learning".

4.3.2 Summary of pre-research interview – Teacher B

This section will look at the responses from the interview with Teacher B. Teacher B is a newly qualified teacher in key stage one. The discussion began with Teacher B stating that assessment in mathematics was an ongoing process throughout the year and involved placing the class into categories on their current ability levels and knowledge of mathematics topics. Information on the children's learning is collected from the teaching assistant's observations, as well as discussions with the class and work recorded in their text-books. Summative assessments were also used every half term to measure progress. Teacher B emphasised that formative assessment was beneficial as it allows the teacher to monitor children's understanding and address any misconceptions. In addition, it was highlighted that the core subjects of English and mathematics received the most formative feedback. Teacher B's thoughts on the summative assessments were mixed, stating that they are useful for spotting some weaker areas of children's learning. However, they thought "some summative aspects do not show a pupils full understanding and ability, which can be quite restricting." When discussing assessment methods used for mathematics in their school, Teacher B revealed that more methods of assessment were needed to provide a greater picture of the children's learning. Additionally, they stated that "the more options and methods available to teachers, the greater the picture we can build of their overall learning and better prepare them in the future".

The conversation then progressed onto stealth assessment using computer games and asked for their thoughts on assessing children in this way. Teacher B appeared to be rather positive about this method, stating that current assessments can cause a lot of stress and anxiety for both teachers and pupils. “It also sounds like it could be done fairly easily without much time and effort going into the assessment. Potentially the teacher starting the game off and allowing the children to work independently. Depending on the criteria and algorithms used, it has the potential to identify areas of strengths and weaknesses that may be overlooked on a day to day basis.” Despite this, Teacher B also expressed one concern, that the teacher is not always necessarily going to see the learning happen first hand.

The interview then discussed Teacher B’s thoughts on children playing computer games, “As an avid gamer myself, I see the benefits of playing video games. It has the potential to develop problem solving, literacy and numeracy skills, social interaction, response times, reflexes and so much more.” Despite this, Teacher B thought that computer games should be played in balance, with children having a healthy balance of playing computer games and activities that are not related to technology. Teacher B carried on the conversation by stating, “Nonetheless, there are many games that are now being used to involve technology in schools and are used to enhance learning. Educational computer games are also used to bring differentiation into a classroom and can be a good resource for children with SEN. Additionally it is important that children play age appropriate games and if they are playing older age category games then they need to be informed what they might see, do or hear in the game and why these may not be appropriate in real life.” The discussion continued by asking for their views on computer game learning. It was stated that despite being an advantageous method, there needs to be a balance of learning styles used, in order to be fully inclusive. Additionally, it was highlighted that some families may not have access to the required technology for this type of learning method to be used outside of school. Despite this, Teacher B believed this method of learning has huge potential, but could encounter problems with some educators and parents, “I do not think large gaming companies see profit in this area and more conservative educators and parents can often push video games aside." Teacher B did reveal that their school have used computer games previously in mathematics lessons and for some homework tasks. Finally, Teacher B thought that stealth assessment and computer game learning needed to be purposeful and targeted at the right time in the learning process.

Engagement and motivation in mathematics was the next topic of discussion, with Teacher B stating that when their lessons are fun, engaging and challenging, pupil participation in the lesson increases. Additionally, motivation for the subject is higher when something different or new included in the lesson. When asked whether they thought computer games would make any difference to motivation and engagement, Teacher B responded, "Children become excited when they talk about their latest game that they are playing at home. I think this would affect motivation and engagement for those children that enjoy playing computer games and have had access to games before." Despite this, Teacher B also thought that it had the potential to be non-encouraging for those children that are not interested or do not like playing computer games. The final question asked if they thought stealth assessment and computer game learning could benefit the children of tomorrow. Teacher B stated "If technology continues to develop the way that it is at the moment, then I definitely think it has a place in the classroom. However, it needs to be purposeful and targeted at the right time in the learning process. I do not think that it could be used alone as a learning tool."

4.3.3 Comparison of pre-research interviews – Teacher A and Teacher B

This section will compare both sets of responses that were provided by Teacher A and Teacher B, looking at the similarities or differences. The first question asked for their thoughts on how they go about assessing in mathematics. Both teachers mentioned that assessment in this subject was a continuous process. Teacher A collects information on the children's learning by doing cold assessments which look at prior learning and using this information to fill the gaps of knowledge. Whereas, Teacher B uses observations, group discussions and work recorded in the children's text-books to determine their level of understanding. Despite slight differences in the techniques of assessing, both use formative and summative methods. It is likely that the differences to their chosen assessment techniques is down to the children's age and stage of learning.

After comparing the two teacher's thoughts on stealth assessment through the use of computer games, it was noticeable that both teachers had slightly different opinions. Teacher A appeared to have mixed thoughts on this method of testing, stating that it would need to be targeted, well planned and must have a purpose. In addition, Teacher A seemed to be concerned about how it would support children's learning and stated that if there is no meaning to it then it will not be supporting their learning. On the other hand, Teacher B viewed things differently in a number of respects. Teacher B seemed rather positive on this method of assessment. Additionally, they highlighted how current assessments can cause stress and demoralise some pupils. They thought this new method of assessment had the potential to spot strengths and weaknesses in the children's learning that might often be overlooked. However, Teacher B did have one slight concern, which was that the teachers are not always witnessing the learning happen first hand.

Question three asked how important formative feedback was in their classrooms and which subjects received the most feedback. When reviewing both teacher's answers, it was clear to see that both of them valued this approach. They both states how this method is the best way of supporting the children's learning and addressing any misunderstandings. Additionally, both address the fact that mathematics and English receive the most formative assessment. When looking at the teachers' thoughts on summative assessment, they both appear to share an understanding of its purpose, but they also had contrasting views on the negative effects. Teacher B stated that the summative approach did not provide a clear picture of the children's full understanding. Whereas, Teacher A shared concerns about how difficult it is to predict how children will react to a test.

When reviewing question five, I discovered that both teachers have slightly different opinions on the topic of children playing computer games. Teacher A chose to focus their answer on the age ratings of games and how he would prefer them to be playing games that include appropriate content for their age range. In contrast, Teacher B stated that they were an avid gamer themselves and understood the potential benefits computer games can have on children. They stated that computer games can help children in a number of different ways, however, they also stated that these games needed to be played in balance with other forms of play. Teacher B also highlighted that computer games can enhance the teacher's differentiation of work and how they can support children with special educational needs (SEN). Despite this, Teacher B shared a similar view to Teacher A on the subject of age appropriate games and that children should only be playing games suitable for their age group. However, it was noticeable that Teacher B appeared to be more open-minded towards the idea of allowing children to play computer games for learning purposes. The conversation then turned to their opinions on computer game learning, with Teacher A highlighting that if targeted correctly they can be useful, but not something that is used all of the time. Nevertheless, Teacher A also stated how computer games such as Minecraft are being recognised as really good learning materials for teaching children programming, game design and computing. Teacher B thought that there was huge potential to this method of learning, but also believed that game-based learning needed to be balanced with other learning styles and addressed the fact that all children learn in different ways. The two teachers both appeared to be open to the idea of computer game learning and shared similar views that they should be targeted and balanced with other learning styles.

Question seven revealed that both teachers already had some experience of using computer games in the classroom. Teacher A mentioned that the children have played games for mathematics and English, but they are only used when relevant to the learning. Additionally, it was revealed that the school uses a computer game to add a competitive aspect to mathematics learning, with classes competing against one another for points. Teacher B also had experience of using computer games for mathematics, but also revealed that these games were generally used more often in Key Stage 2. It was interesting to discover that both teachers had already used computer games in some form, despite them both having slightly different opinions on the subject. The following question asked whether any other technology was used for their mathematics lessons. It was discovered that both teachers used similar technological tools in their lessons, with interactive white boards and iPads being used to create a more visually appealing lesson and to record evidence of the work completed by the class.

Question nine asked about children’s general motivation and engagement levels within mathematics lessons. Teacher B stated that children’s involvement in the lessons increases when the learning was fun, challenging and when something different was brought into the lesson. However, Teacher A shared some concerns about motivation, revealing that there is a general disengagement towards mathematics and that current methods of teaching in the subject are not ideal. Additionally, it was mentioned that this was one of the reasons why more technology is being included in mathematics; to keep the learning varied and engaging. These statements made it appear that some teachers seem to be struggling to keep older children engaged with the subject. However, both highlighted the fact that children become more engaged when something new is added to the lessons. This led to further discussion about whether computer games would have any effect on motivation and engagement levels in mathematics. Both Teacher A and Teacher B shared a similar view that computer games could have a positive effect. Nevertheless, they both mentioned that computer games need to have a purpose and must only be used at the right time. Teacher B raised one concern about using computer games, stating that many children will enjoy this approach to learning, but it could be non-encouraging for those children that do not like playing these games.

Question eleven aimed to get their thoughts on the assessment methods used for mathematics. Both teachers shared similar opinions and that more than one method of assessment needed to be used to create a broader picture of children's learning. The final question asked both teachers whether they thought stealth assessment and computer game learning could benefit the children of tomorrow. Teacher A believed if it was used correctly then it could be beneficial, however, it was also mentioned that stealth assessment appeared to be quite a closed procedure and might only work for specific aspects of the learning. In contrast, Teacher B thought that it should definitely have a place in the classroom. However, they shared a similar view to Teacher A, that it needed to be used correctly and at the right time.

Despite the difference of teaching experience between the two teachers, there were a number of similarities to their answers on the subjects discussed. However, the teacher with least amount of experience (Teacher B), emerged as the more open minded towards stealth assessment and computer game learning. Despite this, it was interesting to discover that computer games have featured in both of their classrooms previously.

4.3.4 Comparison of pre- and post-interview – Teacher A

It was important to see if the opinions of the classroom teacher (Teacher A) had changed over the one-week period. This was also vital to analyse so I could attempt answer research question four, which aimed to discover if Teacher A found the game data useful and could progress the children's future learning with this data. Both interview transcripts with Teacher A can be found in Appendix 19 and 21.

The first question asked for the teacher's thoughts on the computer game used in this study. Teacher A stated that the computer game filled the children with confidence. Despite already using one game for mathematics, he further mentioned that it was good to have something completely new and was intrigued to investigate more games. Teacher A's opinion did not change that much from the start of the process, as they had already used computer games in the classroom and could see some benefits of them being used for learning purposes. However, despite stating that it was a good game, Teacher A also mentioned that the children were often choosing the easier times tables to play.

There were some slight differences to the teacher's opinion when asked about their thoughts on computer games being used to assess learning. In the pre-research interview his response focused more on the children and how the game would have to planned and implemented correctly or it would not benefit the children's learning. In the post-interview, Teacher A stated that if used correctly, it could be a powerful tool for teachers. However, Teacher A did have the same opinion that stealth assessments would have to be carefully planned and not just used randomly.

Question three asked Teacher A what they thought of the data received from the computer game. This question was important, because it relates closely to one of the research questions. It was surprising to hear that the teacher did not find the data wholly reliable, because it only provided information on which times table the children preferred to play. This then led to the next question which asked if the computer game provided enough information on the learner's competencies. Teacher A did not think the game provided enough information and that the game needed to restrict the amount of attempts the children could play each times table. This was interesting to hear, because despite the data appearing to offer very little to Teacher A, he did mention previously that the game filled the children with confidence.

Question five asked for an opinion on children playing computer games. Previously in the first interview, Teacher A focused a lot on how computer games should be age appropriate. This opinion did not change in the post interview; however, he did accept that computer games will provide a release for children. The conversation then proceeded to asking for their thoughts on computer game learning. In the pre-interview, Teacher A had stated that if targeted correctly then it can be successful, but not used primarily all of the time. In the post-interview Teacher A's opinion changed very little, however, he did state that computer game learning if planned correctly can be powerful and engage children.

The next question asked if they noticed any differences to the engagement of the children playing the computer game compared to their engagement in regular mathematics lessons. Teacher A stated that the children seemed to become more engaged as the week progressed. Despite this, he was not sure whether this was down to them becoming more confident generally with the work, or because the children were approaching the same times tables throughout the week. When asked if the children appeared more motivated to learn by playing the game, Teacher A thought they were. Furthermore, he mentioned that the computer game was far more engaging for them than learning by rote. Teacher A was asked if he thought the children were more motivated to learn after playing the computer game. Teacher A mentioned that this was difficult to judge but did think the children would have preferred to continue playing the game instead of re-joining the lesson.

The final question asked whether Teacher A thought stealth assessment and computer game learning could benefit children of tomorrow. The responses from both interviews were very similar. Teacher A believes that if stealth assessments were to be implemented and planned correctly then they could be beneficial for children in mathematics.

4.4 Observation results

The observations were carried out over the one-week period, monitoring the engagement and motivation of both the control group and experimental group. The experimental group were observed in their regular mathematics lessons, as well as when playing the Sundae Times computer game. Whereas, the control group were only observed during the regular mathematics lessons. The observations of both groups were completed once per day, with the regular mathematics lessons lasting approximately 60 minutes and the computer game observations lasting 20 minutes. In order to work out how engaged and motivated each participant was with the learning, they were observed on how many times they carried out specific actions, as well as observing their general body language.

The actions observed during these times were:

1. Did they offer help to others?
2. Did they ask for help?
3. Did they look at another participants screen/ work?
4. Did they answer questions?

At the end of each observation, I categorised the participant's engagement and motivation levels into three groups of high, medium and low. For the purposes of all graphs listed below, High = 3, Medium = 2 and Low = 1. The experimental group are listed in the results as participants 1 to 5, with the control group being listed as participants 6 to 10.

4.4.1 Day 1 Observations

Figure 13 reveals the engagement and motivation levels recorded during the mathematics lesson on day one. This lesson took place in the morning and was a mixture of the teacher using the interactive white board and the class completing tasks in their workbooks. In this lesson, the children were learning about different fractions. When looking at the engagement levels of both groups, the experimental group had 60% (n=3) of the participants that showed a high level of engagement, with the other 40% (n=2) showing medium engagement levels. In contrast, the control group had 20% (n=1) of the participants showing high levels, 40% (n=2) showing medium levels and 40% (n=2) with low levels of engagement. Figure 13 also shows the level of motivation both groups showed towards the learning. The experimental group fared slightly worse than the control group in this category. Participant 2 was the only member in the experimental group to show a high level of motivation. On the other hand, the control group had (n=2) participants showing high levels of motivation towards the learning.

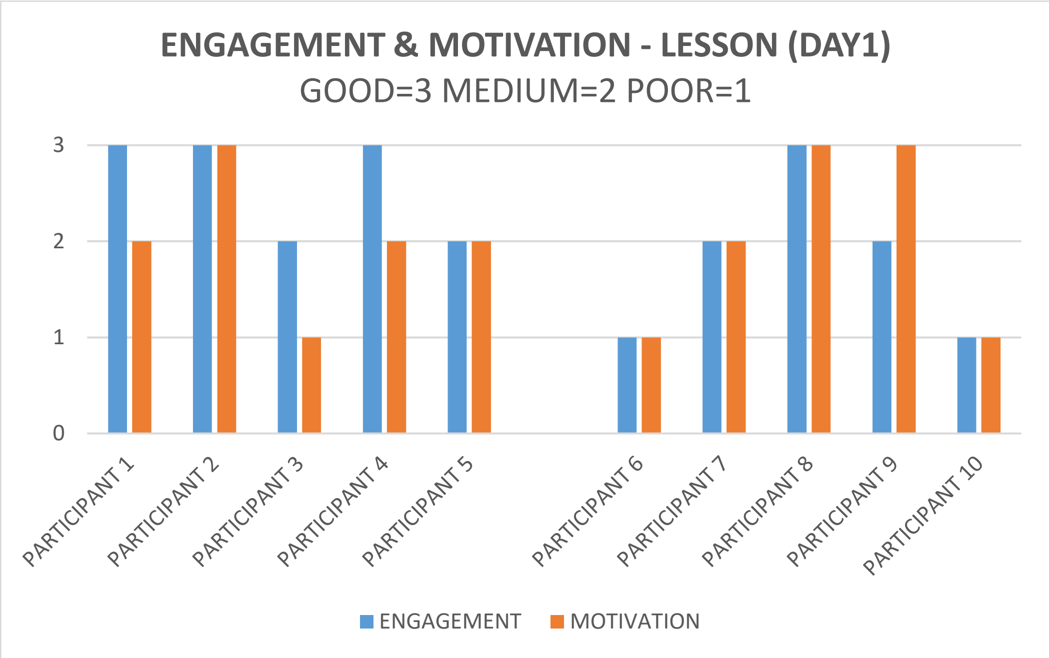


Figure 13 – Day one engagement and motivation of the experimental group and control group during the regular mathematics lesson.

If you then look at the experimental group's engagement and motivation whilst playing the computer game in figure 14, it is quite visible there are some significant differences. During the time I observed them playing the computer game, 100% (n-5) of participants showed a high level of engagement and motivation towards the learning. This was compared to 60% high levels of engagement and 20% high levels of motivation in the regular mathematics lesson. It must be noted that the total amount of time participants had to play the game was slightly less than 20 minutes on day one, due to technical problems with the school laptops.

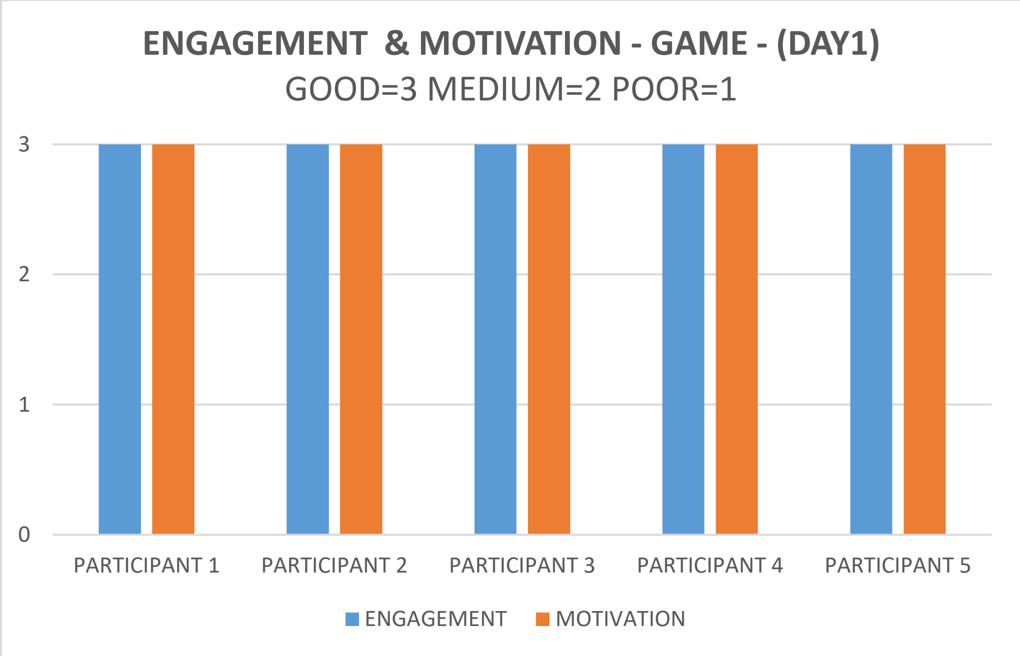


Figure 14 – Day one engagement and motivation of the experimental group when playing the Sundae Times computer game

4.4.2 Day 2 Observations

Figure 15 shows the engagement and motivation levels of both groups during the mathematics lesson on day two. These observations took place in the morning, with the mathematics lesson consisting of a mixture of interactive white board learning, working in small groups and working in textbooks. In this lesson, the children were learning about fractions and decimals. When analysing the observation data from the mathematics lesson, it reveals that the engagement levels of the experimental group was slightly lower than the day one results. The experimental group had 40% (n=2) of participants displaying high engagement levels and 60% (n=3) that showed a medium level during the lesson. In contrast, the control group showed improvements to their engagement levels when compared to the previous day. The control group had 60% (n=3) of participants that displayed a high level of engagement throughout the lesson. They also had one participant that showed a medium level and one participant that showed a low level of engagement. When analysing both of the groups' motivation, it appeared to show that the experimental group were more motivated towards the learning tasks. The observation data shows 60% (n=3) of the experimental group displayed high levels of motivation; an increase of 40% from the previous day. Figure 15 also shows that the control group's motivation was unchanged from the previous day, with the same two participants (P8 & P9) showing high motivation levels. Additionally, all other participants in the control group showed the same level of motivation during the lesson.

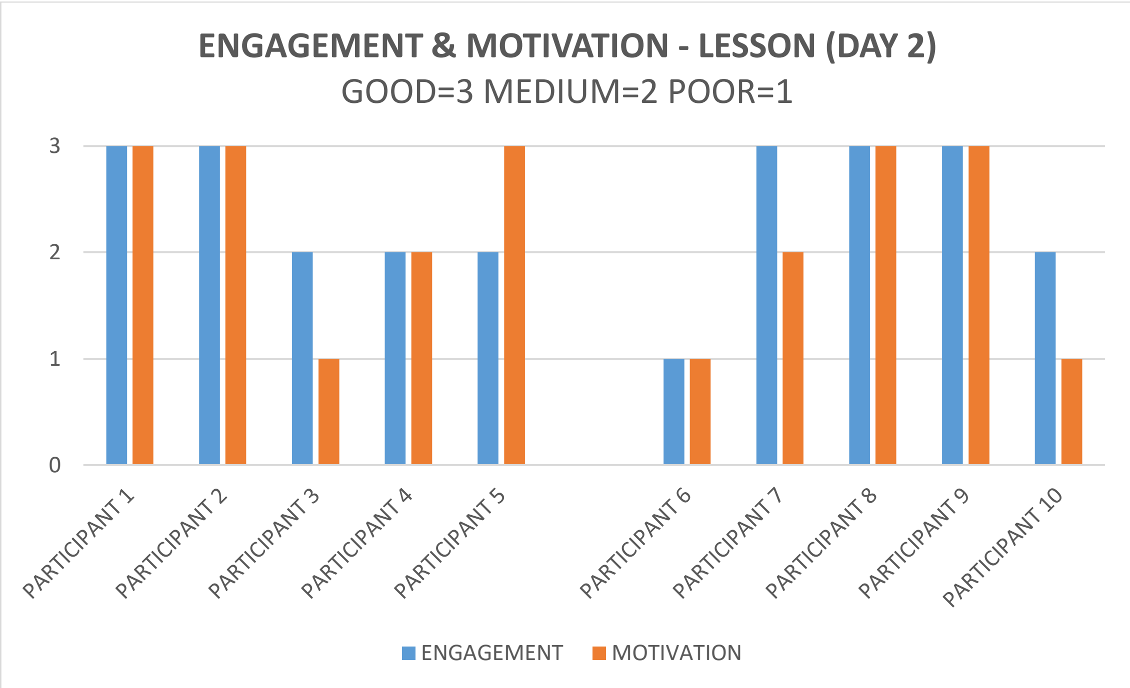


Figure 15 – Day two engagement and motivation levels of the experimental and control groups during the regular mathematics lesson.

The computer game observation also took place in the morning, with the experimental group playing the game for the full twenty-minute period. When analysing the data of the experimental group in figure 16, it shows high motivation and engagement levels from all participants. In total 100% (n=5) of participants had high levels of motivation and engagement with the learning task. There is quite a difference between these results and those taken from the mathematics lesson, whereby only 40% (n=2) showed high levels in both engagement and motivation categories.

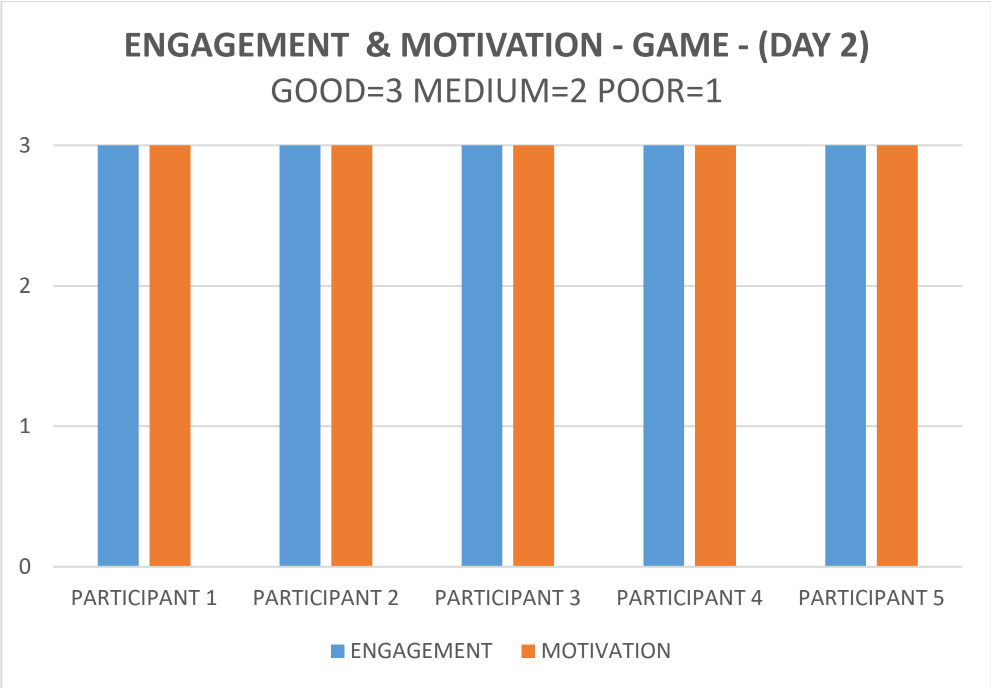


Figure 16 – Day two engagement and motivation of the experimental group when playing the Sundae Times computer game

Whilst carrying out the day two observations, it appeared that the experimental group participants were relying less on the teacher and did not look at their fellow participants work for reassurance as often, as seen in figures 17a and 17b. The additional notes I took during this observation picked up some interesting outcomes. During the lesson, participant 4 showed medium engagement and motivation, often looked confused, needed assistance from the teaching assistant and regularly looked at other classmates work to see how to complete the tasks. However, during the computer game observation, participant 4 appeared to be fully engaged and motivated, seemed confident with the learning task, did not require assistance from the teacher and did not seek help from any other participants computer screen. Figure 17b shows how many times each of the experimental group looked at another peer's work for assistance. The results show that whilst playing the game they were far less reliant on others work and more focused with their own learning. Figure 17a also shows the number of times each participant required additional support from the teacher.

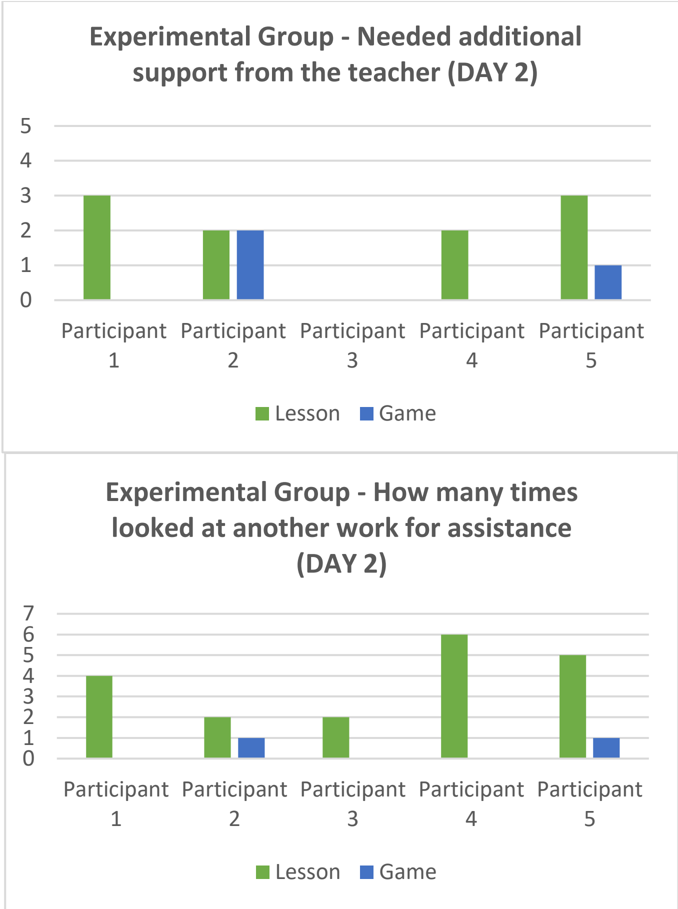


Figure 17a & 17b – The number of times where participants asked the teacher for help during the lesson and when playing the game (17a). The number of times where participants looked at another person's work or screen for assistance (17b)

4.4.3 Day 3 Observations

The day three observations took place during the morning, with the mathematics lesson consisting of tasks using the interactive white board and the children working in their textbooks. In this lesson, the teacher introduced the children to more fractions and decimals. Figure 18 shows the two groups' engagement and motivation for day three. When analysing the data for the experimental group during the mathematics lesson, it showed that 60% (n=3) of the participants had high levels and 40% (n=2) with medium levels of engagement throughout. These results showed a 20% increase in the high engagement category, when compared to the previous day. In contrast, the control group's results showed a decrease of 20% in the high engagement category. The control group had 40% (n=2) showing high levels, 20% (n=1) with medium levels and 40% (n=2) showing low engagement levels. However, when analysing the motivation of both groups during the mathematics lesson, the results show that both groups had slight increases in this category. The experimental group had 80% (n=4) of participants showing high levels of motivation towards the learning, an increase of 20%. This compared to 60% in the day two results. These results were also 20% higher than the control group, who in comparison had 60% (n=3) of participants showing high levels of motivation. Additionally, one participant in the control group (P10) displayed low levels of both engagement and motivation during the mathematics lesson.

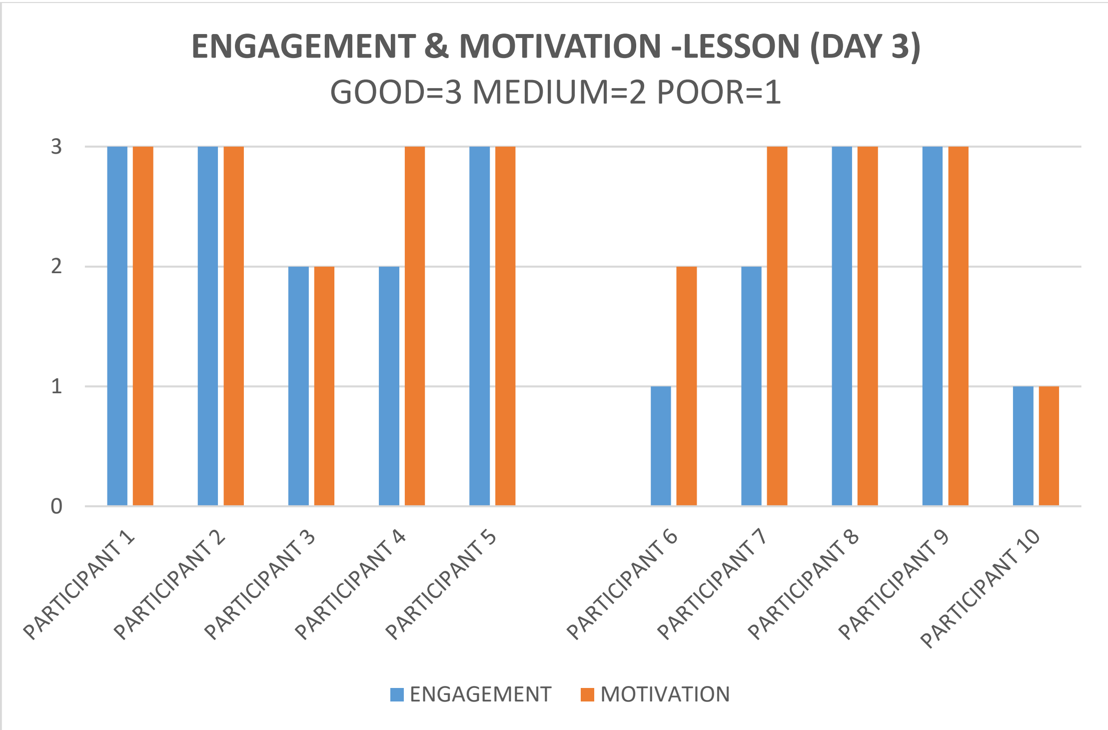


Figure 18 – Day three engagement and motivation levels of the experimental and control groups during the regular mathematics lesson.

The day three observation data of the experimental group playing the computer game can be seen in figure 19. The data reveals that all of the participants showed high levels of engagement and motivation towards the learning task. This was the third day in a row where the experimental group had 100% (n=5) of participants showing high levels of engagement and motivation when playing the computer game. When comparing these results to the observations carried out during the lesson, it reveals that high engagement levels were up 40% and high motivation levels went up by 20%.

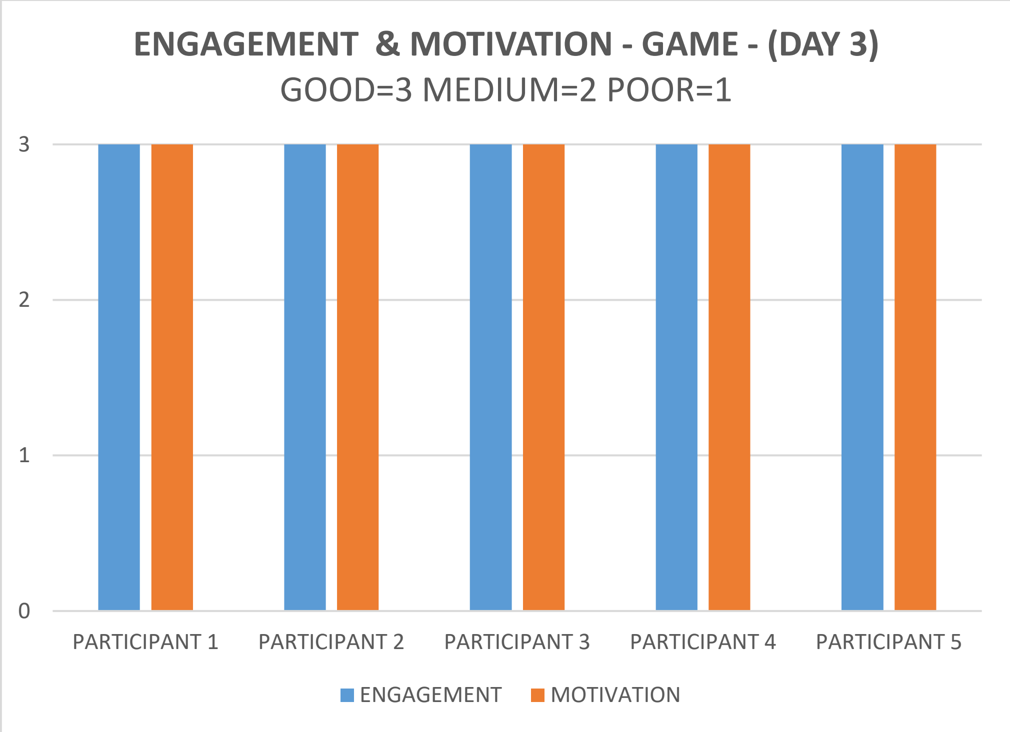


Figure 19 – Day 3 engagement and motivation of the experimental group when playing the Sundae Times computer game

Whilst carrying out the observations on day three, there were also other visible differences between the groups. One of the actions monitored throughout the observations was the number of times each participant offered help or guidance to their peers when needed. When comparing the data of the two groups in figure 20, it shows some clear differences between the lesson and the computer game. In the lesson the data shows that two participants from the control group offered guidance on two occasions. In contrast, the experimental group also had two participants that offered help to their peers during the lesson. However, when you look at the data from the computer game observations, it reveals that the experimental group were much more willing to offer help or guidance to their peers. The total number of times they offered help to others during the computer game was 9. This was compared to just 2 times during the lesson and 4 times when compared with the control group. Whilst carrying out the observations, it appeared that the experimental group were more confident with the learning during the computer game, which resulted in them being more willing to assist others when needed.

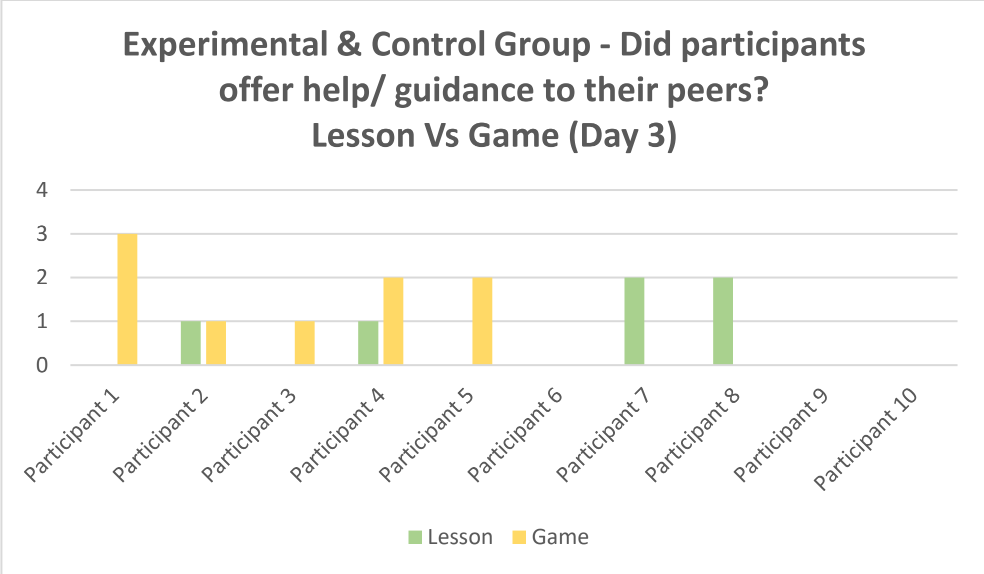


Figure 20 – Day 3 – How many times the participants offered help or guidance to peers during the lesson and the computer game.

4.4.4 Day 4 Observations

The day four observations took place in the morning, with the lesson consisting of the class carrying out various tasks on their tables, as well as activities set by the teacher on the interactive white board. In this lesson, the children were learning about improper fractions. Figure 21 shows the observation data from the lesson for both the control group and experimental group. The experimental group data is different from the control group data in a number of respects. After examining the experimental groups engagement levels on day four, it shows that 80% (n=4) of participants displayed a high level of engagement with the learning. This was a 20% increase from the day three results and a 40% increase from the day two results. On the other hand, the control group only had 40% (n=2) of participants that displayed a high level of engagement, therefore showing no differences when comparing to the previous day. However, the two participants in the control group (P6 & P10) that had displayed low engagement on day three, made slight improvements, showing an medium level on day four.

When comparing the motivation levels of the two groups, it showed a similar picture. The experimental group displayed 100% (n=5) high motivation levels throughout the lesson. These results were 20% up on the previous day and 40% up when compared to the day two results.

In contrast the control group had three participants that displayed high levels of motivation towards the learning. There was very little change when comparing the results to the previous day, however, participant 6 decreased to a low motivation level. When comparing the two groups alongside each other, the experimental group showed an increase in both categories, whereas the control group showed little to no improvement in either category.

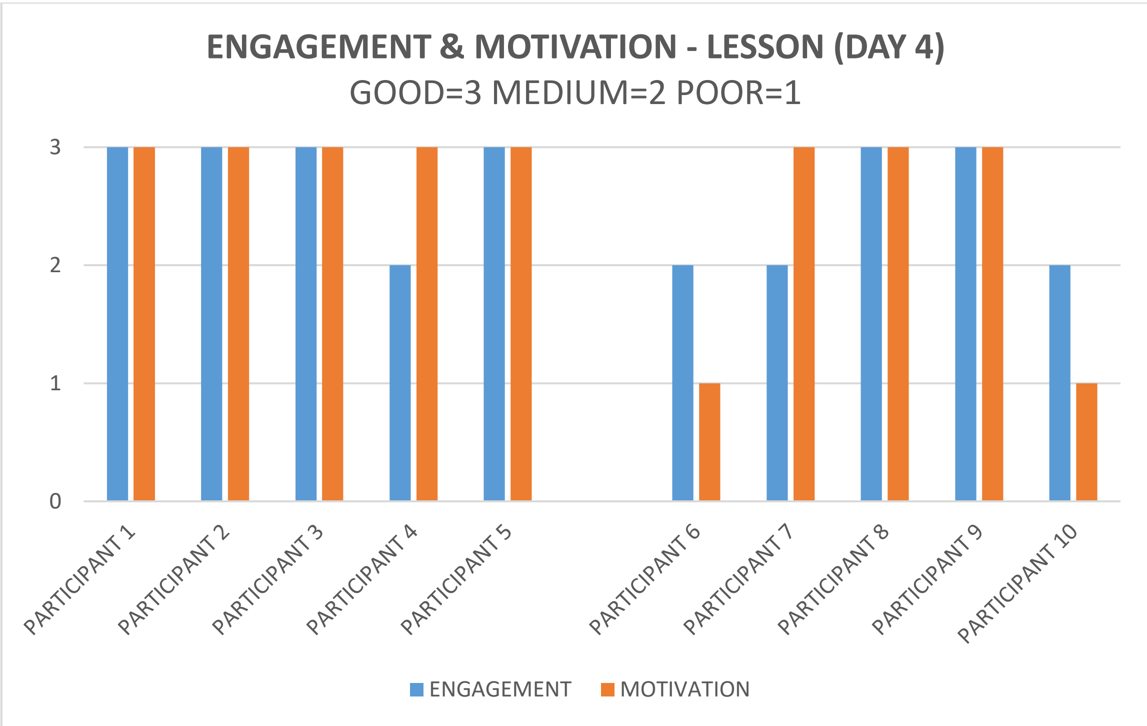


Figure 21 – Day 4 engagement and motivation levels of the experimental and control groups during the regular mathematics lesson.

One of the actions that I was observing during the lesson, was the number of times participants raised their hand to answer questions presented by the teacher. Day four showed some clear differences between the two groups, which supports the results given in figure 21. The data presented in figure 22 shows how each of the participants compared in this category. In total, the control group had ten questions answered, with the highest score coming from participant 8 with five questions answered. The lowest scorer in that group was participant 6, who did not attempt to answer any questions. In contrast, the experimental group had twenty answered questions, over double the total of the control group. The highest score was participant 2, answering six questions and the lowest was participant 5 with two. Moreover, four of the participants in the experimental group were in the top five overall scores in this category.

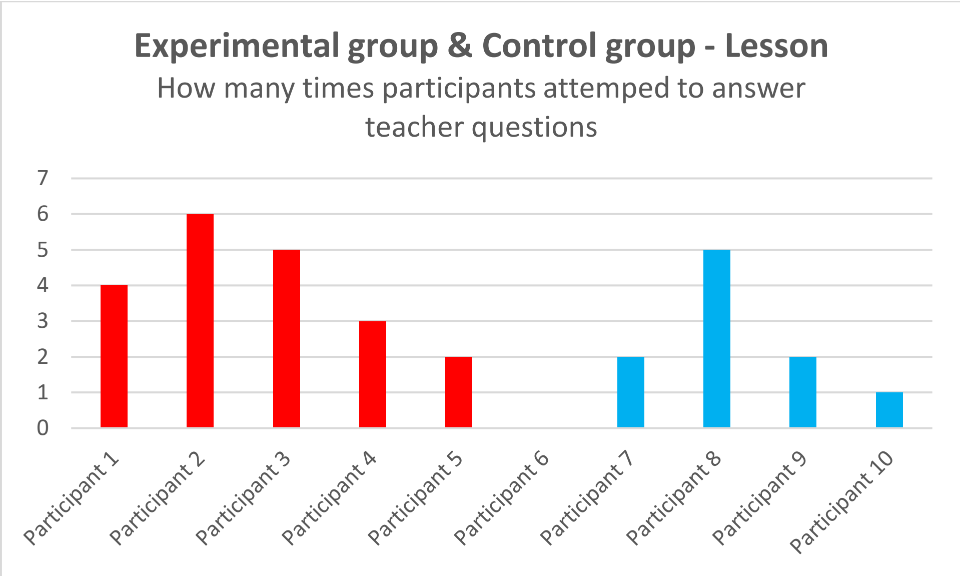


Figure 22 – The number of times participants of both groups attempted to answer teacher questions during the lesson.

Day four observations of the computer game took place in the morning, in the last hour before the class went to lunch. Despite being later in the morning than the previous observations, there was no change to the experimental group's engagement and motivation levels. Figure 23 shows that the group showed 100% (n=5) high levels of engagement and motivation. There was very little difference between the computer game and the lesson, with only participant 4 increasing their engagement level. These results mean that the level of engagement and motivation during the computer game observations were unchanged since day one.

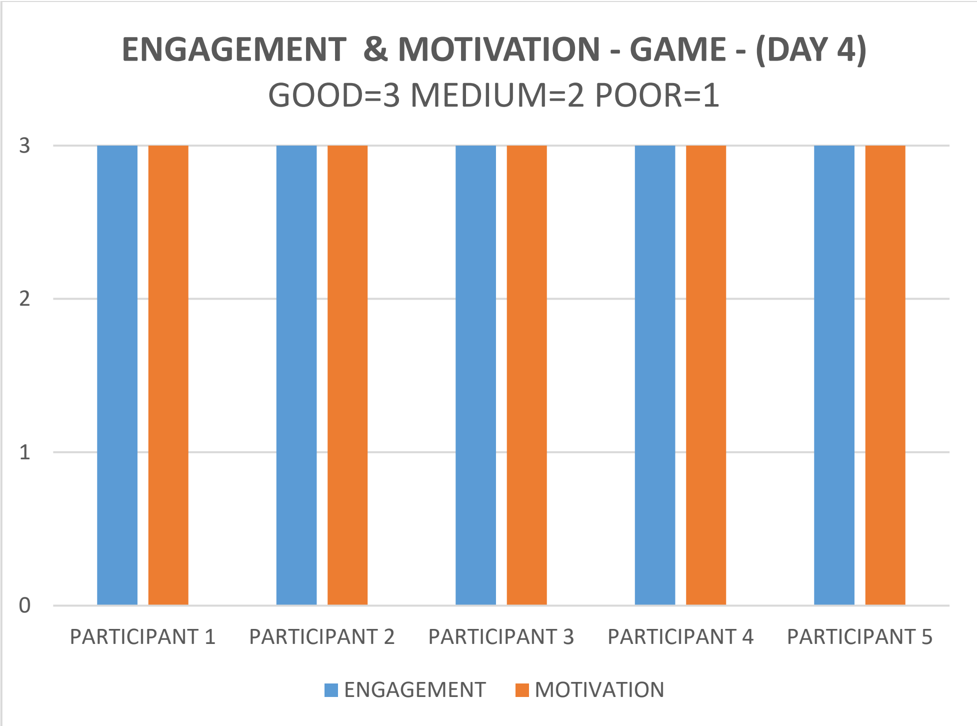


Figure 23 – Day 4 engagement and motivation of the experimental group when playing the Sundae Times computer game

4.4.5 Day 5 Observations

The day five observations took place in the morning, with the computer game observation taking place straight after registration and the lesson observation later in the morning. The lesson involved a lot of practical work with peers and also interactive white board activities. This lesson involved converting improper fractions. Figure 24 displays the data of both groups' engagement and motivation levels during the lesson. It is clear that the control group's engagement was much higher than the previous day. In total, 80% (n=4) of participants in the control group showed high levels of engagement, which was a 40% increase from the day 4 results. In contrast, the experimental group displayed 100% (n=5) high levels of engagement and was 20% higher than the previous day. When analysing the motivation levels of both groups, figure 24 shows equally good scores for both groups. The control group had 80% (n=4) of participants that showed high levels, with one participant showing medium motivation. This was a 20% increase when compared to the previous day. The most visible improvements came from participant 6 and 10, who showed an increase in both categories. The experimental group's results were unchanged from the previous day with all five participants displaying high motivation levels towards the learning. This was the first lesson observation where 100% of participants in both groups showed high levels of engagement and motivation. Despite this, there were only slight differences between the two groups in all of the actions observed.

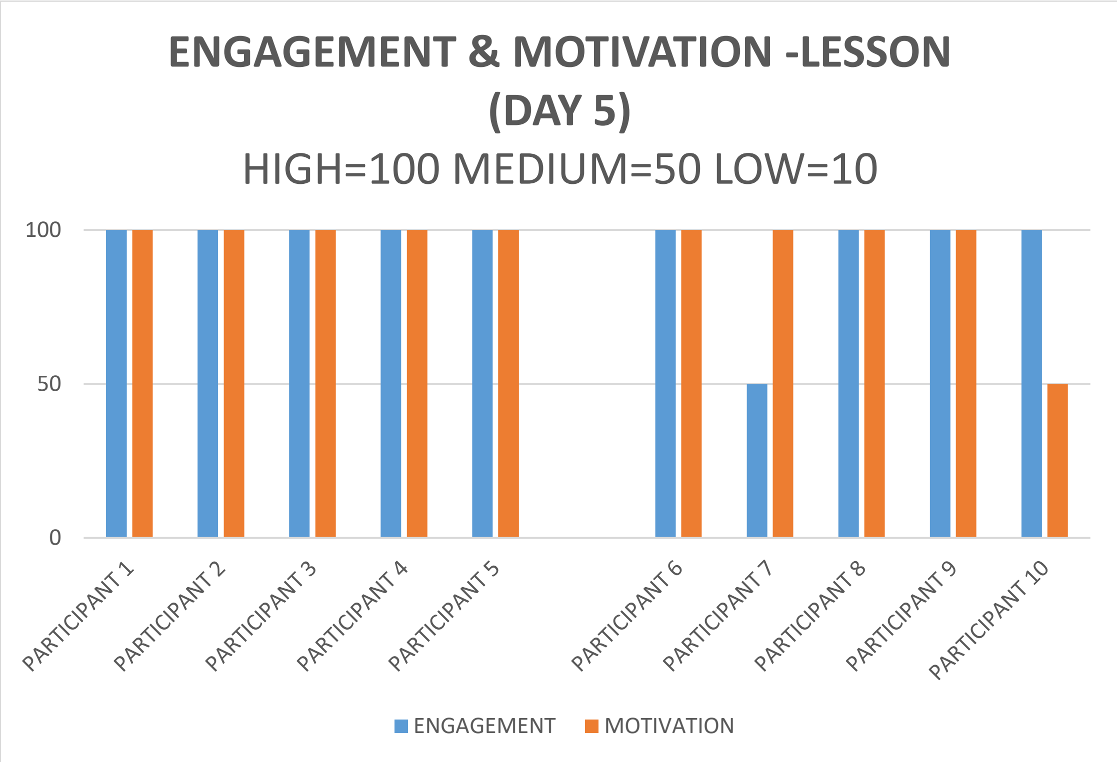


Figure 24 – Day 5 engagement and motivation levels of the experimental and control groups during the regular mathematics lesson.

The computer game observations showed some slight differences to previous days. Figure 25 shows that 80% (n=4) of the experimental group showed high levels of engagement and motivation. However, participant 5 displayed a decrease in both categories. In my observation, it appeared that participant 5 started off the learning well, but quickly became distracted and showed lower levels of motivation towards the learning task. This was the first time any participant in the experimental group had failed to show high levels of engagement and motivation in the computer game observations. It was also the first occasion where the experimental group had scored higher in the lesson observation, than the computer game observation.

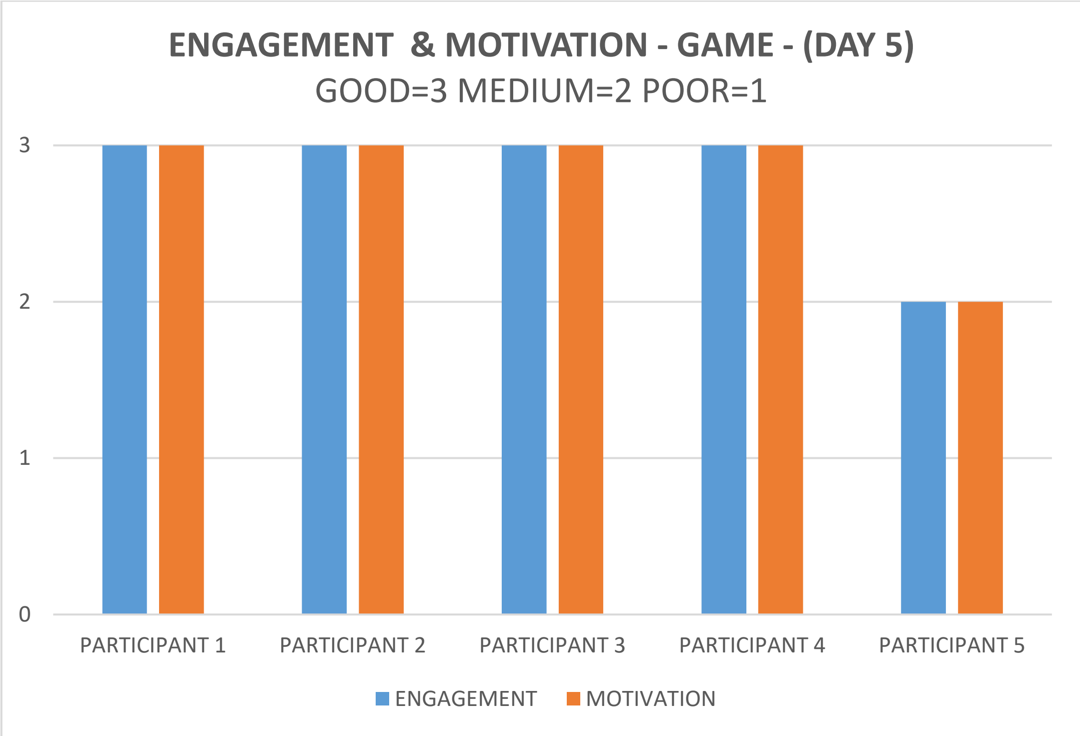


Figure 25 – Day 5 engagement and motivation of the experimental group when playing the Sundae Times computer game

4.4.6 Summary of observation results

This section will summarise the observations and compare the overall engagement and motivation scores between the two groups. It will also compare the results of the experimental group whilst in the lessons and when playing the computer game. The results have been displayed for each day with high = 3, medium = 2 and low = 1. The tables included in this section show the overall weekly totals, with the maximum score for each group being 15 per day.

Figure 26 shows the overall engagement levels between the two groups during the mathematics lessons. This graph shows that the experimental group had a higher levels of engagement in four of the observations, with the control group scoring slightly higher on day two. Despite this, the two groups showed an increase to engagement levels as the week progressed, with both showing high levels of engagement on day 5.

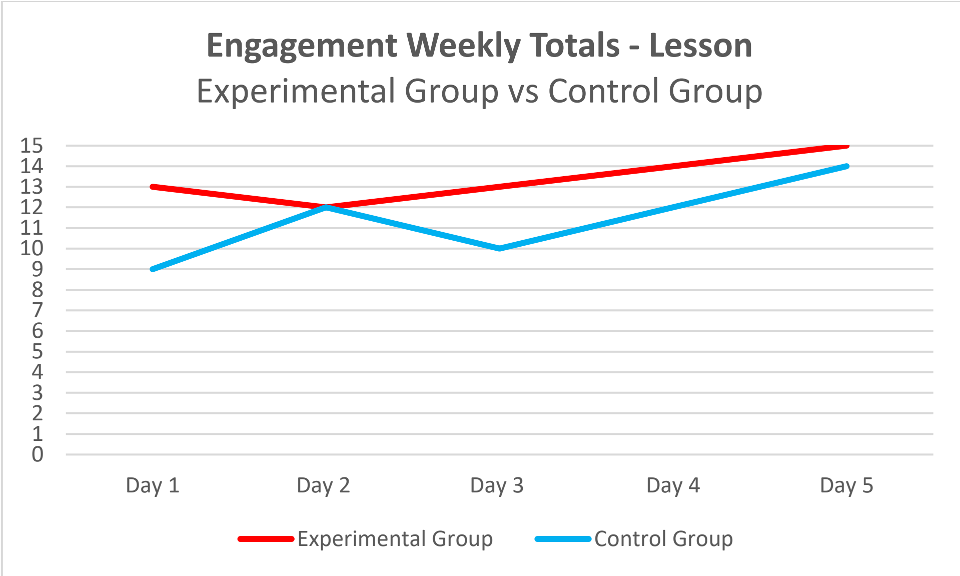


Figure 26 – Engagement weekly totals for the lesson observations

Figure 27 compares the two groups overall weekly motivation totals during the lesson observations. The table shows that both groups scored the same on day one. However, it was the experimental group that showed a constant improvement in this category, scoring maximum points on both day four and day five. In contrast, the control group made improvements but at a much lower rate and failed to reach a maximum score of 15 in this category. However, it must be noted that both groups scored high levels of motivation at the end of the week. Overall, the experimental group outperformed the control group in 80% of the observations in both categories.

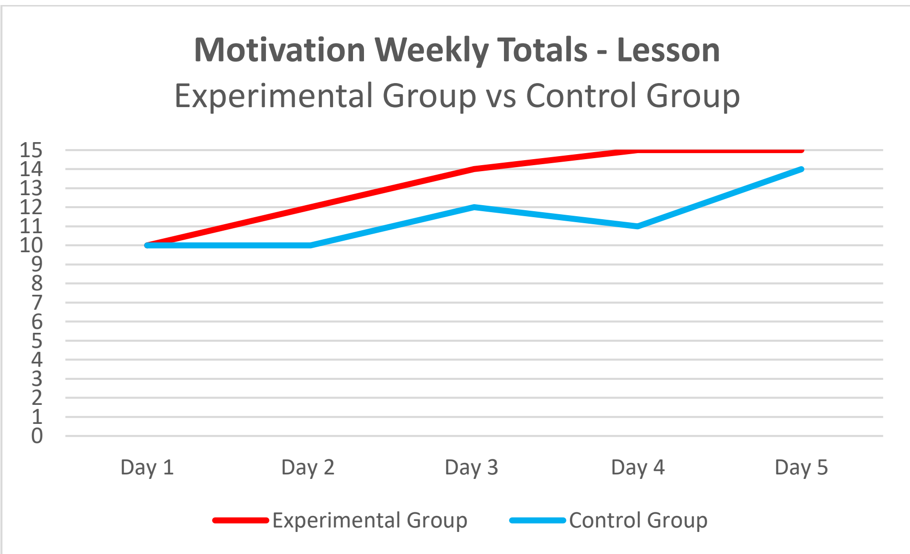


Figure 27 – Motivation weekly totals for the lesson observations

The next comparison will be of the experimental group's engagement and motivation levels during the lesson and whilst playing the computer game. Figure 28 shows the weekly totals of the group's engagement levels. The graph clearly shows that for the first four days, the engagement levels whilst playing the computer game were at a high level. The group scored a maximum score of 15, meaning they displayed high engagement levels for 80% of the observations. However, the last day results reveal a difference with the overall engagement increasing in the lesson and decreasing slightly for the computer game.

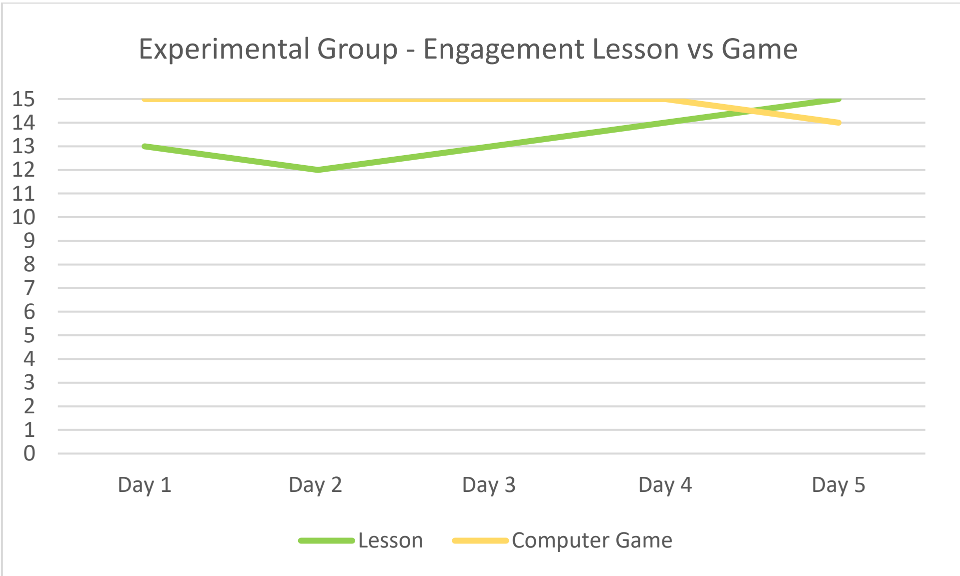


Figure 28 – The overall engagement levels of the experimental group whilst in the lessons and when playing the computer game.

The overall motivation levels of the experimental group tells a similar story to the previous graph. In figure 29 we see that the participants showed higher motivation levels whilst playing the computer game for the first three days. The group scored a maximum of 15 for the first four days, however, like the engagement results, the final day shows the results decreasing slightly. In contrast, the motivation levels during the lesson started off as medium but increased as the week progressed. Day four and five show the participants having maximum motivation scores during the lesson. Despite this, motivation levels for the computer game were higher for 60% of the week.

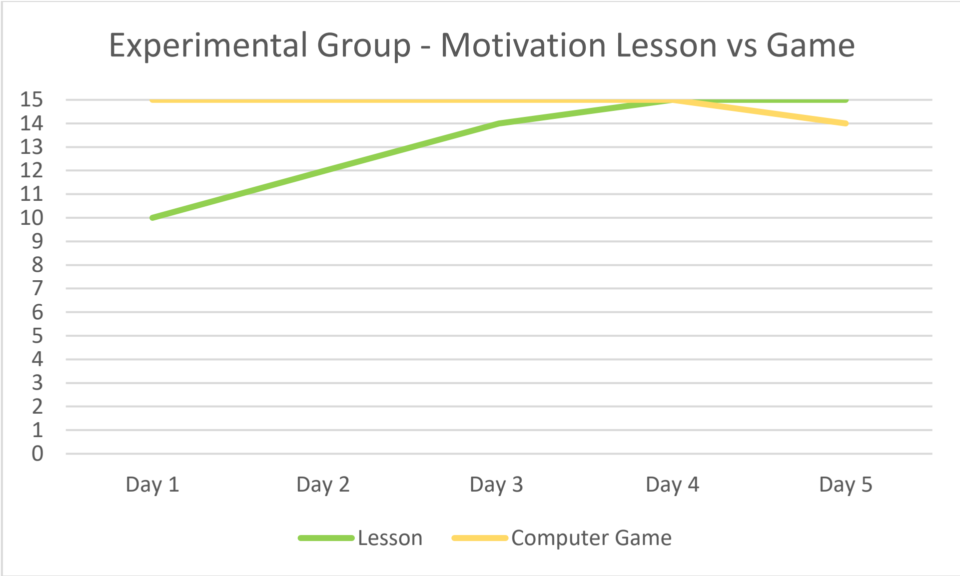


Figure 29 – The overall motivation levels of the experimental group whilst in the lessons and when playing the computer game.

4.5 Computer game data results

The computer game played by the participants also collected data on which of the times tables they attempted and monitored their success rate in each of the different levels. All of the gameplay data for each participant playing the game was sent directly to the teacher's administrator account. The purpose of this evaluation aspect of the game, is so the teachers have all of the information on their children's learning and to identify weaker areas of their learning. The evaluation data sheets provided from the Sundae Times game give the teacher a colour coded key which shows the different levels of achievement, as seen in the top left hand side of figure 30. In order to acquire bronze, silver or gold level of achievement, a participant has to pass all of the times tables in that specific level. If they have attempted each of the times tables, but not passed, they will have a red box next to their name. If they have failed to attempt all of the times tables in that level, it will show a grey box next to their name.

The participants in the experimental group had the opportunity to complete three different levels of the Sundae Times game. Each of these levels had different times tables for the participants to complete. The teacher made it clear to the participants at the start of the week that they should attempt all three levels throughout the week. The first level consisted of the 2 times table through to the 5 times table. The next level tested the participants understanding of the 6 times table through to the 9 times table. The final level tested understanding in the 10, 11 and 12 times tables. The participants were each given individual log in usernames and passwords, to ensure their data was recorded correctly and reliably. The usernames given out to the participants can be seen in figure 30 and are listed as Maths Ninjas 1 to 5. Therefore, Participant 1 was given the username Maths Ninja 1, Participant 2 was given Maths Ninja 2, Participant 3 was given Maths Ninja 3, Participant 4 was given Maths Ninja 4 and Participant 5 being given Maths Ninja 5. This was done to ensure there was no confusion when analysing the participant's results and to make it easier for the teacher to identify which results belonged to which child.

Figure 30 displays the data received from the first level of the computer game, which included the two, three, four- and five-times tables. It is visible from this image that each of the participants attempted this level at least 5 times throughout the week. Participant 4 attempted the level more than any other participant, having eight attempts, closely followed by participant 2 on seven attempts. Participant 1, 3 and 5 each had five attempts at this level over the one-week period. The high score column shows each of the participants highest scoring round within the level. This is determined by the number of problems solved within the time limit and the accuracy of the answers given. It is also visible in figure 30, that the highest score achieved within this level was shared by both participant 3 and 5, scoring 30 points each. This was followed by participants 4 and 2, each scoring 20 points each and participant 1 scoring the lowest with 10 points. However, having the highest score in one of the times tables does not mean you will necessarily pass the level, which is reflected in the overall achievement levels of the participants.

MANGAHIGH

Sundae Times - Understanding the ×2, ×3, ×4 and ×5 times tables

Class: Class 1

Set Date: 07/02/18

Due Date: 24/02/18

KEY	
	Not Assigned
-	Not Attempted
x	Tried but not passed
B	Proficient - Bronze
S	Advanced - Silver
G	Exceptional - Gold

Rank	Student	Sundae Times - Understanding the ×2, ×3, ×4 and ×5 times tables	High Score	Number Of Attempts
1	Maths Ninja 4	B	20	8
2	Maths Ninja 1	B	10	5
3	Maths Ninja3	x	30	5
4	Maths Ninja5	x	30	5
5	Maths Ninja 2	x	20	7

Figure 30 – Data from Sundae Times computer game for the x2, x3, x4 and x 5 times tables

When analysing the overall achievement of the experimental group, only 40% (n=2) of the participants passed level one and gained the bronze award. The other 60% (n=3) of participants failed to pass the level. Despite having the highest score of the week, participant 3 did not pass all of the times tables within this level. The highest achiever in level one was participant 4 with a high score of 20 points and also reaching the bronze pass award. However, none of the participants reached the advanced silver or exceptional gold level.

MANGAHIGH

Sundae Times - Understanding the ×6, ×7, ×8 and ×9 times tables

Class: Class 1

Set Date:	07/02/18
Due Date:	24/02/18

KEY	
	Not Assigned
-	Not Attempted
x	Tried but not passed
B	Proficient - Bronze
S	Advanced - Silver
G	Exceptional - Gold

Rank	Student	Sundae Times - Understanding the x6, x7, x8 and x9 times tables	High Score	Number Of Attempts
1	Maths Ninja 4	x	5	2
2	Maths Ninja5	x	5	1
3	Maths Ninja 2	x	0	1
-	Maths Ninja3	-	-	0
5	Maths Ninja 1	x	0	4

Figure 31 – Data from Sundae Times computer game for the x6, x7, x8 and x9 times tables

The next image in figure 31 shows the results from the experimental group for level 2 of the computer game. This level consisted of the six, seven, eight and nine times tables. What is evident from this image, is that the participants attempted this level a lot less than level 1. Participant 1 attempted this level more than any other participant, with a total of 4 attempts over the course of the week. Participant 4 was next, attempting the level on two occasions, with participants 5 and 2 only having one attempt each. However, the results in figure 31 also show that participant 3 did not attempt this level at all throughout the week. If we analyse the difference between the number of attempts of the first two levels, it is clear that the participants seemed to be more confident in the level 1 times tables, as seen in figure 32. The experimental groups total number of attempts for level 1 was 30, compared to level 2 with just 8 attempts and an overall difference of 22 attempts. Participants 2, 3, 4 and 5 all made considerably less attempts in level 2 when compared to level 1. However, participant 1 only made one less attempt in level 2 than they did in the first level.

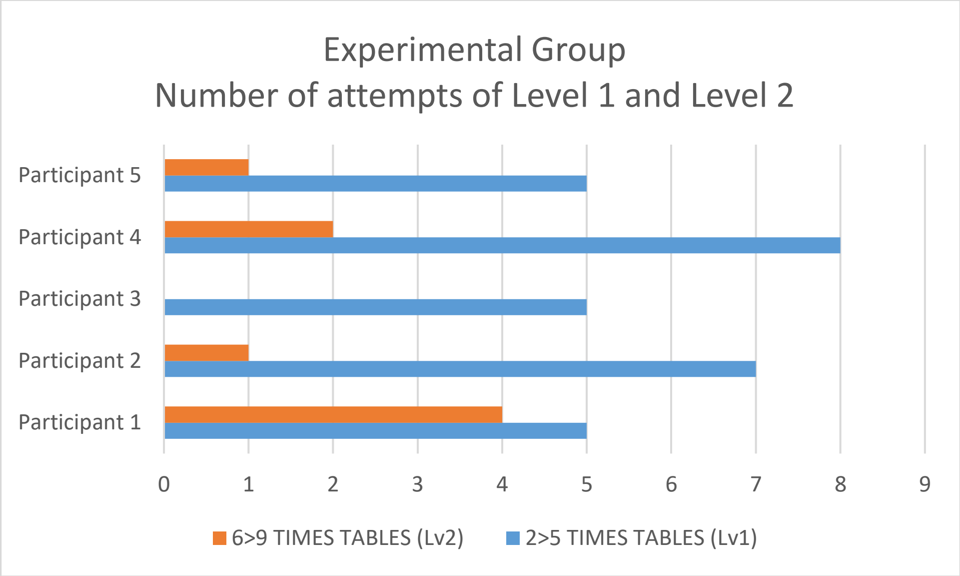


Figure 32 – Difference in the number of attempts between level 1 and level 2

The high score column in figure 31 reveals that level 2 was extremely tough for all members of the group, with only two of the participants managing to score any points. Participants 4 and 5 shared the top score with 5 points each. Despite attempting this level on four occasions, participant 1 failed to score any points and this was the same outcome for participant 2. These results tell me that the participants had a very low success rate, with correct answers given and the accuracy of their answers. This was reflected in the group's overall grades for level 2, as seen in figure 31. It reveals that 80% (n=4) of the group failed to reach the bronze pass grade for the level and the other 20% (n=1) failed to even attempt the level.

Figure 33 reveals the results from the experimental group when attempting level 3 of the computer game. This level consisted of the ten, eleven and twelve times tables. It was clear when analysing the results from this level, that many of the participants attempted these times tables more often than the other two levels. In total, the group attempted this level 37 times throughout the week, 7 more times than level 1 and 32 times more than level 2. Participant 1 attempted this level more than anyone else, with a total of 12 attempts. This was followed by participants 4 and 5 having made 8 attempts each, participant 2 with 7 and participant 3 only having 2 attempts.

MANGAHIGH

Sundae Times - Understanding the ×10, ×11 and ×12 times tables

Class: Class 1

Set Date: 07/02/18

Due Date: 24/02/18

KEY	
	Not Assigned
-	Not Attempted
x	Tried but not passed
B	Proficient - Bronze
S	Advanced - Silver
G	Exceptional - Gold

Rank	Student	Sundae Times - Understanding the x10, x11 and x12 times tables	High Score	Number Of Attempts
1	Maths Ninja 2	x	50	7
2	Maths Ninja3	x	50	2
3	Maths Ninja5	x	45	8
4	Maths Ninja 4	x	45	8
5	Maths Ninja 1	x	20	12

Figure 33 – Data from Sundae Times computer game for the x10, x11, and x12 times tables

The high scores in figure 33, appear to be lot higher in this level than the other two. Participants 2 and 3 scored highest with 50 points each, closely followed by participants 4 and 5 who scored 45 points each. Despite attempting this level more than anyone else, participant 1 scored lowest with just 20 points. However, these results also show that the participants had more success and accuracy with their answers in these times tables. Despite having more attempts and scoring higher in level 3, 0% (n=5) of participants managed to pass all of the times tables and achieve the bronze pass award.

4.5.1 Summary of computer game data

Throughout the week the experimental group played the computer game for a maximum of twenty minutes per day. Furthermore, each participant could choose which level of the Sundae Times game they wanted to play. The results from the game have displayed which of the times tables the group preferred to play and which one of the levels they had the most success.

Figure 34 displays the total number of attempts each of the participants made on all three levels. Level 3 appeared to be most popular with the group, with a total number of 37 attempts made over the one-week period. In total, 40% (n=2) of participants attempted this level more than any other, with another 40% (n=2) attempting level 1 and 3 an equal number of times. Participant 3 was the only member of the group to play level 1 more than anyone else. It was clearly the case that level 2 was more challenging for the participants, which appeared to reduce the amount of time they spent attempting it.

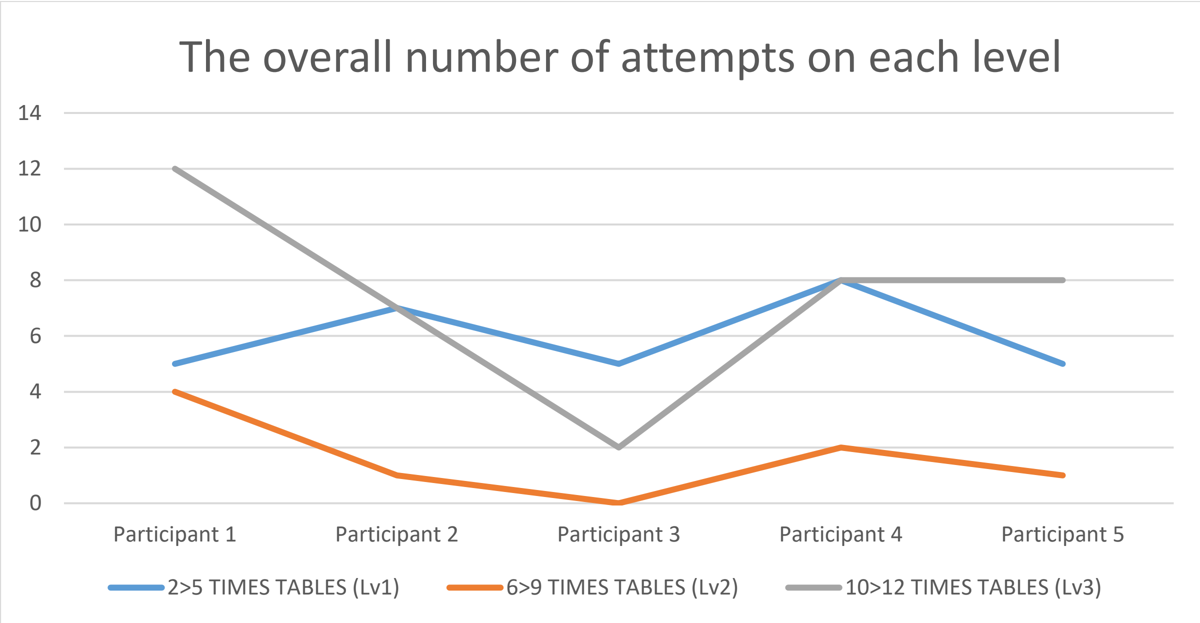


Figure 34 – The total number of level attempts each participant made during the one-week period.

When analysing the participants high scores over the three levels, it is clearly visible that level 3 had the highest success rate. In total, 100% (n=5) of the group scored their highest total in level 3. Figure 35 shows that level 2 had the lowest success rate, with 60% (n=3) of participants failing to score any points whatsoever. This evidence also suggests that level 2 was more challenging for the participants, because the number of correct answers and accuracy of their answers was much lower. When assessing the overall achievement of the group, the results showed me that only 2 participants throughout the week managed to pass one of the three levels, which was level 1. Overall, the data did not reveal which individual times table were weakest for each participant, however, it did show which group of times tables needed more attention and further practise. It also showed which of the times tables the participants were most confident with.

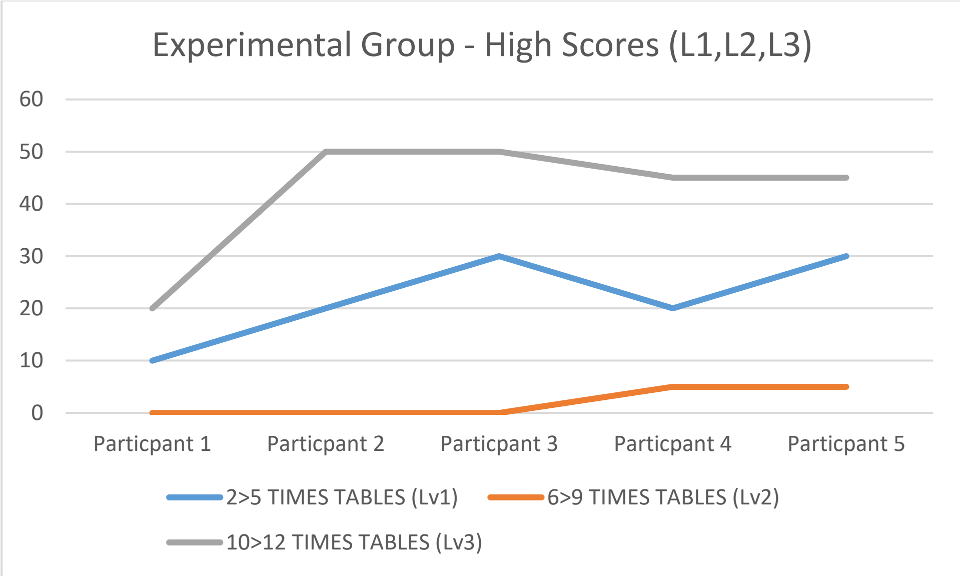


Figure 35 – Overall high scores in each of the three levels

Chapter 5 Analysis and Discussion

5.1 Introduction

In order to answer the research questions, I will now discuss the results presented in the previous chapter and compare the findings to any relevant literature. Through both qualitative and quantitative data collection methods, I was able to build a greater picture of the results and recognise certain themes. This chapter will be split into subsections, with each section aiming to answer one of the four research questions.

5.1.1 Research Question 1 – Does the computer game used enhance the level of achievement more than the conventional instructional approach?

Data collected in the pre and post-tests, post-research teacher interview and the computer game will be analysed for this research question. Interpreting the data through these various methods will identify whether or not the computer game enhanced the level of achievement. The pre-test results in section 4.2 revealed that out of the 10 participants, 80% (n=8) of the scores were of a similar level and all within 23 points of one another. The remaining 20% (n=2) were higher than the average. These figures strengthened the teacher's theory that all of the participants were of a similar ability. Whilst analysing the pre-test scores of the participants, it also revealed that only 10% (n=1) managed to score over 50% of the answers correctly.

Student performance on the post-test was statistically significant, with results revealing that all of the participants in both groups had increased their overall score. However, I wanted to see if the experimental group had increased their achievement levels more so than the control group. Despite the control group scoring slightly higher test scores, the results indicated that the experimental group had in fact made the most improvement over the one-week period. The experimental group had increased their overall points total by 114 points. In contrast the control group only increased their overall points total by 86 points, 28 points lower than the experimental group.

When analysing the two groups in more depth, it was discovered that the achievement levels of some participants had significantly increased, especially those in the experimental group. The biggest increases in the experimental group came from participants 4, 5 and 2 who improved their overall score by 154%, 120% and 53% respectively. In comparison, the three highest increases in the control group were from participants 6, 10 and 7 who improved by 44%, 33% and 28%. Furthermore, when analysing the two groups pre and post-test mean average, this also shows the experimental group had made the most progress. The control groups pre and post-test mean was 60.4 and 77.6 respectively, increasing by 17.2. However, the experimental groups pre and post-test mean equalled 33.2 and 56 respectively, meaning they had a greater increase of 22.8.

Figure 9 in section 4.2 shows how the experimental group made the greatest improvement throughout the week. Despite the control group having the two highest scoring participants, the pre and post test data showed that the achievement levels increased more for the experimental group that played the computer game. However, it is also important to analyse the computer game data to see if this was the reason for the increase of achievement levels or if there were other factors involved.

The data received from the computer game in section 4.5, revealed that the participants seemed to play the times tables of which they were most confident and avoided the trickier times tables. Evidence suggested that the 6, 7, 8 and 9 times tables were the more challenging, with the lowest scores achieved and a total of 8 attempts, the lowest of the three levels. The highest scores came from level 3 which consisted of the 10, 11 and 12 times tables. All of the participants achieved their best score in level 3, with the total number of attempts for the week being 37. This was closely followed by level 1, consisting of 2, 3, 4 and 5 times tables and had 30 attempts throughout the week. The number of attempts at levels 3 and 1 were much higher than level 2, which made it appear that the participants were more confident with these levels. However, when looking at the overall achievement of the group, the data suggested that the participants struggled to pass many of the times tables. The results revealed that only two participants throughout the week managed to pass one of the three levels, which was level 1. The overall data received from the computer game could not tell me whether the children made progress in the game throughout the week, because it only gave me a summary of their overall achievement.

Finally, the classroom teacher (Teacher A) post-research interview data needs to be considered. One of the answers received in the interview (Section 4.3.6) supports the computer game data above. Question 1 asked Teacher A for their thoughts on the computer games used in the study. Teacher A responded that the game *"filled the children with confidence".* However, Teacher A also had additional thoughts on the game, *"whilst it was a good game, it did seem that the children were choosing the easier options and times tables they were already confident with"*. This answer supports the computer game data which revealed the participants regularly steered towards the times tables they were more familiar with and also scored highest in these times tables. However, it is important to recognise that the teacher did notice that the computer game increased the participants' confidence with the learning.

5.1.2 Research Question 2 – Is stealth assessment using game-based learning a practical method for assessing achievement in mathematics?

Interpreting the data collected in the teacher interviews and the computer game will identify whether or not stealth assessment using game-based learning is a practical method for assessing mathematics achievement. The pre-research interviews of teacher A and teacher B in section 4.3.1 and 4.3.3 respectively, revealed the views and opinions from an experienced teacher and one that is newly qualified. I have selected specific questions to analyse that relate closely with the research question.

It was vital to understand how each of the teachers currently assess their class in mathematics. Therefore, question one asked the teachers how they currently went about assessing mathematics in the classroom. Teacher A stated that a range of techniques were used, using formative and summative methods, as well as a range of computer aids that support the assessments. Teacher B assesses the class using observations from the TA, as well as writing notes on their understanding based on peer discussion and uses summative assessments.

In question two the teachers were asked for their thoughts on the stealth assessment method through the use of a computer game. Teacher A stated that they would have no issue with this method, as long as *“it is productive, and it is targeted”.* Furthermore, it was stated that if there was no meaning to it, then it would not be supporting the children’s learning sufficiently. Teacher B was more open to the idea, stating *“I really like this idea”.* Additionally, Teacher B responded, *“Depending on the criteria and algorithms used, it has the potential to identify areas of strengths and weaknesses that may be overlooked on a day to day bases”*. However, they did express another viewpoint, which was that the teacher is not always seeing the learning happen first hand.

Question twelve asked for their views on the assessment methods currently used in mathematics. Teacher A thought that all methods needed to be used together to build a broader picture of the child’s learning. Additionally, stating *“They might be really strong with calculations and then you come to shape work and they do not feel as strong. If you use a summative assessment that primarily focuses on numbers, then you are not going to see their weakness as much or as clearly. Whereas, the formative method would pick up on that sort of thing as well”*. Teacher B thought there should be more methods used to assess children’s learning, giving teacher’s a wider view of children’s learning. Furthermore, Teacher B maintained that with more methods available, then teachers can create a greater picture of each child's learning and better prepare them in the future.

Finally, the last question asked whether they thought stealth assessment and computer game learning could benefit the children of tomorrow. Teacher A stated, *"If used correctly, but all depends on why it is being used"*. Additionally, they thought that stealth assessment was quite a closed procedure. However, Teacher A also mentioned that if it was to be used for assessing mathematics, it would have to be intrinsically linked and would have to be really subtle. Teacher B appeared to be more open to the idea of using stealth assessment, stating *"If technology continues to develop the way that it is at the moment, then I definitely think it has a place in the classroom".* However, Teacher B also thought that it would need to be purposeful and targeted at the appropriate time in the learning process.

The post-research interview data in section 4.3.6 will be analysed next, to see if Teacher A's opinion on stealth assessment had changed throughout the week. In question two, Teacher A was asked for their view on computer games being used to assess children's learning. Teacher A's response was *"If used correctly, I think it could be a powerful tool for teachers, but it must be used alongside careful planning and implementation, not just thrown in randomly"*. Question four wanted to discover whether the computer game had provided the teacher with enough information on the children's competencies. However, Teacher A stated, *"No, I don't think so. There needed to be restrictions on the times tables the children could play in order to test them effectively and to stop them from revisiting the times tables they prefer"*. The final question asked if stealth assessment and computer game learning could benefit the children of tomorrow. Teacher A appeared to be more open to the idea, stating that *"if implemented and planned correctly, then yes. If it was used as a lesson replacement, then no I do not think it would"*

The computer game data in section 4.5 is also required for research question two. Did the data received from the game show that this method was a practical method of assessing children's mathematics knowledge? The game data provided, can be seen in figure 27, 28 and 30. It displays the number of attempts taken on each of the three levels, as well as the participants high scores for each level. It was discovered that level 3 was the most popular with the group, with 37 attempts made over the one-week period, 7 more than level 1 and 29 more than level 2. Furthermore, it revealed that the highest scores were achieved in the 10, 11 and 12 times tables. The computer game also showed the participants overall achievement for the week, which was displayed with specific pass levels they could achieve. However, only 2 participants passed one of the three levels. The computer game did not provide information on the scores achieved in the individual times tables or show whether they had progressed over the week. Therefore, it was difficult to build a picture of the participants overall achievement on the computer game.

5.1.3 Research Question 3 – Does the computer game increase engagement and motivation towards mathematics learning?

The data collected in the observations of both the computer game and classroom lessons and the post-research interview of the teacher will be analysed for research question two. These two sources of data combined will help identify if the computer game increased engagement and motivation towards mathematics learning.

<u>Day 1</u>

The mathematics lesson observations on day one (section 4.4), revealed that the experimental group had 60% (n=3) of participants displaying high levels of engagement, with the other 40% (n=2) showing medium levels. In contrast, the control groups engagement levels were slightly worse, with only 20% (n=1) of the participants showing a high level of engagement and 40% (n=2) displaying low levels. The observations were also investigating both group's motivation levels during the mathematics lesson. This experimental group only had 20% (n=1) of the participants displaying high motivation towards the learning. The control group had 40% (n=2) of the participants showing high motivation levels, however, 40% (n=2) also displayed low motivation. When analysing the computer game results, the experimental group displayed 100% high levels for engagement and for motivation. The high engagement levels for the computer game was 60% higher when compared to the lesson. Furthermore, the high motivation levels for the group was 80% higher when compared to the lesson.

Day 2

The mathematics lesson observations saw the experimental groups engagement decrease when compared to day one. They displayed 40% high engagement, with 60% medium engagement. In contrast, the control group had increased the number of participants displaying high engagement. The control group showed 60% (n=3) high engagement, which was a 20% increase when compared to the previous day. The motivation levels of the control group were unchanged, with only 40% (n=2) of the participants displaying high motivation levels towards the learning. However, the experimental group performed a lot better in this category, with 60% (n=3) of the participants showing high levels of motivation, an increase of 40% from day one. Day two results for the computer game were unchanged, with the experimental group displaying 100% high levels of engagement and motivation.

Results from day two also revealed that the experimental group were relying less on the teacher and their peers whilst playing the computer game. The total number of occasions participants asked the teacher for assistance during the lesson was 10 times and during the computer game was 3. The participants also looked at other classmates work for assistance a total of 17 times during the lesson. However, whilst playing the computer game, the group only looked at another’s work on 2 occasions. The observations revealed that the participants were much less reliant on looking at their peers work for reassurance and were more focused with their own learning.

Day 3

Day three revealed that the experimental group were more engaged with the mathematics lesson than the previous day. In total, 60% (n=3) showed high levels of engagement, with 40% (n=2) showing medium. Whereas the control group only having 40% (n=2) of the group display high levels, 20% (n=1) medium levels and 40% low levels of engagement. Motivation levels for day three improved for both the experimental group and the control group. The experimental group had 80% (n=4) of their group show high levels of motivation, 20% up on the previous day. On the other hand, the control group only displayed 60% (n=3) high motivation. The computer game results were once again unchanged, with the experimental group showing 100% high levels of engagement and motivation.

The results of day three also revealed some other interesting differences. The number of occasions the participants offered help to others was vastly different between the two observations. The total number of times the participants in the experimental group offered assistance to others whilst playing the game was 9. During the mathematics lesson this figure was only 2. It appeared that the group was a lot more confident with the computer game learning tasks, which meant that they were more willing to assist others.

Day 4

The observations revealed that the levels of engagement and motivation for learning were much higher in the experimental group. The mathematics lesson observation showed that the experimental group had 80% (n=4) high levels of engagement, which was 20% higher than the previous day. In contrast, the control group only displayed 40% (n=2) high engagement, which was unchanged from the day three results. When analysing the motivation levels, the experimental group scored 100% (n=5) high motivation levels, whereas the control group only displayed 60% (n=3) of high motivation levels. Day four results for the computer game showed that the experimental group had 100% (n=5) high levels of engagement and motivation. This was the fourth day in a row that the group had shown these levels of engagement and motivation.

Day 5

Day five revealed increases for both groups in each category. During the lesson observations the experimental group displayed 100% (n=5) high engagement levels, 20% higher than the day four results. This was compared to 80% (n=4) in the control group, however, this was up 40% on the previous day. The experimental group also showed 100% high motivation levels, which was the same as day four. The control group displayed 80% (n=4) high motivation, which showed an increase of 20% from the results on day four. The results from the computer game observation, showed a decrease in both categories for the experimental group. Only 80% of the participants displayed a high level of engagement and motivation.

Over the five-day period, the experimental group displayed higher levels of engagement in the mathematics lessons for four out of the five days. The results revealed the same outcome for the motivation category, with the experimental group scoring higher in four of the five days. When analysing the experimental groups lesson and computer game results, it revealed that the computer game came out on top for both categories. The engagement and motivation levels whilst playing the computer game was higher than the lesson results for the first four days. However, the last day of observations showed that engagement and motivation was slightly higher during the lesson.

The post-research interview with Teacher A in section 4.3.6 also has a part to play with this research question. Question one asked the teacher for their thoughts on the computer game used in this study. Teacher A responded that it had filled the participants with confidence, despite being similar to a game previously played in class. It was important to find out from the teacher, whether they noticed any differences to the participants engagement and motivation. Therefore, question eight asked Teacher A if they had witnessed any differences to the engagement levels of the participants playing the computer game compared to their engagement in the regular mathematics lessons. Teacher A responded *"They seemed to be more engaged as the week went on definitely. Whether that was because of the game or whether that was them becoming more confident generally with the work. However, it could also be because the children kept approaching the times tables, they felt more confident with".* Question nine asked whether the teacher thought the participants were more motivated to learn by playing a computer game. The response from Teacher A was "Yes, I do. It is far more engaging for them than learning by rote". Finally, Teacher A was asked in question ten, if they thought the participants were more motivated to learn mathematics after playing the computer game. Teacher A thought this was a difficult question to answer, however, thought that the participants would have preferred to continue using the game rather than taking part in the regular maths lessons.

5.1.4 Research Question 4 – Does the teacher find the data collected from the computer game useful and could this be used to progress the children's future learning?

Research question four requires interpretation of the data collected in both the pre and post-research teacher interviews in sections 4.3.1 and 4.3.6. This will be to identify whether the teacher found the computer game data useful and potentially use this to progress the children's learning in the future. The data analysed will be from Teacher A who was the classroom teacher.

The pre-research interview wanted to gain their initial thoughts on the idea of assessing using computer games, whereas the post-research interview aimed to focus on their thoughts after viewing the data and how this might be used. In the pre-research interview, Teacher A was asked for their thoughts on the method of stealth assessment using computer games. The initial response was mixed from, stating that *"If it is productive and it is targeted and not used just off the cuff, then I have no issue with it. However, it would need to be planned in and there* *needs to be a purpose to it. If there is no meaning to it, then it will not be supporting their learning at all"*.

In the post-research interview, question three asked Teacher A for their views on the data received from the computer game. Teacher A did not think the data received was totally reliable, stating *"I need to look at it in a bit more detail. However, from what I have seen already, it told me which times tables the children prefer to be tested on as they revisited the same ones often as the week progressed. I don't think it is wholly reliable because of this."* The conversation continued with question four asking if the method of using the computer game to stealth assess provided them with enough information on each of the learner's competencies. Teacher A responded *"No, I don't think so. There needed to be restrictions on the times tables the children could play in order to test them effectively and to stop them from revisiting the times tables they prefer."*

5.2 Discussion

This section will discuss the findings in section 5.1, to see whether there are any links to the literature previously found and to answer my research questions. I will be discussing each of the four research questions in the order they were analysed. The findings presented in the analysis section 5.1.1, focused on whether the computer game enhanced the level of achievement more so than the conventional instructional approach. These findings are supported by various literature found in chapter two.

Research by Eyyam and Yaratan (2014) revealed that the use of educational technology had positive effects on children's academic achievement. Additionally, research of 12,000 children in Australia found that those who played computer games achieved higher scores in mathematics assessments (Gibbs, 2016). The computer game used in my study was played by the experimental group participants for 20 minutes per day over a one-week period.

Wouters et al., (2013) discovered that when computer games are played on numerous occasions, it leads to more beneficial learning outcomes for children than conventional learning methods. Clark et al., (2016) supports this claim, stating that when children play computer games over multiple sessions, it can lead to significantly better learning outcomes. My findings in pre and post-test results definitely appear to link closely with both Wouters et al., (2013) and Clark et al., (2016) theories. The results showed that some participants in the experimental group made improvements of 154%, 120% and 53%. In comparison, the highest improvements in the control group was only 44%, 33% and 28%. Cognitive research specialist, Daphne Bavelier argues that when children play computer games responsibly and in small doses, it can have powerful impacts and enhance their learning, attention and vision (Bavelier, 2012). Smale (2013) argues that computer games allow children to learn by doing things and that knowledge is easier to learn whilst playing a game rather than direct instruction from the teacher. This appeared to be the case in my study, because the results from the post-test reveal that the experimental group made greater improvements than the control group.

The computer game data revealed that the participants in the experimental group struggled to pass many of the times table levels. The data also showed that only two of the participants throughout the week managed to pass one of the three levels. However, the participants in the experimental group managed to show greater overall improvements in the post-test than their peers in the control group. This links closely to research by Liang-Vergara (2014) who used a computer game called ST Math, which was designed to teach children mathematics whereby they learn to fail in order to learn. The ST Math game taught children about perseverance, presenting them with mathematical problems in order to move a penguin character across the screen. This concept is similar to the Sundae Times game used in my study, whereby the children answered mathematical questions to build the biggest ice cream sundae. The findings from Liang-Vergara (2014) revealed that the ST Math game was frustrating and difficult to complete for many of the children, but it taught the children that failure was ok. Furthermore, it also revealed the children’s summative assessment results after playing the game had either doubled or tripled. The data from the computer game in my study, revealed that the game was fairly difficult for the participants to complete. However, 60% of them managed to double their achievement in the post-test, with 20% tripling their achievement. Gould (2012) points out that sometimes learning does not always come from playing the computer games, but it can become the context for learning. Bai et al., (2012) states that when computer games are used for learning, they can give children visual representations that help generate mental models of mathematical concepts.

There was one limitation to the data received from the computer game. The data did not tell me whether the participants made progress in the game throughout the week, with it only revealing a summary of their overall performance in each level. Additionally, in the post-research interview with Teacher A, they mentioned that the game filled the children with confidence. This must also be taken into consideration, that the game might not have not have enhanced their learning but increased their confidence with times tables and therefore enabled them to achieve higher results in the post-test.

Therefore, after considering all of the data for research question one, my study concluded that the participants playing the computer game significantly improved. However, with the game data showing low pass rates at the end of the week, it was difficult to say whether or not the computer game was the sole reason for the enhanced post-test results. However, previous research also stated that difficult games can enhance achievement levels (Liang-Vergara, 2017). Woulters et al., (2013) states that in comparison to conventional learning methods used in the classroom, the benefits of playing computer games may only pay off after children have played multiple sessions, in order for them to get used to the game. Therefore, I believe that the computer game did boost the level of achievement of the experimental group. However, additional research over a longer period of time would enhance these findings and provide a better insight into the link between computer games and academic achievement.

The findings in the analysis section 5.1.2 were linked to research question two; whether stealth assessment using game-based learning is a practical method for assessing achievement in mathematics. In order to find out whether this would be a practical method to assess mathematics, specific questions from the teacher interviews will be discussed, as well as the data received from the computer game. The findings in my study did not entirely support what was found in the literature.

The pre-research interviews started by asking how the two teachers go about assessing mathematics in their class. Butt (2010) stated that many teachers often feel constrained by summative tests and this reduces the chances of them giving alternative methods a greater role in directing children's learning. However, the results from Teacher A and B interviews revealed that this did not appear to be the case within their classrooms. Teacher A mentioned that many assessment methods are currently used, for example formative, summative and a range of computer aids are used to support assessments. Teacher B assessed their class using observations of work, observations of peer discussions and summative tests. Kelly (2009) argues that new approaches to assessment are needed. Shute et al., (2013) thinks that schools need assessments that measure what children actually can do with the knowledge. These views were supported by Teacher B when asked about the current assessment practice in mathematics. Teacher B stated *"There needs to be more methods used to assess learning that gives a wider view of the pupils as a learner. The more options and methods available to teachers, the greater the picture we can build of their overall learning and better prepare them in the future".*

Kaya (2010) argues that a large proportion of teachers believe that computer games should only be used to supplement learning in the classroom, but not as tools for assessing children's learning. However, this view was not fully supported in the pre-research interviews, with both teachers appearing to have no problems with stealth assessment. When asked for their thoughts on stealth assessment using computer games, Teacher A responded *“If it is productive and it is targeted and not used just off the cuff, then I have no issue with it. However, it would need to be planned and there needs to be a purpose to it”.* Teacher A said that if this method was to be used for assessing mathematics, it would have to be carefully linked and be really subtle. Teacher B stated that they really liked the idea of stealth assessment. Furthermore, Teacher B revealed, *“Depending on the criteria and algorithms used, it has the potential to identify areas of strengths and weaknesses that may be overlooked on a day to day basi*s”. Additionally, Teacher B thought that stealth assessment definitely has a place in the classroom if the technology continues to develop at the current rate.

The literature revealed that researchers in the USA had discovered that stealth assessment through computer games enhanced children’s achievement and enabled teachers to grasp the strengths and weaknesses of their children (Shute, et al., 2016). Despite the experimental group showing an increase in their levels of achievement, it was difficult to determine whether this increase was due to the computer game. The data from the Sundae Times computer game used in my study, only revealed that two participants passed one of the three levels. However, it did not give me details on whether the children had made progress as the week progressed. Data in the post-research interview with Teacher A challenges Shute et al., (2016) theory. When asked if the stealth assessment had provided them with enough information on the children’s strengths and weaknesses, Teacher A responded *“No, I don’t think so.”* Webb et al., (2013) thinks there are still significant challenges that remain with the development of stealth assessment programmes. Furthermore, Psotka (2013) states that many teachers are waiting for definitive evidence that computer games are more effective than traditional methods. However, Teacher A was asked for their thoughts on computer games being used to assess children’s learning. Teacher A responded, “If used correctly, I think it could be a powerful tool for teachers.”

The Sundae Times computer game provided limited data on the children's learning and could not show me a detailed break-down of how they managed in each times table. Therefore, I cannot say at this point whether or not stealth assessment is a practical method of assessing mathematics. The literature suggests that this method of assessment can work, but also that more work is needed in developing stealth assessment programmes. Further research is required using different games, a larger sample of participants and a longer research period in order to gain a better insight into this assessment method for mathematics.

The findings in section 5.1.3 focused on research question three; whether the computer game increased engagement and motivation towards the learning of mathematics. The results from this study were supported by various literature in chapter two. Malone (1981) stated that there are various features that make learning fun and intrinsically motivating, these include informational complexity, responsiveness, challenge and fantasy. Furthermore, that computer games are clear examples of a highly motivating activity (Malone, 1981). This is supported by Shute and Ventura (2013) who argue that game-based learning has been discovered to be a powerful method for keeping children engaged and motivated to learn. Plass et al., (2012) states that as long as computer games have a balance of enjoyment and challenge, they have the ability to keep children engaged with the learning. Research in the United States looked into the effects of computer games on motivation. The researchers discovered that after playing their computer game, the children's achievement was significantly improved and their motivation to learn mathematics was greatly enhanced (Bai et al., 2012). The findings from my observations support this theory. In my study, the experimental group showed higher levels of engagement and motivation in the classroom lessons than the control group as the week progressed. Overall, the experimental group showed higher levels of engagement and motivation in 80% of the classroom observations. Furthermore, they consistently showed high levels in both categories when playing the computer game. In addition, their engagement and motivation levels during the mathematics lessons improved dramatically as the week progressed. These results are supported by research from cognitive research specialist

Daphne Bavelier (2012), who discovered that playing computer games responsibly and for short periods of time, can enhance children’s attention and learning.

The post-research teacher interview partly supports these results. When asked about their views on computer-game learning, Teacher A responded, “If used and planed correctly they can be powerful and engage children.” Teacher A was asked if they had noticed any differences to the participants engagement levels throughout the week. *“They seemed to be more engaged as the week went on definitely. Whether that was because of the game or whether that was them becoming more confident generally with the work.”* Additionally, the teacher was asked whether they thought the experimental group were more motivated to learn by playing the computer game. Teacher A responded, *“Yes, I do. It is far more engaging for them than learning by rote.”*

However, Glaser (2018) is critical of schools that use technology for learning purposes, arguing it has brought more harm than good, with children are becoming hooked and losing interest in more wholesome activities. The results from the teacher interviews in my study suggest otherwise. Moreover, the use of technology is beneficial for keeping more children engaged and motivated with mathematics. Teacher A was asked what technology is currently used in mathematics lessons. It was discovered that various forms of technology are used to help make the lessons more visually appealing and to record the children’s work. Additionally, Teacher A was also asked about the children’s general motivation and engagement levels with mathematics.

“It is a very tricky one. The methods we have to use at the moment state that we have to move all the children on together. However, you can see a general disengagement at times from those children that pick up the concepts quite quickly compared to others. I am quite lucky with my class, as generally they are quite motivated towards maths. However, I know that some other teachers do have a tough time with this aspect. So, like I said previously, we are

using more technology in the classrooms to add something extra to the lessons and keep the learning varied. But I think the current methods of teaching mathematics, are not ideal." – Teacher A.

This response revealed that more technology is being used across the school to keep mathematics learning varied and to increase the motivation levels when learning mathematics.

One of the actions monitored during the observations, was the number of times the participants socially interacted and offered assistance to one of their peers. This was one aspect which helped determine how engaged and motivated they were with the mathematics learning in the classroom and the computer game. Bouck et al., (2007) states that the use of technology in the classroom encourages cooperation amongst children. Research by Williamson (2009) discovered that many teachers felt social interactions were an aspect often overlooked when using game-based learning in the classroom. However, interactions between children were shown to have strengthened after playing a computer game for learning purposes (Williamson, 2009). Further research by Liang-Vergera (2014), revealed that playing tricky mathematical games encouraged children to work collaboratively, which drives the motivation to learn more about the subject and complete further tasks. The data from my study shows some similarities to this literature. On day three of the observations, the data showed that during the lesson the control and experimental groups' both had two participants that offered help to one of their peers. However, when looking at the number of interactions during the computer game observation, it revealed the experimental group were much more willing to interact and help their peers. The total number of times the experimental group members offered guidance to others during the game time was 9. It appeared that the experimental group were much more confident with the learning during the computer game observation. Furthermore, the Sundae Times game proved to be quite challenging for most of the participants. These results show similarities to the results listed in the study by Liang-Vergera (2014).

Despite the results suggesting that the computer game increased their engagement and motivation with mathematics, it is important to also consider some limitations that came up throughout the week. One limitation was that the teacher allowed the participants to pick and choose which times tables they wanted to play on the computer game. There were no restrictions to the number of times they could play the same times tables. This meant it was possible for them to choose the times tables they were more confident and familiar with, which could have affected their engagement and motivation towards the learning task. Another limitation to consider is the duration of the observations. The lesson observations lasted for one hour, whereas the computer game observations were twenty minutes. The question needs to be asked, whether the results would show the same levels of engagement and motivation if the computer game was played for a longer duration. Finally, it is important to consider that these results were only based on my opinion and observations. Therefore, the results could be seen differently if more people observed the participants. However, the results collected in this study do suggest that the computer game did increase the engagement and motivation towards the learning.

Research question four aimed to find out if the data collected from the computer game was useful for the teacher and could it be used to progress the children's learning in the future. The findings from the teacher interview in section 5.1.4 did not support much of the literature. However, the findings in this study were only based on one teacher's opinion and the results might have been different with a larger sample size.

Shute et al., (2016) states that stealth assessment using computer games allow schools to measure children's learning continually, with the teacher able to change the level of difficulty based on each child's outcome. Furthermore, this method gives teachers information on children's competencies which can then be used formatively for future planning and learner development (Shute & Ventura, 2013). The computer game used in this study did give the option to set the level of difficulty, however, for the purposes of this study the children were able to choose which of the times tables they wanted to play. Marsh (2007) argues that schools should be using more computer-based programs which give children and teachers instantaneous feedback on their learning. This is supported by Manning (2017), stating that forms of technology should to be used to reduce the paperwork for teachers and allowing them to give prompt feedback to children.

The post-research interview with Teacher A revealed that the computer game did not deliver the desired information required to give detailed formative feedback to the children. Question three of the interview asked, what is your view of the data you received from the computer game? Teacher A stated, *"I need to look at it in a bit more detail. However, from what I have seen already, it told me which times tables the children prefer to be tested on as they revisited the same ones often as the week progressed. I don't think it is wholly reliable because of this."* Additionally, Teacher A was asked whether this method provided them with enough information on the participants competencies. The response was, *"No, I don't think so. There needed to be restrictions on the times tables the children could play in order to test them effectively and to stop them from revisiting the times tables they prefer."* Despite the teacher revealing the game did not provide them with enough information, it did tell me which times tables the children scored lowest and attempted on less occasions. Therefore, this information might be seen differently by other teachers, allowing them to focus more on the times tables that the participants avoided. However, the results from the teacher interview suggest that the teacher did not find the information from the game useful and it could not be used to progress the participants future learning.

5.3 Conclusion

This study aimed to examine the effectiveness of a mathematics computer game to see if it could enhance achievement, assess the children's learning, increase engagement and motivation towards mathematics and provide information for the teacher to progress any future learning. Firstly, the results suggested that the computer game had positive effects on enhancing the children's level of achievement in mathematics. This was consistent with some of the literature which emphasised the benefits computer games can have on children's academic achievement. The results from the pre and post-tests revealed that the experimental group made greater gains than the control group over the one-week period. Each of the participants in the experimental group played the computer game for 20 minutes per day. My findings link closely with research by Wouters et al., (2013), who found that when computer games are played on numerous occasions it leads to higher achievement than traditional learning methods. The results also revealed that the experimental group had struggled to pass many of the levels on the computer game. These findings are consistent with a previous study, which found that difficult mathematics computer games can actually teach children to learn through failure and can lead to higher summative assessment scores (Liang-Vegera, 2014). The evidence has led me to conclude that the computer game did enhance achievement more than conventional methods.

Results from the pre-research interviews found that both teachers thought that stealth assessment using computer games could work well if planned correctly and uncover greater knowledge of children's competencies. The literature suggested that new approaches to assessment are needed to measure more of what children know (Kelly, 2009; Shute et al., 2013). The interview results support this view with Teacher B arguing more methods should be used to build a greater picture of children's learning. Despite the difference of experience between the two teachers, they shared many similar views. The literature also revealed that previous research had discovered that stealth assessment using computer games had enabled teachers to grasp the strength and weaknesses of their children (Shute et al., 2016). However, the results from my study do not support this view. The post-research interview revealed that the computer game did not provide the teacher with enough information on the children's learning during that week. The computer game did however show which of the times tables the participants preferred to play and scored highest. Despite much of the literature supporting stealth assessment as a tool for teachers, the evidence suggests that this computer game was not practical for assessing the children's achievement in mathematics.

Results from this study also found that the computer game had positive effects to the children's engagement and motivation levels. Evidence from the observations revealed that the experimental group had high levels of engagement and motivation during gameplay. Furthermore, the experimental groups engagement and motivation increased significantly in the mathematics lessons as the week progressed and was higher than the participants in the control group. These results are consistent with the literature which suggested computer games are clear examples of a highly motivating activity (Malone, 1981). It is also consistent with research from Shute & Ventura (2013) who state that game-based learning activities are a powerful method for keeping children engaged and motivated to learn. The results of my study link closely to another previous study which discovered that children's achievement and motivation to learn mathematics greatly improved after playing a computer game (Bai et al., 2018). The computer game also appeared to increase the interactions between the experimental group participants, finding that they were more willing to assist their peers with learning tasks than the control group participants. This linked to the literature which stated the use of technology in the classroom encourages cooperation amongst children.

Results from the post-research teacher interview indicate that the computer game did not provide the teacher with enough useful information to progress the children's future learning. Teacher A revealed that the data was not entirely reliable and did not provide sufficient information on the participants competencies. This did not seem to support what was found in the literature, which suggested that stealth assessment using a computer game allows teachers to measure children's learning continually, giving them information that can then be used formatively for future planning and learning (Shute & Ventura, 2013; Shute et al., 2016). However, it is important to remember that the results from the post-research interviews were only from one teacher's point of view and the data may have been interpreted differently by other teachers.

The literature has shown many developments to our education system over the past few centuries. However, recent changes by the government have meant more focus is being placed on the core subjects. Children are also now able to attend many different types of school, each teaching various versions of the National Curriculum and some not having to follow this curriculum at all. Evidence reveals that mathematics achievement levels in English schools is way below other western countries such as Finland. Computer games could be the tool our schools need to increase the level of achievement, as they have proven to promote critical thinking and problem-solving skills, which are highly regarded in our ever-advancing society. Governments around the world are constantly comparing international achievement and there is now growing support internationally for children to be assessed on their problem-solving skills. Computer games can now be played against other people around the world, therefore, in future years it might be possible for them to be used for assessment purposes and to compare achievement internationally. Furthermore, research is also suggesting that when computer games are played in responsible amounts, they can help children achieve higher summative assessment scores. This could be really important for our education system which focuses heavily on summative assessments.

The literature also stated that the National Curriculum has not developed in line with technological advancements, with children still learning the same facts their parents learnt, leading to alienated groups of children (Robinson, 2010). Therefore, schools are often using more reward-based systems for memorising facts, completing tasks, good behaviour and achieving good grades in order to keep children motivated to learn in the classroom (DfE, 2014; Hepburn, 2015; DfE 2012; Robinson, 2010). However, these extrinsic rewards have been found to destroy any intrinsic motivation towards learning (Malone, 1981; Reiss, 2012). Furthermore, by rewarding the memorisation of facts can leave children more dependent on the teacher and less likely to become autonomous learners. Computer games could be the answer, with this study showing positive outcomes to the engagement and motivation levels during gameplay, which also increased during the mathematics lessons. Furthermore, this method alongside regular mathematics lessons has shown to increase the level of achievement more so than just using conventional teaching methods. Further research into educational games that can offer these things and provide teachers with detailed information on learning, could help improve the quality of formative feedback given to children, which has been shown to be very effective in other higher achieving countries such as Finland.

In a society of rapid social and technological change, it will be important to find new ways for teachers to assess and improve achievement levels in mathematics. More importantly, we must find methods to assess children’s knowledge that reduces the chance of test related stress, which currently effects many in the current education system. This study has led me to think that stealth assessment and computer games can benefit the children of tomorrow. However, there are still significant challenges with the development of stealth assessment programmes and research will need to continue to find the most effective computer games that can help both children and teachers.

This was only a small-scale classroom-based case study, entailing comparison of test scores, observations and teacher interviews. Therefore, it did have some limitations that need to be mentioned. The study took place over a relatively short period of time, only had a small sample of participants and thus only produced a limited amount of data. The study could have used a larger sample of participants, more than one school or taken place over a longer period of time. However, there is now a greater realisation that large sample sizes are not always a necessary requirement for all research projects (Punch & Oancea, 2014). Furthermore, Punch and Oancea (2014) state that a well-executed small-scale study can make important contributions and can open paths to larger projects. This is supported by the methods used by Jean Piaget, one of the most influential thinkers in education history, who regularly used methods such as the case study to conduct observational research with small samples of participants (Pound, 2012). Despite this, it is important to recognise that the study was unable to look at the long-term effects of stealth assessment and computer-game learning. This study only looked at the effects of a computer game towards learning, engagement and motivation over a one-week period. This is a limitation, as it is possible that computer-game learning might increase motivation on a short-term basis, but this might decrease over a longer period of time. It is possible the game could have had a novelty effect, with the more traditional approaches to learning mathematics less engaging than learning from a computer game. However, the teacher did mention that game-based learning had been used previously in mathematics.

5.3.1 Opportunities for further research

If I am to continue this research at a higher level, there are certain things that would need to be done differently. The study could be extended in the future and there are definitely opportunities for further research in this area. The first area I would develop, is having a larger sample size of both children and teachers. This would give more concrete results on the effectiveness of stealth assessment and game-based learning. It would also be interesting to research the effectiveness of stealth assessment and game-based learning in different key stages and potentially other areas of the National Curriculum. Additionally, the next study would need to be extended over a longer period of time, to examine the long-term effects on achievement, engagement, and motivation in mathematics. There are also opportunities for further research into different educational game providers and which games are currently used most in schools. Furthermore, if I was to look at multiple educational games, it would be important to research how effective they are for stealth assessment and game-based learning purposes. In addition, which games are most effective at producing information for teachers to use in their classrooms. This study has encouraged me to continue researching stealth assessment and game-based learning and I will look to incorporate this in my own classroom one day.

5.3.2 Contribution to knowledge

Although this study was relatively short and had a small number of participants, the results reveal that the computer game had positive effects on the experimental group's level of achievement in mathematics. However, this study has made a clear contribution to knowledge with regards to the engagement and motivation levels surrounding computer games and mathematics learning. The research revealed that the experimental group's engagement and motivation was at a much higher level in the mathematics lessons after they had played the computer game. The children's engagement and motivation levels were consistently high throughout the week whilst playing the computer game and this clearly had a positive impact in their mathematics lessons, with results showing a sharp increase in their engagement and motivation towards the learning. This links closely to previous research studies by Bai et al, (2018), which also showed that children's motivation to learn mathematics greatly improved after playing computer games. Not only were the children more engaged, they were more willing to support their peers and answer questions presented by the teacher. These results were further supported in the post-research interview with the class teacher. Therefore, it is satisfying to know that this study has shown that small amounts of game-based learning can have positive effects on mathematics learning in the classroom.

Word Count: 46,134

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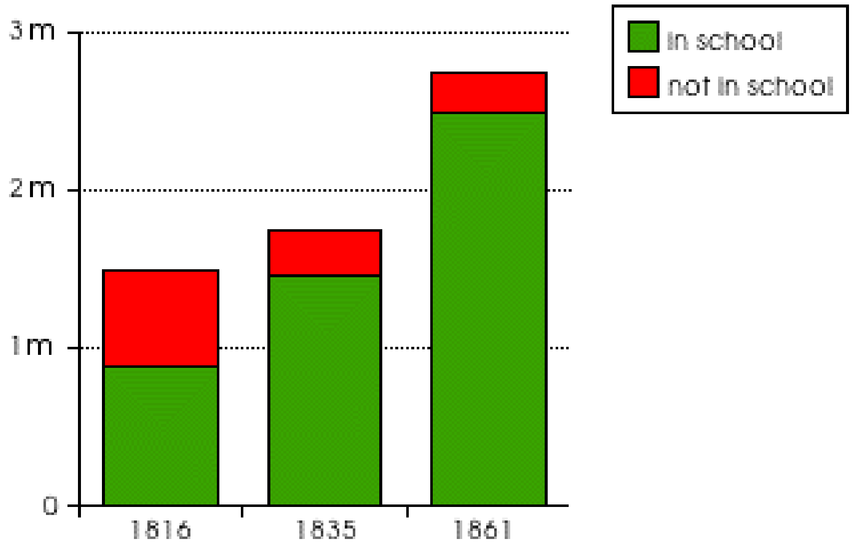
(vii) Appendix

Appendix 1 - Proportion of children in school 1816 – 1861

(Gillard, 2010)



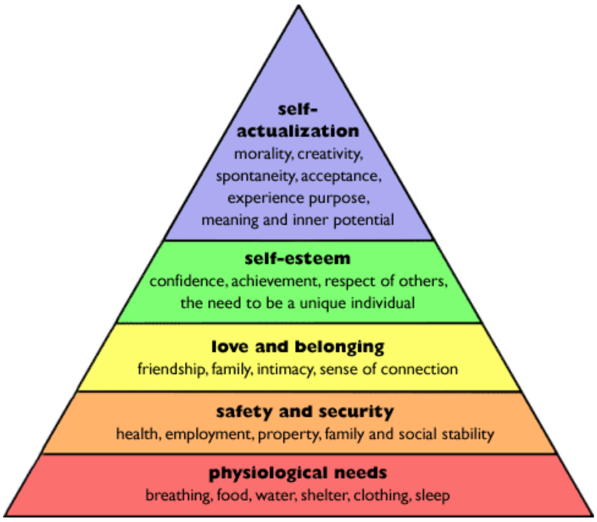
Appendix 2 - Time spent on different curriculum areas 1980's

(Bennett & Desforges, 1991)

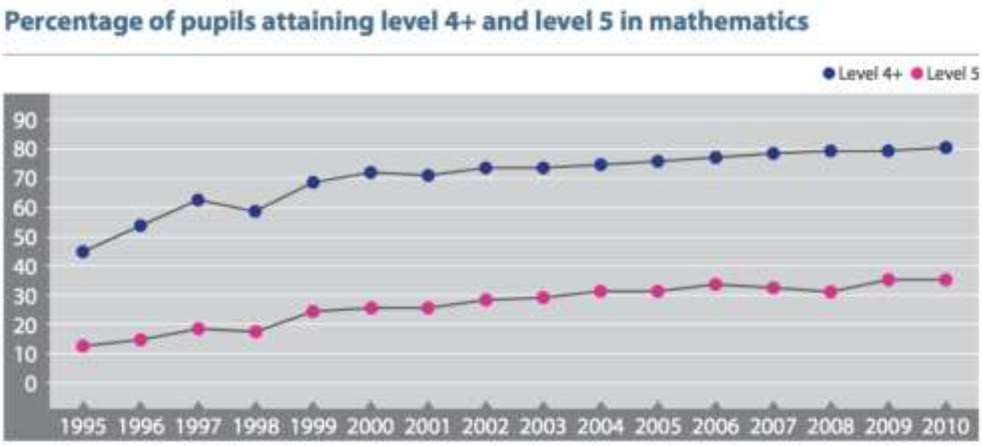
TABLE 2. Time Spent on Different Curriculum Areas

	Hours per Week	
	Average	Range
Mathematics	4.25	2–7
Language	7.5	4–12
Environment Studies	3.25	0–7.5
Aesthetics	2.5	0–4.25
Physical Education	2.5	0–5
Social/Moral	1.5	0–3
Transition	3.25	2–5

Appendix 3 - Maslow's Hierarchy of Needs
(Mcleod, 2018)



Appendix 4 - Mathematics achievement - primary
(DfE, 2010)



Appendix 5 - TIMSS 2015 Mathematics assessment results

(Gurney-Read, 2016)

TIMSS: International mathematics achievement

Search

Country	Score (Age 9-10)	Score (Age 13-14)
Singapore	618	621
Hong Kong SAR	615	594
Korea	608	606
Chinese Taipei	597	599
Japan	593	586
Northern Ireland	570	-
Russian Federation	564	538
Norway	549	512
Ireland	547	523
England	546	518
Belgium-Flemish	546	-
Kazakhstan	544	528

TIMSS

Appendix 6 - PISA 2015 Mathematics assessment results

(Ward, 2016)

Maths

2015 (2012)

Rank	*Country*	*Score*
1 (2)	Singapore	564 (573)
2 (3)	Hong Kong (China)	548 (561)
3 (6)	Macao (China)	544 (538)
4 (4)	Taiwan	542 (560)
5 (7)	Japan	532 (536)
6 (1 – as Shanghai)	Beijing-Shanghai-Jiangsu-Guangdong (China)	531 (613 – as Shanghai)
7 (5)	South Korea	524 (554)
8 (9)	Switzerland	521 (531)
9 (11)	Estonia	520 (521)
10 (13)	Canada	516 (518)
11 (10)	Netherlands	512 (523)
12 (22)	Denmark	511 (500)
13 (12)	Finland	511 (519)
14 (21)	Slovenia	510 (501)
15 (15)	Belgium	507 (515)
16 (16)	Germany	506 (514)
17 (14)	Poland	504 (518)
18 (20)	Republic of Ireland	504 (501)
19 (30)	Norway	502 (489)
20 (18)	Austria	497 (506)
21 (23)	New Zealand	495 (500)
22 (17)	Vietnam	495 (511)
23 (34)	Russia	494 (482)
24 (38)	Sweden	494 (478)
25 (19)	Australia	494 (504)
26 (25)	France	493 (495)
27 (26)	**United Kingdom**	**492 (494)**
28 (24)	Czech Republic	492 (499)
29 (31)	Portugal	492 (487)
30 (32)	Italy	490 (485)

Appendix 7 - Pre-& Post Research Times Tables Challenge conducted by both groups of participants.

Times Tables Challenge

Name.. Date.. 5 minutes.........Ready, Steady, GO!!

X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X 10	X 11	X 12
7 x 2 =	7 x 3 =	9 x 4 =	3 x 5 =	11 x 6 =	5 x 7 =	0 x 8 =	2 x 9 =	10 x 10 =	7 x 11 =	0 x 12 =
9 x 2 =	12 x 3 =	0 x 4 =	8 x 5 =	2 x 6 =	10 x 7 =	12 x 8 =	4 x 9 =	1 x 10 =	5 x 11 =	9 x 12 =
6 x 2 =	8 x 3 =	6 x 4 =	9 x 5 =	0 x 6 =	1 x 7 =	9 x 8 =	6 x 9 =	7 x 10 =	12 x 11 =	2 x 12 =
12 x 2 =	1 x 3 =	12 x 4 =	5 x 5 =	10 x 6 =	8 x 7 =	3 x 8 =	11 x 9 =	4 x 10 =	0 x 11 =	10 x 12 =
8 x 2 =	5 x 3 =	2 x 4 =	11 x 5 =	7 x 6 =	3 x 7 =	10 x 8 =	0 x 9 =	11 x 10 =	6 x 11 =	7 x 12 =
11 x 2 =	2 x 3 =	8 x 4 =	0 x 5 =	3 x 6 =	9 x 7 =	6 x 8 =	12 x 9 =	5 x 10 =	4 x 11 =	1 x 12 =
3 x 2 =	11 x 3 =	3 x 4 =	2 x 5 =	12 x 6 =	4 x 7 =	5 x 8 =	10 x 9 =	6 x 10 =	8 x 11 =	3 x 12 =
1 x 2 =	0 x 3 =	10 x 4 =	6 x 5 =	4 x 6 =	2 x 7 =	1 x 8 =	8 x 9 =	8 x 10 =	1 x 11 =	5 x 12 =
5 x 2 =	3 x 3 =	5 x 4 =	7 x 5 =	1 x 6 =	11 x7 =	8 x 8 =	1 x 9 =	3 x 10 =	9 x 11 =	11 x 12 =
2 x 2 =	10 x 3 =	1 x 4 =	12 x 5 =	8 x 6 =	0 x 7 =	4 x 8 =	5 x 9 =	2 x 10 =	3 x 11 =	6 x 12 =
0 x 2 =	6 x 3 =	11 x 4 =	10 x 5 =	5 x 6 =	7 x 7 =	2 x 8 =	9 x 9 =	12 x 10 =	10 x 11 =	8 x 12 =
4 x 2 =	4 x 3 =	7 x 4 =	1 x 5 =	9 x 6 =	6 x 7 =	11 x 8 =	3 x 9 =	0 x 10 =	2 x 11 =	11 x 12 =
10 x 2 =	9 x 3 =	4 x 4=	4 x 5 =	6 x 6 =	12 x 7 =	7 x 8 =	7 x 9 =	9 x 10 =	11 x 11 =	4 x 12 =

Appendix 8 - Teacher Interview questions

Teacher Interview Questions

My interview of the teacher will be based around the following questions.

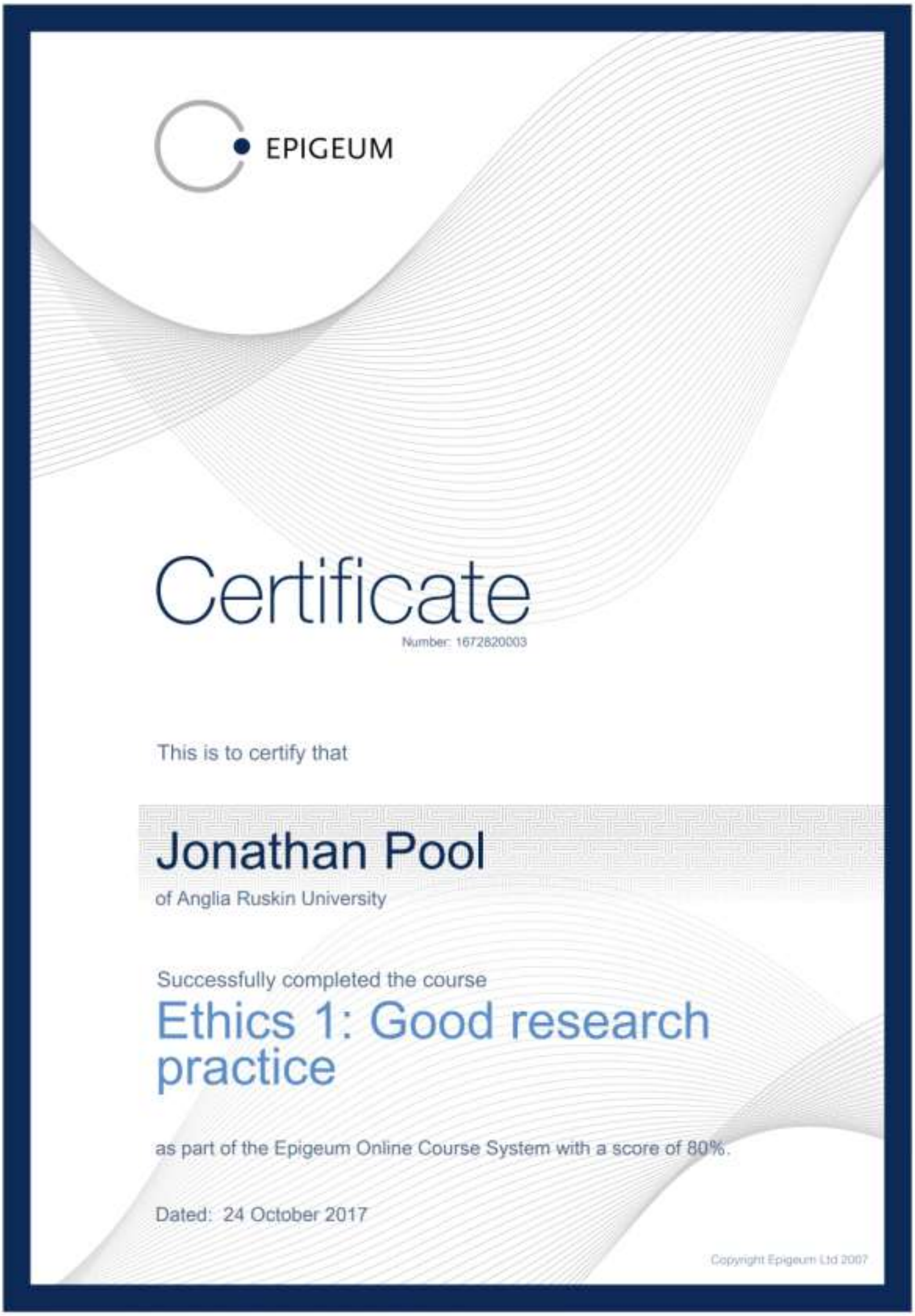
Pre-research Interview

1. How do you go about assessing in mathematics?
2. Stealth assessment is a method of testing that uses computer games to invisibly capture gameplay data, giving teachers information on children's competencies, which can be used formatively for future planning and learner development. What are your thoughts on methods of assessing children in this way?
3. How important is formative feedback in your classroom and which subjects get most feedback?
4. What do you think of the summative assessment method?
5. What are your thoughts on children playing computer games?
6. What are your views on computer-game learning?
7. Has your school ever used computer games as a learning tool?
   -If so, what curriculum subjects did they cover?
8. Do you use any form of technology in your maths lessons?
9. What are your thoughts of children's general motivation and engagement levels with maths?
10. What are your thoughts on current methods of teaching maths?
11. Do you think using computer games would have any effect on motivation and engagement?
12. What are your thoughts on the assessment methods used for mathematics?
13. Could stealth assessment and computer game learning benefit the children of tomorrow?

Post-research Interview

1. What are your thoughts of the computer game used in the study?
2. What are your thoughts on computer games being used to assess children's learning?
3. What is your view of the data you received from the computer game?
4. Do you think this method provided you with enough information on the learner's competencies?
5. What are your thoughts on children playing computer games?
6. What are your views on computer-game learning?
7. Would you consider using computer games in the future?
8. Did you notice any differences to the engagement levels of the participants playing the computer game compared to their engagement when taking part in your regular maths lessons?
9. Do you think the participants were more motivated to learn by playing a computer-game?
10. Do you think stealth assessment and computer game learning could benefit children of tomorrow?

Appendix 9 - Successful completion of Ethics 1: Good Research Practice



EPIGEUM

Certificate

Number: 1672820003

This is to certify that

Jonathan Pool

of Anglia Ruskin University

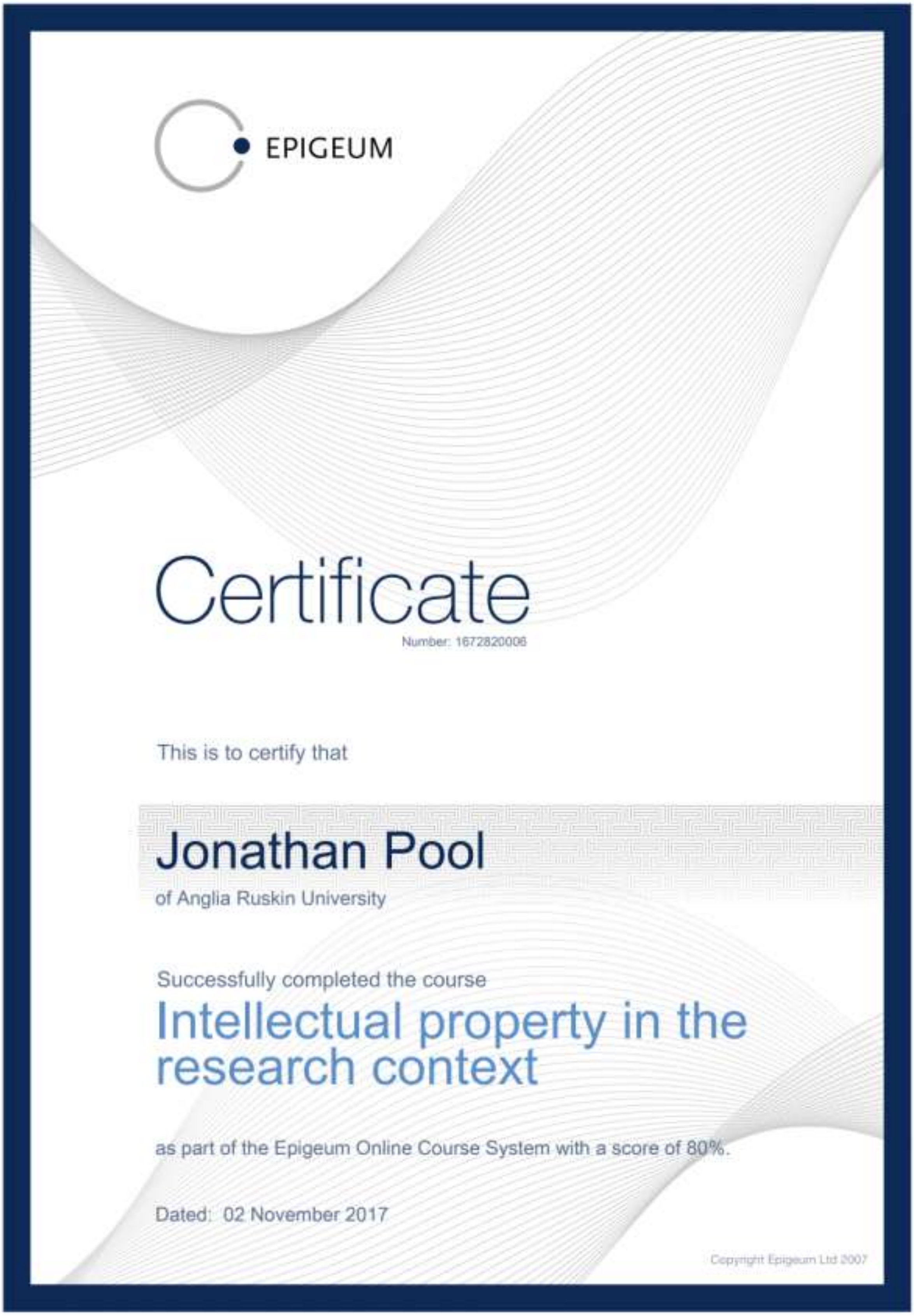
Successfully completed the course

Ethics 1: Good research practice

as part of the Epigeum Online Course System with a score of 80%.

Dated: 24 October 2017

Appendix 10 - Successful completion of Intellectual property in the research context


EPIGEUM

Certificate

Number: 1672820006

This is to certify that

Jonathan Pool

of Anglia Ruskin University

Successfully completed the course

Intellectual property in the research context

as part of the Epigeum Online Course System with a score of 80%.

Dated: 02 November 2017

Appendix 11 - Stage one ethics application form

Anglia Ruskin University

Stage 1 Research Ethics Application Form

Section 1: Details of the Researcher and their Research

N.B. If you are conducting research that involves 'animals (dead or alive) and significant habitats', please use the Stage 1 Research Ethics Application Form involving Animals and Habitats (www.anglia.ac.uk/researchethics).

Applicants carrying out research with children or vulnerable adults may also need to carry out an online Safeguarding course and submit the pass certificate with their ethics application. Please refer to the Question Specific Advice for the Stage 1 Research Ethics Application Form at the above weblink.

Researcher details	
First name	Jonathan
Family name	Pool
Department/Faculty	Health, Social Care & Education
Email address	jonathan.pool@pgr.anglia.ac.uk
Name of Institution where you study or work (if not Anglia Ruskin)	
Are you: *Please tick*	☐ Postgraduate Research (PGR) Student
Students (including staff proposing research on a course/programme)	
Your SID	1408867
Your course/programme title	MPhil Education and Social Care
Name of your First Supervisor (for PGR) or Supervisor (for UG	Snezana Lawrence
Research details	
Title of your research project *N.B. For UG/PGT students, this is not the title of your research module*	Stealth assessment and computer game learning: could this benefit the children of tomorrow?

Name and institutional affiliation of any research collaborators	
Date of application	09/01/2018
Start date of proposed research	12/02/2018
Brief Project Summary (up to 700 words) Please summarise your research in non-specialist language. Please describe where relevant. *Methodology* *Theoretical approaches* *Research questions* *Details of participant population (recruitment, inclusion and exclusion criteria*	My proposed area of research will be assessment in education, looking at stealth assessment through the use of computer games. This research will focus on educational computer games that assess mathematics. The aim of this study is to analyse computer game's role in assessment and seek an understanding of their role to enhance the level of achievement in schools. My plan is to do a literature review and interviews with educators and game designers, and also carry out some primary research using a mathematics computer game programme in a classroom. I have been in contact with a leading global games designer and have been given permission to use their games for my study. I have also been given permission by a local school to work with a KS2 teacher and a year 5 class. The research model will be based on the 'control group' methodology. My research would be to work with the teacher who would select 3-5 children of a similar ability to play the computer game for one week, with 3-5 other children of a similar ability to the first group to take part in the teacher's regular mathematics lessons. Before starting the classroom research, I will interview the teacher to get their perspective on computer games and their views on this type of learning and assessment. The teacher has agreed to give the whole class a short maths quiz at the start of the week which will show their current knowledge on the subject. The participants playing the maths game would do so for 20 minutes per day, which would be set up and monitored by the teacher. The type of game will be chosen to focus around their weekly learning objectives e.g. multiplication or measurement. The children will not be given information about the purpose of the project, because stealth assessment requires the children to be unaware that an assessment is taking place. This reduces the chances of any assessment anxiety and allows me to observe their natural reactions to playing the game. All data from the game gets sent straight to the administrator account, which myself and the teacher will have access to. I will provide information sheets for the teacher on how to set up and play the game, as well as sending out parent consent letters and a separate information sheet. My role will be to observe the children from a distance, using an observation schedule checklist to monitor their levels of engagement and interaction with the game and their peers. The teacher will explain to the children that I am only there to write notes on how they play and interact with the game. At the end of the week the teacher will give the whole class the another maths quiz related to their learning that week, to see which group of children scored highest and to compare to the quiz at the start of the week. This would then be followed up with a second interview of the teacher to get their opinion of the data he received, whether the teacher noticed any differences in the engagement between the two groups and finally to see if the teachers' perception of computer-game learning changed over the week. I want to see whether these games can assess children's learning, enhance classroom learning, keep them engaged with the subject and finally what data the teacher can use from these games to progress future learning.

Please explain the potential value of your research to society and/or the economy and its potential to improve knowledge and understanding.	I believe this research will benefit those in the primary teaching profession. Current methods of summative assessment in schools cause high levels of stress for many children and fail to provide information on the full range of educational outcomes needed in a society of rapid social and technological change. This is why I have an interest in alternative methods of assessment such as stealth assessment using computer games, because of its use of technology to try and improve the experience of assessment and learning for children and giving teachers more detailed information on the child's learning. This detailed information can then be used formatively to support their learning further and progress future learning. My research will hopefully inspire teacher's to incorporate more computer game learning programs into their classrooms, giving them an alternative resource for learning and assessment.

3

Section 2: Research Ethics Checklist (Refer to Section 3 for an explanation of the colour coding.)

N.B. If you are conducting research that involves 'animals and significant habitats', please use the Stage 1 Research Ethics Application Form involving Animals and Habitats (www.anglia.ac.uk/researchethics).

You must provide a response to ALL questions. Please refer to the Question Specific Advice for completing the Stage 1 Research Ethics Application Form for guidance.

	Will your research (delete as appropriate):			
1	Involve human participants?	●	YES	
2	Utilise data that is not publically available?	●		NO
3	Create a risk that individuals and/or organisations could be identified in the outputs?	●		NO
4	Involve participants whose responses could be influenced by your relationship with them or by any perceived, or real, conflicts of interest?	●		NO
5	Involve the co-operation of a 'gatekeeper' to gain access to participants?	●	YES	
6	Offer financial or other forms of incentives to participants?	●		NO
7	Involve the possibility that any incidental health issues relating to participants be identified?	●		NO
8	Involve the discussion of topics that participants may find distressing?	●		NO
9	Take place outside of the country where you work and/or are enrolled to study?	●		NO
10	Cause a negative impact on the environment (over and above that of normal daily activity)?	●		NO
11	Involve genetic modification of human tissue, or use of genetically modified organisms classified as Class One activities?[1].	●		NO
12	Involve genetic modification of human tissue, or use of genetically modified organisms above Class One activities?[2].	●		NO
13	Collect, use or store any human tissue or DNA (including but not limited to, serum, plasma, organs, saliva, urine, hairs and nails)?[3]	●		NO
14	Involve medical research with humans, including clinical trials or medical devices?	●		NO
15	Involve the administration of drugs, placebos or other substances (e.g. food, vitamins) to humans?	●		NO

[1] Email FST-Biologicalsafety.GMO@anglia.ac.uk for further information.

[2] As above.

[3] For any research involving human material you must contact Matt Bristow (matt.bristow@anglia.ac.uk) for further guidance on how to proceed

16	Cause (or have the potential to cause) pain, physical or psychological harm or negative consequences to humans?	●		NO
17	Involve the collection of data without the consent of participants, or other forms of deception?	●		NO
18	Involve interventions with people aged 16 years of age and under?	●		NO
19	Relate to military sites, personnel, equipment, or the defence industry?	●		NO
20	Risk damage/disturbance to culturally, spiritually or historically significant artefacts/places, or human remains?	●		NO
21	Contain research methodologies you, or members of your team, require training to carry out?	●		NO
22	Involve access to, or use (including internet use) of, material covered by the Counter Terrorism and Security Act (2015), or the Terrorism Act (2006), or which could be classified as security sensitive?[4]	●		NO
23	Involve you or participants in a) activities which may be illegal and/or b) the observation, handling or storage (including export) of information or material which may be regarded as illegal?	●		NO
24	Does your research involve the NHS (require Health Research Authority and/or NHS REC and NHS R&D Office cost and capacity checks)?	●		NO
25	Require ethical approval from any recognised external agencies (Social Care, Ministry of Justice, Ministry of Defence)?	●		NO
26	Involve individuals aged 16 years of age and over who lack 'capacity to consent' and therefore fall under the Mental Capacity Act (2005)?	●		NO
27	Pose any ethical issue not covered elsewhere in this checklist (excluding issues relating to animals and significant habitats which are dealt with in a separate form)?	●		NO

Please note that the Faculty Research Ethics Panel (FREP) will refer to the Office of the Secretary and Clerk any application where, in the view of the Chair, the proposed research poses a risk of a legal or security related nature to Anglia Ruskin University. The Chair will seek guidance from the Secretary and Clerk before the FREP decides if the proposed research can be granted ethical approval and/or the nature of any special arrangements which need to be put in place.

[4] The Counter Terrorism and Security Act (2015) and Terrorism Act (2006) outlaws web posting of material that encourages or endorses terrorist acts, even terrorist acts that have occurred in the past. Sections of the Terrorism Act also create a risk of prosecution for those who transmit material of this nature, including transmitting the material electronically. The storage of such material on a computer can, if discovered, prompt a police investigation. Visits to websites related to terrorism and the downloading of material issued by terrorist groups (even from open-access sites) may be subject to monitoring by the police. Storage of this material for research purposes may also be subject to monitoring by the police. Therefore, research relating to terrorism, or any other research that could be classified as security-sensitive (for example, Ministry of Defence-commissioned work on military equipment, IT encryption design for public bodies or businesses) needs special treatment. If you have any doubts about whether your research could be classified as security-sensitive, please speak to your FREP Chair.

Section 4: Project details

Management of Ethical Risk

For each of Questions 1-11 and Question 27, where you have responded 'Yes', please explain for the committee how you justify and will manage the ethical risk created. Your research is in the Yellow risk category.

Q1. Involve human participants?

The research will involve 3-5 children from a year 5 class. The children will be taking part in the research by playing a mathematics computer game for a duration of 20 minutes per day, over a one-week period. This time was chosen so the children get to play the whole game and so it does not take them away from classroom activities for too long. The mathematics game will be focused around the topic children are currently learning in class. This is to ensure that there is minimal disruption to the weekly learning outcomes for the children. The teacher has confirmed this will be ok and it will fit into their weekly mathematics planning. The teacher will be in control of setting up the mathematics game for the children taking part, so all participants feel at ease and the teacher knows exactly what aspects the children will be learning throughout the game. My role will be to observe them playing the game, monitoring different actions and engagement levels whilst interacting with the game. The teacher has confirmed this will cause no disruption to the children's learning and as the game will be played at a time when the whole class is completing computer-based tasks and will be under his and the TA's supervision.

Q5. Involve the co-operation of a 'gatekeeper' to gain access to participants?

This will be overcome by having a consent letter or email from the gatekeepers (headteacher & teacher) that they approve of this access. Consent letters and information about the research will also be sent to all parents.

Other Ethical considerations

There are also other ethical considerations to consider with this type of research. I will be writing letters of consent to all parents to ensure all children are given permission to take part in the research. However, I may encounter problems if parents decide their children cannot take part in the study. It must also be noted that parents may give permission, but the child may not want to take part. This will be overcome by the teacher selecting which pupils will take part and will take part in the research at a time where all pupils are completing computer-based tasks. The teacher will only select participants after all consent forms have been returned. This will reduce the risk of the children of not wanting to take part, as the teacher will be treating it like any other learning activity. Further issues could arise if the school or teacher decides to re-consider taking part in the research. I must also take into account that some of the participants might be doing extra maths revision away from school, which could affect the overall data collected between the two groups of children. However, I have been informed by the teacher that all children do mathematics homework online and this is logged onto a school database. So, all children doing revision at home will have this set by the teacher and have the same learning tasks to complete. This will reduce the risk of participants doing extra maths revision, which may affect the overall data collected.

Section 3: Approval process

All student applications must be sent to your Supervisor for checking.
Your Supervisor must then forward the application to the DREP/FREP (as appropriate)

FREP = Faculty Research Ethics Panel
DREP = Departmental Research Ethics Panel

NO answered to all questions
Risk category Green

Complete Section 5 of this form and then send it to your DREP (or FREP for the Faculty of Medical Science only).
You do not require ethical approval from a committee.
You can start your research immediately.

YES to any of Questions 1-11 and/or 27 but NO to all other questions
Risk category Yellow

Complete Section 4 and 5 of this form and submit it, and the Participant Information Sheet (PIS) and Participant Consent Form (PCF), to your DREP (or FREP for Faculty of Medical Science only). Your faculty may require further documents.
You need to wait for ethical approval before you start your research.

YES to any of Questions 12-23
Risk Category Red

Complete Section 5 of this form and complete the Stage 2 Approval form. Submit both, and any other documents required, to your FREP.
If you answered YES to Question 22 you must also complete and submit for consideration by the committee the Stage 3 Approval form.
You need to wait for ethical approval before you start your research.

YES to any of Questions 24-26
Risk Category Purple

You need external approval(s) which, if granted, may be regarded as equivalent to approval from an Anglia Ruskin ethics committee.

Refer to the Question Specific Advice for the Stage 1 Research Ethics Application Form and Code of Practice for Applying for Ethical Approval for further information

You need to wait for ethical and/or governance approval before you start your research.

Section 5: Confirmation/Declaration statements

	Confirmation Statements (delete as appropriate)	
1	I have completed the relevant training in research ethics.[5]	Yes
2	I have consulted the Research Ethics Policy and the relevant sections of the Code of Practice for Applying for Ethical Approval, available at www.**anglia.ac.uk/researchethics.**	Yes
3	I have completed a Risk Assessment (Health and Safety) and had it approved by the appropriate person.[6]	Not applicable
4	My research complies with the UK Data Protection Act (1998) and/or the data protection laws of the country where the research is being conducted.[7]	Yes
5	For research funded externally where the funding was acquired via Anglia Ruskin, I have completed a Project Risk Assessment.[8]	Not applicable
6	I have attached my confirmation of passing a Safeguarding course.	Yes
7	If my research project involves a contract between Anglia Ruskin University and an external party, I have had the contract approved by the Secretary and Clerk's Office[9]	Not applicable

Confirmation of Data Storage Compliance

By sending this form you confirm that:

- Physical documents containing personal or confidential information will be stored securely and only accessible to the research team and other authorised individuals.
- You will not store protected information [as defined by the Data Protection Act 1998] in personal cloud services, such as Dropbox, Google Drive or Microsoft OneDrive as their quality or security cannot be guaranteed.
- Any portable media, such as USB storage devices, removable hard drives, CDs or DVDs, that are used to hold personal, confidential or sensitive data will be securely stored on-premises and appropriately encrypted when used off-premises.
- Access to our remote desktop facilities will always be via an approved connection.

The preferred storage solution for electronic files is on a University server accessed from a password protected computer.

Please consult our IT Acceptable Use Policy for further information and guidance: http://web.anglia.ac.uk/it/policy/

Applicant Declaration

[5] Where required, UG or PGT students must submit confirmation with this form that they have passed the on-line ethics training. Some courses have exemption from this requirement. Please check with your supervisor.
[6] For research conducted at ARU including Ixion, University Centre Peterborough and College of West Anglia, go to http://web.anglia.ac.uk/anet/staff/sec_clerk/gen_info.phtml for the relevant guidance. Students at other institutions must follow local processes.
[7] For guidance go to web.anglia.ac.uk/anet/staff/sec_clerk/dpa.phtml
[8] For details go to web.anglia.ac.uk/anet/rdcs/compliance/faqs.phtml
[9] For details go to http://web.anglia.ac.uk/anet/staff/sec_clerk/

Appendix 12 - Participant Information Document and Consent Form

Anglia Ruskin University

|

Participant Information Sheet

Project: Stealth Assessment and Computer Game Learning: Could this benefit the children of tomorrow?

I would like to invite you to take part in my project. I want to learn about assessment in education, looking particularly at stealth assessment through the use of educational computer games.

Before you decide I would like you to understand why the research is being done and what it involves.

I will go through the project information with you and answer any questions you have. Please ask if there is anything that is not clear.

What is Stealth Assessment?
Stealth assessment is a method of testing that uses computer games to invisibly capture gameplay data, giving teachers information on children's competencies, which can be used formatively for future planning and learner development (Shute & Ventura, 2013). It uses evidence-centred design (ECD) assessment frameworks, which are placed into the fabric of a gaming environment. Whilst children interact with the game, they are constantly presented with complex problem-solving tasks, which draw upon their creative skills, knowledge and understanding of the topics that teachers are looking to assess (Shute & Ventura, 2013). The evidence needed to assess acquired knowledge is provided by the children's actions within the game. Shute et al., (2016) states that the dynamic nature of stealth assessment allows schools to measure learner competencies continually, with teachers able to change the level of difficulty based on children's outcomes, and provides teachers with more information for future learning within the classroom.

What is the purpose of the project?
The aim of this study is to analyse computer games' role in assessment and seek an understanding of their role to enhance the level of achievement in schools. Current methods of summative assessment in schools can cause high levels of stress for many children and fail to provide information on the full range of educational outcomes needed in a society of rapid social and technological change. This is why I have an interest in alternative methods of assessment such as stealth assessment, because of its use of technology and its aim to improve the experience of assessment for children. Furthermore, it can give teachers more detailed information on a child's learning. The research will focus on computer games that assess mathematics.

Do you have to take part?
It is up to you to decide whether you would like to take part. If you decide that you do not want to take part, then you do not have to give any reason.

If you do decide to take part then I will ask you to sign a consent form, which I will also give you a copy for your own reference.

What will happen if you take part?
I will meet with you to carry out a short interview to discuss your perceptions on stealth assessment and computer game learning. I will also ask you to choose 3-5 children to take part in the computer game learning for 20 minutes per day for one week. The computer game will be related to their mathematics learning you are doing in class. At the end of the week the children in your class take a regular mathematics quiz to measure their learning that week. The data from the game you will have full access to and can see how each child is progressing throughout the week. I will then interview you at the end of the week to see if your perceptions have changed and whether the information you have received from the game could be of any use for future classroom learning. My role throughout the week will simply be to observe the children interacting with the game and their engagement with regular curriculum maths lessons.

What are the possible disadvantages and risks of taking part?
I hope that the project will be interesting for you and the children in your class taking part.

- The teacher interview aspect of the research could take up to 30 minutes to complete.
- Finding 20 minutes per day for the children to play the computer game.

What are the possible benefits of taking part?
I cannot promise the project will help you, but some aspects hopefully may be of interest for future mathematics learning within your classroom. This project might also offer data that could potentially enhance the mathematics curriculum in the future and offer teachers further resources to enhance the learning experiences of their children.

Will taking part in the project be kept confidential?
I will follow ethical practice and all information about you and those in your classroom will be handled in confidence. The school, your name and participant names will not be used in the research and will be referred to as: e.g. School A, Teacher A and Pupil A. If you join the project, some parts of the data collected for the project will be looked at by authorised persons from Anglia Ruskin University. They may also be checked by other authorised persons to check that the project is being carried out correctly. All will have a duty of confidentiality to you as a research participant.

All information collected throughout the week will be kept strictly confidential, stored in a locked cabinet and on a password protected document. All research data recorded on the voice recording device will be removed and stored securely on a password protected file. Access to this file will be restricted to myself and authorised research persons at Anglia Ruskin University.

What will happen if you do not want to carry on with the project?
Your participation is voluntary and you are free to withdraw at any time, without giving any reason for doing so. If you withdraw, information collected up until that point in time cannot be erased but you can request to have it excluded from the project. After the research has finished it will not be possible to exclude the data from the analysis section.

If you have any questions or would like to participate in this project, then please contact:

Jonathan Pool (Postgraduate Researcher)
Tel:

Email: jonathan.pool@pgr.anglia.ac.uk

Snezana Lawrence (Project Supervisor)
Email: snezana.lawrence@anglia.ac.uk

If you have any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact research@anglia.ac.uk and your communication will be re-directed to an independent person as appropriate.

Gatekeeper Consent Form

Title of Project: Stealth Assessment and Computer Game Learning: Could this benefit the children of tomorrow?

Name of Researchers: Jonathan Pool

Please tick to confirm your understanding of the study and that you are happy for your organisation to take part and your facilities to be used to host parts of the project.

Please add some brief information about your project here that clarifies exactly what the gatekeeper is agreeing to

- **To participate in two short interviews (pre and post research) to discuss stealth assessment and computer game learning**
- **Observe 3-5 children to take part in the computer game learning. This will be done for 20 minutes per day for one week. The computer game will be related to the class learning that term.**
- **Observe at the end of the week the whole class to taking part in a short mathematics quiz, to compare data of those playing the game with the remaining class members.**
- **To allow the researcher to observe the participants playing the game and maths lessons throughout the week.**

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that participation of our organisation and pupils in the research is voluntary and that they are free to withdraw at any time, without giving a reason and that this will not affect legal rights. ☐

3. I understand that any personal information collected during the study will be anonymised and remain confidential. ☐

4. I agree for our organisation and pupils to take part in the above study. ☐

5. I agree to conform to the data protection act ☐

Name of Gatekeeper:	Date:	Signature:
Name of Researcher:	Date:	Signature:

Appendix 13 - Parent information document and consent

Re: Parental Consent Letter

Dear Sir/ Madam

My name is Jonathan Pool and I am a Postgraduate Researcher at Anglia Ruskin University. As part of my course I am carrying out a study looking at how educational computer games can be used in the classroom to assess mathematics and whether they can be used to enhance engagement and achievement.

I am writing to ask if you would be willing to give permission for your child to participate in the study.

This will involve your child playing a mathematics computer game for 20 minutes per day for one week. The game will be played at an appropriate time during each day to ensure that it does not interfere with their key learning. The children taking part in the study will be chosen at the beginning of the week by [redacted], with my role being to observe how each child interacts with the game, compared with their regular mathematics lessons. At the end of the week the class will be given a maths quiz to see what learning has taken place throughout the week. Your child's participation in this research will be treated confidentially and all information will be kept anonymously.

This research has been given ethical approval from the Departmental Research Ethics Panel in the Faculty of Health, Social Care and Education at Anglia Ruskin University. If you have any comments or questions about the research please contact my supervisor, Dr Snezana Lawrence or myself using the contact details provided below.

Many Thanks in advance for your consideration of this project. Please let me know if you need more information. I would appreciate it if you could complete the attached permission slip and return it to [redacted] by Monday 5th February 2018.

Yours sincerely,

Jonathan Pool
Postgraduate Researcher

Jonathan Pool (Postgraduate Researcher)
Tel:
Email: jonathan.pool@pgr.anglia.ac.uk

Snezana Lawrence (Project Supervisor)
Tel :
Email: snezana.lawrence@anglia.ac.uk

Parental Consent form

I understand that my child's participation in this study will involve:

- Playing a mathematics computer game for 20 minutes per day over a one-week period.
- During this activity, notes will be taken by the researcher on how your child interacts with the computer game and all information will be fully anonymised

I understand that my child's participation in this study is entirely voluntary and that they can withdraw from this research at any time without giving a reason.

I understand that their participation will be treated confidentially, and all information will be stored anonymously and securely. All information appearing in the final report will be anonymous.

I, ____(Name) consent to Jonathan Pool proceeding with this study.

Signature of Parent/ Guardian: ....

Date: ....

Name of Child: ....

Appendix 14 - Computer Game Instructions

Login Instructions

([redacted])

1. Open Internet Browser: Google/ Internet Explorer
2. Type in Mangahigh website address: https://app.mangahigh.com/en-gb/login
3. Enter User Name
4. Enter Password
5. Enter School ID: [redacted]
6. Select your Year of Birth & character picture
7. Game: Sundae Times – Choose which times tables game you would like to play

Choose from…

- x2, x3, x4, x5
- x6, x7, x8, x9
- x10, x11, x12

8. Click 'Play' button
9. Click 'Solo'
10. Play and have FUN!

Gamers

Name	Username	Password
	pupil1	[redacted]
	pupil2	[redacted]
	pupil3	[redacted]
	pupil4	[redacted]
	pupil5	[redacted]

Appendix 15 - Ethical Approval from DREP at Anglia Ruskin University

Anglia Ruskin University

30th January 2018

Cambridge & Chelmsford

Chelmsford Campus
Bishop Hall Lane
Tel: 01245-493131
Int: +44 (0)1245-493131

Jonathan Pool

Dear Jonathan,

Principal Investigator	**Jonathan Pool**
DREP Number	**FHSCE-DREP-17-067**
Project Title	**Stealth assessment and computer game learning: could this benefit the children of tomorrow?**

I am pleased to inform you that your ethics application has been approved by the Departmental Research Ethics Panel (DREP) under the terms of Anglia Ruskin University's Research Ethics Policy (Dated 8 September 2016, Version 1.7). Approval by DREP is subject to ratification by the FREP.

Ethical approval is given for 3 years from 30th January 2018. If your research will extend beyond this period, it is your responsibility to apply for an extension before your approval expires.

It is your responsibility to ensure that you comply with Anglia Ruskin University's Research Ethics Policy and the Code of Practice for Applying for Ethical Approval at Anglia Ruskin University available at www.anglia.ac.uk/researchethics including the following.

- The procedure for submitting substantial amendments to the committee, should there be any changes to your research. You cannot implement these amendments until you have received approval from DREP for them.
- The procedure for reporting accidents, adverse events and incidents.
- The Data Protection Act (1998) and General Data Protection Requirement from 25 May 2018.
- Any other legislation relevant to your research. You must also ensure that you are aware of any emerging legislation relating to your research and make any changes to your study (which you will need to obtain ethical approval for) to comply with this.
- Obtaining any further ethical approval required from the organisation or country (if not carrying out research in the UK) where you will be carrying the research out. This includes other Higher Education Institutions if you intend to carry out any research involving their students, staff or premises. Please ensure that you send the DREP copies of this documentation if required, prior to starting your research.
- Any laws of the country where you are carrying the research and obtaining any other approvals or permissions that are required.
- Any professional codes of conduct relating to research or requirements from your funding body (please note that for externally funded research, where the funding has been obtained via Anglia Ruskin University, a Project Risk Assessment must have been carried out prior to starting the research).

- Completing a Risk Assessment (Health and Safety) if required and updating this annually or if any aspects of your study change which affect this.
- Notifying the DREP Secretary when your study has ended.

Please also note that your research may be subject to monitoring.

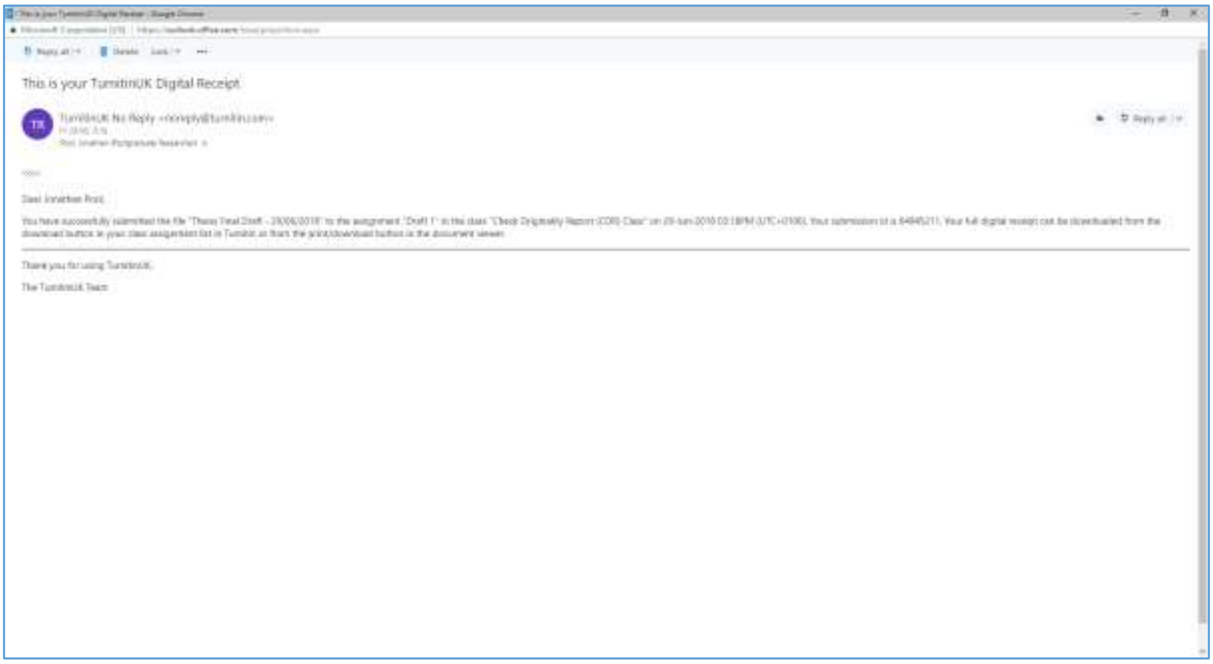
Should you have any queries, please do not hesitate to contact me. May I wish you the best of luck with your research.

Yours sincerely,

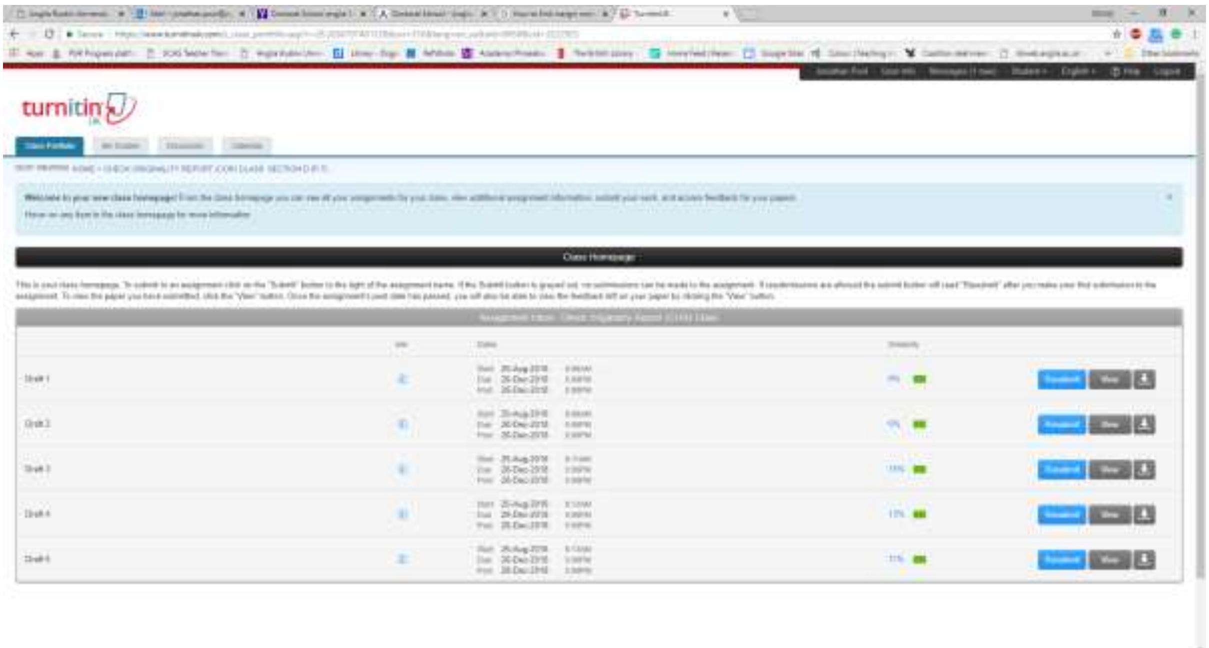
Dr. Niamh O'brien (Vice Chair)
For the FHSCE Department Research Ethics Panel (DREP)
T: 0845 196 4197
E: Niamh.obrien@anglia.ac.uk

Copy to: Snezana Lawrence

Appendix 16 – Turnitin Digital Receipt



Appendix 17 – Turnitin Originality Draft Page



Appendix 18 – Observation Schedule document

Stealth Assessment and Computer-game learning: Could this benefit the children of tomorrow?

Observation Schedule Design: The observation schedule is made up of three columns, a column will record the time a point of interest is noted (event recording). The column beside this is where the type of action should be stated followed by a column that allows for more description (descriptive approach) providing further details on the observation that I believe is important to the study. Below is a tally chart which will keep track of certain actions throughout the lesson.

Contextual Information:

Age of Pupils in the class: ....

Year group:................

Day (circle): Mon Tue Wed Thu Fri

Time of visiting: ....

Brief description of participants activity:

	Number of times this has been observed:				
Interaction/ Engagement	Child A	Child B	Child C	Child D	Child E
Engagement (G=Good, M= Medium, P=Poor)					
Motivation G=Good, M= Medium, P= Poor)					
Did they offer help to others? e.g. teamwork					
Did they ask for help?					
Looking at another participant's screen/ work?					
Show competitive natute?					

Time	Action witnessed	Further Notes or description For example: Does it appear the participants are enjoying the activity?
	<u>Participant A</u>	
	<u>Participant B</u>	
	<u>Participant C</u>	
	<u>Participant D</u>	
	<u>Participant E</u>	

Appendix 19 – Pre-research interview with Teacher A

Teacher A

Intvr: Question one, how do you go about assessing in mathematics?

Resp: We use a range of techniques, we will look at cold assessments which will look at children's prior learning, areas of development and areas of strength. We then use this when we teach to try and build the gaps of knowledge before the actual lessons, which gives the children that find aspects difficult a stepping stone. We use formative and summative assessment regularly and use quizzes to see how children have progressed and what areas they still need support with and target interventions to help. Summative assessment will be done every half-term to see the children's progressing and at the end of the year to see if they have made the levels expected. We also use a range of computer aids to support the assessments.

Intvr: Out of the formative and summative assessment methods you mentioned, which method is used more?

Resp: We use formative more and only use the summative as a summary every term to look at progress throughout the year.

Intvr: Question two. Stealth assessment is a method of testing that uses computer games to invisibly capture gameplay data, giving teachers information on children's competencies, which can be used formatively for future planning and learner development. What are your thoughts on methods of assessing children in this way?

Resp: If it is productive and it is targeted and not used just off the cuff, then I have no issue with it. However, it would need to be planned in and there needs to be a purpose to it. If there is no meaning to it, then it will not be supporting their learning at all.

Intvr: Question three. How important is formative feedback in your classroom and which subjects get most feedback?

Resp: That's hard, I try to put a lot of emphasis on it and try to balance feedback across all subjects. English and Maths are the ones that obviously get the most formative feedback because it is a way of revisiting areas of learning to try and support them.

Intvr: Why does English and maths get the most feedback?

Resp: We do more formative assessment in these subjects as the children do more of these lessons throughout the week. However, I like to give formative feedback in all the subjects that I teach. I think that children's formative assessment and peer assessments are key in the curriculum and in order to help their development throughout the year. They need to hear feedback from their peers to understand what their friends think they are doing well and what areas of support they need, in order to promote their own learning.

Intvr: Question four. What do you think of the summative assessment method?

Resp: That's opening up a can of worms. I know why it is needed. It is there to hold schools to account and it is there to look at children's progress. I don't think it should just be used by itself. We mainly use formative assessment, but summative is used at the end of each term. The year 6 children will get summative at the end of the summer term with their SATS, which measures learning in Science, Grammar and Maths to see if they are at the end of year expectations and sometimes you don't know how a child may react to a test, which is a problem. I do not think children's learning should be based around a test, but there is a use to summative assessments. I do not think that they should be the only way to assess my children.

Intvr: OK, question five. What are your thoughts on children playing computer games?

Resp: In all honesty, it depends on the games. I've got children in my class that I know have played video games that have a rating of 18 and above and I am not keen on that as I do not think they are cognitively ready to be presented with things like that, however they do play them, and it is a way they can learn about the world in different ways. Again, I think it is all about the purpose, why they are being played, are they being used as a stop-gap or are they being used to support the children's learning? I have no issue with them playing them, as long as they are age appropriate, that's the big thing for me.

Intvr: Interesting. What are your views on computer-game learning?
Resp: I think as I said before, if they are targeted correctly they can be very successful and useful, I don't think they could be used primarily all the time, but I think they could be embedded in the curriculum. I know for example that Minecraft do a whole thing on Minecraft programming and that's really strong. The children are able to design their own games and I terms of computing, I think it is really strong.

Intvr: Question seven. Has your school ever used computer games as a learning tool? If so, what curriculum subjects did they cover?
Resp: I think with maths and English we use them to teach with, but we ensure there is a relevance and they aren't just used as a stop gap.

Intvr: So just to expand on what you mentioned about using computer games for Maths and English, what games or programmes do you use?
Resp: We use a game called TT Rock Stars, where the children can go online and practise maths skills. They can earn coins if they answer questions correctly and they get to compete in gigs against other children across the class. We also have a battle of the bands where the different classes earn points over the term and compete to be the highest scorers.

Intvr: That is very interesting that computer games are already being used for certain purposes. Question eight is, do you use any other form of technology in your maths lessons?
Resp: We obviously use the interactive whiteboard for many aspects of the learning. It creates a different type of visual for the children and they can come up and draw and write on the

board. It makes the lessons more visually appealing; I think. We use an app on the iPad called 'Explain Everything', where the children can record themselves on how to perform certain calculations and to look at different mathematical problems and they record their explanations step by step on how to do it, whilst drawing it out. We use pic collages on the iPad to take pictures of the work they do.

Intvr: Do you use that in every lesson or as a reward?

Resp: We use it in lessons most of the time, but we try and vary it. We tend to only use the technology when its relevant and it can add something extra to their learning experience.

Intvr: Question nine. What are your thoughts of children's general motivation and engagement levels with maths?

Resp: It is a very tricky one. The methods we have to use at the moment state that we have to move all the children on together. However, you can see a general disengagement at times from those children that pick up the concepts quite quickly compared to others. I am quite lucky with my class, as generally they are quite motivated towards maths. However, I know that some other teachers do have a tough time with this aspect. So, like I said previously, we are using more technology in the classrooms to add something extra to the lessons and keep the learning varied. But I think the current methods of teaching mathematics, are not ideal.

Intvr: That is interesting to hear and brings me onto my next question. Question ten, what are your thoughts on current methods of teaching maths?

Resp: It is a mastery approach at the moment, which I agree with to an extent. I think you can disengage those children that are very strong mathematicians, because they already know it and its about moving on together and at a group pace. However, we also use a tool today which is called diagnostic questions, which is about looking at children pre-existing knowledge. So, it is like an online quiz and I've noticed already that there are a lot of gaps in all the children’s learning and even those that are perceived as strong at maths, it still means that they will still all move on together. However, once they grasp the tasks, they tend to disengage quite quickly. So, it is good in one sense that we all get to move on and work together at the same pace, but sometimes I think we also need to be a little more open-ended with those children. Also, those children who find it really difficult, we ensure we don’t move on too quickly for them. There is a really difficult balance with this approach at the moment and supporting every single learner. We can’t differentiate quite as strongly as we use to be able to in maths.

Intvr: Ok great, they were some really interesting points. Question eleven. Do you think using computer games would have any effect on motivation and engagement?

Resp: If the children enjoy it then yes, definitely. As long as It wasn’t overdone and used too much, I guess. It is all about the right timing for it to be used and the purpose the game is being used for.

Intvr: Question twelve. What are your thoughts on the assessment methods used for mathematics?

Resp: They all need to be used together. You cannot use one over the other, because you need to look at the broad picture for a child. They might be really strong with calculations and then you come to shape work and they do not feel as strong. If you use a summative assessment that primarily focuses on numbers, then you are not going to see their weakness as much or as clearly. Whereas, the formative method would pick up on that sort of thing as well.

Intvr: So, do you think that your end of year summative assessments should have some sort of formative aspect to them as well?

Resp: The teacher submits their assessments, but if their assessment results are not in line with the summative assessment standards then you would be asked why. However, it does always depend on what the children are asked in the summative assessments. However, I do think that it should be more teacher assessed, but that is my opinion and we should be trusting the teachers to know where the children are at throughout the school year. But we need to make sure the teachers are moderated and that is the best way of doing it. We need to moderate teacher's judgements, just like we do with writing.

Intvr: My final question. Question thirteen. Could stealth assessment and computer game learning benefit the children of tomorrow?

Resp: If used correctly, but all depends on why it is being used. I think for times tables yes, but like you witnessed today, a lot of my children find times tables tricky.

Intvr: Do you think it could be used in other areas of Maths?

Resp: To an extent, it is quite a closed procedure. It would have to be intrinsically linked and it would have to be really subtle. It must be that the children were learning and tested on what they were doing, rather than just playing a game, if you get what I mean, to support all areas of learning.

Intvr: Thank you for your time.

Appendix 20 – Pre-Research interview with Teacher B

Intvr: Question one. How do you go about assessing in mathematics?

Resp: On-going assessment mostly. The TA takes notes during the teacher input of what children are contributing to the lesson and the understanding children show during group discussion. We use think-pair-share and continuous provision. I also make on-going notes using a grid, which allows me to place children into three categories of 'working towards', 'working at' and 'greater depth'. I place children where I think they are at the end of a lesson depending on verbal feedback and the work in their text-books. There is also a summative assessment week after every half-term.

Intvr: Great, thank you. Question two. Stealth assessment is a method of testing that uses computer games to invisibly capture gameplay data, giving teachers information on children's competencies, which can be used formatively for future planning and learner development. What are your thoughts on methods of assessing children in this way?

Resp: I really like this idea. Assessment is known to cause a lot of stress and anxiety for both staff and pupils. It can be demoralising for some children if they do not do well or as well as they had hoped. It also sounds like it could be done fairly easily without much time and effort going into the assessment. Potentially the teacher starting the game off and allowing the children to work independently. Depending on the criteria and algorithms used, it has the potential to identify areas of strengths and weaknesses that may be overlooked on a day to day basis. It is difficult to assess where every child in your class is exactly. Another view however, is that the teacher isn't seeing the learning happen first hand.

Intvr: My third question is, how important is formative feedback in your classroom and which subjects get most feedback?

Resp: It is important that pupils are provided with on-going, beneficial feedback whilst they are working on something. By doing this, teachers can monitor understanding as well as address any misconceptions there may be. Core-subjects, on-going verbal feedback is given during lessons and notes in work-books.

Intvr: Which subjects get the most feedback though?

Resp: In my experience it is maths and English that receive the most feedback.

Intvr: Question four, what do you think of the summative assessment method?

Resp: Summative assessment methods give an overview and a way to monitor development throughout the year and give me an idea of what areas children need to work on. However, some summative aspects do not show a pupils full understanding and ability, which can be quite restricting.

Intvr: Great, thank you for that. My next question is, what are your thoughts on children playing computer games?

Resp: As an avid gamer myself, I see the benefits of playing video games. It has the potential to develop problem solving, literacy and numeracy skills, social interaction, response times, reflexes and so much more. However, I think that video games should be played in balance. Children should still have a healthy balance with playing other games and activities that are not related to technology. Nonetheless, there are many games that are now being used to involve technology in schools and are used to enhance learning. Educational computer games are also used to bring differentiation into a classroom and can be a good resource for children with SEN. Additionally it is important that children play age appropriate games and if they are playing older age category games then they need to be informed what they might see, do or hear in the game and why these may not be appropriate in real life.

Intvr: Question six. What are your views on computer-game learning?

Resp: If computer-game learning enhances pupil progress within education, then it can be seen as an advantage. But there needs to be a balance of learning styles used, as all children are unique and learn in different ways. Relating it to an inclusion, some families may not be able to access the technology or computers for this type of learning. However, I think there is certainly huge potential, but I do not think large gaming companies see profit in this area and more conservative educators and parents can often push video games aside.

Intvr: Interesting points, thank you. Moving onto question seven. Has your school ever used computer games as a learning tool? If so, what curriculum subjects did they cover?
Resp: We have used them in mathematics and homework is sometimes completed online as well. Interactive games are used during maths as 'fill ins' or quick oral mental maths activities. However, I know that games are used a little more in key stage two.

Intvr: Question eight. Do you use any form of technology in your maths lessons?
Resp: Not so much in year one. Interactive white boards and iPads are used during maths lessons to record the learning that has taken place. Pupils also occasionally like to take pictures of their work.

Intvr: Moving on to question nine. What are your thoughts of children's general motivation and engagement levels with maths?
Resp: Pupils participation and involvement enhances when lessons are fun, engaging, challenging with aspirational expectations yet achievable. Children's motivation increases when there is something different brought into the classroom.

Intvr: So, do you think computer games could be used more in the mathematics curriculum?
Resp: Potentially yes, but there needs to be a purpose for their use and not just used for the sake of it.

Intvr: Continuing along this theme in question ten. Do you think using computer games would have any effect on motivation and engagement?

Resp: Children become excited when they talk about their latest game that they are playing at home. I think this would affect motivation and engagement for those children that enjoy playing computer games and have had access to games before. However, it could be non-encouraging for children that do not necessarily like computer games.

Intvr: Those are some good points. Thank you.

Intvr: Question eleven. What are your thoughts on the assessment methods used for mathematics?

Resp: There needs to be more methods used to assess learning that gives a wider view of the pupils as a learner. The more options and methods available to teachers, the greater the picture we can build of their overall learning and better prepare them in the future.

Intvr: My last question is, could stealth assessment and computer game learning benefit the children of tomorrow?

Resp: If technology continues to develop the way that it is at the moment, then I definitely think it has a place in the classroom. However, it needs to be purposeful and targeted at the right time in the learning process. I do not think that it could be used alone as a learning tool.

Intvr: Thank you for your time today.

Appendix 21 - Post-research Interview with Teacher A

Intvr: Question one. What are your thoughts of the computer game used in the study?

Resp: It filled the children with confidence, it is very similar to one that is already used in the school. I feel that it was good to have a different game, something that was completely new, and it is something that I can investigate further. It would be interesting to see if there are any other aspects or different games other than times tables that could be used in my maths lessons. However, whilst it was a good game, it did seem that the children were choosing the easier options and times tables they were already confident with.

Intvr: What are your thoughts on computer games being used to assess children's learning?

Resp: If used correctly, I think it could be a powerful tool for teachers, but it must be used alongside careful planning and implementation, not just thrown in randomly.

Intvr: Ok, question three. What is your view of the data you received from the computer game?

Resp: I need to look at it in a bit more detail. However, from what I have seen already, it told me which times tables the children prefer to be tested on as they revisited the same ones often as the week progressed. I don't think it is wholly reliable because of this.

Intvr: Question four. Do you think this method provided you with enough information on the learner's competencies?

Resp: No, I don't think so. There needed to be restrictions on the times tables the children could play in order to test them effectively and to stop them from revisiting the times tables they prefer.

Intvr: What are your thoughts on children playing computer games?

Resp: It is society nowadays. As long as it is age appropriate and not detrimental to children's social communication skills, I accept it will provide a release for them.

Intvr: Ok thank you for that. Question six, what are your views on computer-game learning?

Resp: If used and planned correctly they can be powerful and engage children.

Intvr: Question seven. Would you consider using computer games in the future?

Resp: We already use computer games. As I mentioned in the first interview, we occasionally use them in maths.

Intvr: Did you notice any differences to the engagement levels of the participants playing the computer game compared to their engagement when taking part in your regular maths lessons?

Resp: They seemed to be more engaged as the week went on definitely. Whether that was because of the game or whether that was them becoming more confident generally with the work. However, it could also be because the children kept approaching the times tables they felt more confident with.

Intvr: Ok, that brings me onto my next question. Question nine, do you think the participants were more motivated to learn by playing a computer game?

Resp: Yes, I do. It is far more engaging for them than learning by rote.

Intvr: Do you think the participants were more motivated to learn after playing the computer game?

Resp: It is difficult to say. I think some would have preferred to continue using it rather than re-joining the normal lessons.

Intvr: Ok, question eleven. Do you think stealth assessment and computer game learning could benefit children of tomorrow?

Resp: As I mentioned previously, if implemented and planned correctly, then yes. If it was used as a lesson replacement, then no I do not think it would.