The potential of an interactive game-based software to motivate high-achieving maths students at primary school level

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Abstract

The scope of research that directly investigates the behaviours and attitudes of high-achieving maths students at a primary school level is quite limited. In the past, academic works dealing with elementary students of higher ability have been synonymous with mixed ability studies [50], learning outcomes [54] and direct enquiries on the gifted [38,17]. This outstanding issue combined with the current trend toward online, game-based learning not only proposes a need for investigation but also, an interesting study. This article studies a period of exploration for thirty high-achieving maths students using educational software at an Irish primary school. Data was gathered and analysed and the views and opinions of these high-achieving students are presented in this paper. The primary data collection method used in the investigation was teacher-prompted open-ended questions. The aims of the study were to allow the high-achieving students to explore a new, educational video game-based software and determine whether this exploration was a motivating experience for the students.
Conclusions *reached from this study are presented in a positive light and relate mainly to the current findings of the research itself. Though this study reveals positive experiences and discoveries, it also raises more unanticipated questions. Furthermore, the results of this small-scale research study may be even transferable to other primary educators as it clearly communicates the relationship between interactive game-based software and motivation in high-achieving students.*

1. Introduction

Prior to the Irish economic recession of 2007/2008, Irish primary schools saw huge improvements in the infrastructure of information and communication technology (ICT) and teacher training and this was due to a combination of technological innovations and government funding [46]. This need for improvement was, and still is, essential for an education system seeking to cater for students who will live and work in a rapidly changing world driven by technological innovations.

This road to change, however, is not without its barriers. In more recent years, the race to become *the* ICT school of the future has stagnated significantly. This was due to an inevitable lack of funding as well as an "uneven, haphazard and unstructured approach adopted by successive governments" toward the integration of ICT into schools [24]. Opposition to this technological change has also come from pivotal and even surprising directions. For example, a study by Wolfe

and Flewitt [52] displayed clear evidence of this resistance toward the current shift in pedagogy. Influential stakeholders in the education process, in this case parents and teachers, showed concerns of over exposure to technology with some believing its use may, in fact, impede development. This resulted in restrictions on the amount of time spent by the young students using technology or a discouragement toward its general use. Complementing this view is the work of Bauerlein [5]. In his study, he depicts the downfalls of the current ICT literate generation. He highlights their many shortcomings, including the inability to store knowledge, a decline in spelling and grammar and a general disinterest in reading. The cause of these issues has been firmly pointed towards the over-reliance and even saturation of technology in the lives of young people. A debate has ensued over the role and importance of technology in education and especially at elementary level where its influence can be at its most beneficial or harmful depending on ones view point.

Nonetheless, interactive game-based learning (GBL) has become a central part of everyday school life [36]. In fact, interactive, video game learning has been extensively tried and tested with low-achieving students and children with specific learning difficulties [10, 22, 34]. However, similarly to the challenges technology has faced in education, interactive games have also seen their fair share of criticism from educators in the past. For example, a study by Brody [6] discovered that poorly designed video games led to negative and even boring learning experiences for students. On the other hand, more recent works on interactive game-based learning [19] highlighted the positive effects that the learning approach can have on student progression including the mastery of skills and making learning fun.

However despite the conflicting perspectives above, the scope of research directly dealing with interactive maths-based software and its effects on the high-achieving student is currently limited, especially within an Irish context. This not only identifies a need for inquiry but also offers a promising opportunity for the discovery of new, practice-enhancing knowledge.

This qualitative research study seeks to describe and analyse the process in which students of a primary higher maths programme explore a new online interactive website. The study will also hone in on the opinions and attitudes of the high-achievers over the period October – November 2013 and investigate whether this exploration was a motivating one for the students. It is hoped that that aspects of this study will be applicable to other schools seeking to introduce high-achieving maths students to video game-based learning. At the same time, the goal of this research is not to generalise, but rather to provide further enhancement of existing knowledge relating to GBL and motivation in primary school students.

The investigation will begin by laying out important background information for the reader, thus setting both the theoretical and related contexts. Subsequently, the paper will take on a more descriptive perspective, as both the methodology and ensuing results will be discussed. This article will then focus on key findings and discoveries made during this study. To conclude, the key points of this paper will be summarised as well as a briefing on the paper's contributions and limitations.

2. Theoretical Background

2.1 Motivation

Motivation has been long associated with education as it is rightly seen as a determining factor that helps students to achieve at a high level, or at least, do their very best. As the identification of motivation in high-achieving students was a desired goal of this investigation, it is important to address the term *motivation* by providing a definition of the concept as it pertains to this study. Student motivation, can be defined as a student's "desire to learn" and act upon that urge in an assertive manner [33]. By taking this definition of motivation, the high-achieving students'

attitudes, opinions and actions were highly significant, especially when trying to establish the legitimate presence of motivation. The term *assertive manner* in McLean's [33] definition suggests that the students must have acted or expressed themselves in a positive way or in a way that may have helped, aided or encouraged their learning. A further advantage of this definition is that it made the identification and analysis process less complex, as student attitudes and opinions were easily gathered using a qualitative data collection method.

Copious studies [32, 51, 56, 4, 2] have demonstrated the benefits that motivation can have on student perceptions, attitudes and learning outcomes. Conversely, a lack of motivation has proven to have rather negative effects. As Stipek [48] suggests, the occurrence of motivational problems in young children can lead to a "lack of effort", "poor attention", and even "disruptive behavior" (p.16). A study by Brown, Brown, & Bibby, [7] even discovered that negative feelings may consequently make a student give up learning mathematics altogether. Furthermore, the research of Lepper and Chabay [30] has demonstrated that most learning environments are ineffective without motivation. Relating motivation to high-achieving students, Stipek [48] highlights the need for a focus on high-achieving students as teachers often "assume they do not have motivational problems" (p.16).

Taking the aforementioned studies into consideration, it is easy to concur with the view of McLean [33] when he states that teachers must provide students with the opportunity for achievement that is motivating.

2.1.1 Student Motivation: Intrinsic V Extrinsic

When further examining the concept of academic motivation, two distinct types are generally identified: intrinsic and extrinsic motivation. When an activity is carried out by means of intrinsic motivation, the individual has "engaged in it for its own sake rather than in order to receive some external reward or avoid some external punishment" [32, p.229]. In other words, if intrinsically motivated, a student will take part in an educational activity freely and for reasons that more closely relate to personal enjoyment, interest or self-satisfaction. Intrinsic motivation is associated with student-centered learning and is linked with a more constructivist [16], liberal approach to education. A constructivist approach is an active approach of educational inquiry that builds on the experiences of the children's prior knowledge and interests and then further enhances these experiences through self-reflection. The current Irish primary curriculum, originally designed in 1999, bases its very foundations on this philosophy of education and thus has huge relevance to this research investigation.

Extrinsic motivation describes a slightly different process where a learner would largely take on an activity based on the possibility of gaining an incentive or to avoid a known punishment. Sansome and Harrowitz, [45 p.445] define extrinsic motivation as a type of "motivation based on something extrinsic to the activity" or "something extrinsic to the person". Extrinsic motivation would lend itself very much to a behaviorist approach [47] to teaching and learning where potential incentives or punishments act as "reinforcers" [47 p.39] and are seen as key elements in the learning process.

It was useful to highlight intrinsic and extrinsic motivation for the purposes of the investigation as both have been found to play pivotal roles in young students' school achievement [3]. The desired outcome of this study was that intrinsic motivation would prosper as its advantages (higher academic achievement, greater persistence etc.) have been well documented in many studies [3, 49]

2.1.2 ICT, Digital Game-based Learning and Motivation

Prensky [39] stresses the need for an alternative approach to education for the 21st century learner. He describes how the younger generation "think and process information fundamentally differently from their predecessors" due to their familiarity and experience with ICT. He labels this generation as *digital natives* and suggests that they require an education system that strongly integrates ICT with the curriculum [41]. In his more recent works, he advocates his greater digital vision, one in which teachers and parents recognise the significant role that technology and digital game-based learning can play in raising students interest levels and developing essential skills needed for the future [39, 43].

Other studies [1, 12, 36, 40] have also advocated the advantages that computer game-based learning can have on young learners, including the heightening of motivation levels. Further studies [12, 29, 53, 55] that directly focus on digital game-based learning suggest that these systems can significantly promote learners' self-awareness, learning motivation, and willingness to engage in the learning process. The works of James Paul Gee are well renowned and highly recognised in the area of digital game-based learning. He cuts to the core of the concept as he describes the very nature of digital games and their place in the learning process: "Digital games are, at their heart, problem solving spaces that use continual learning and provide pathways to mastery through entertainment and pleasure" [19].

Additionally, digital game-based learning can be seen as a direct approach in making the learning of mathematics fun for children while also allowing them to reach their educational goals [9]. Playing and having fun are proven ways in which young children learn effectively [9]. *Fun* can be recognised as an even more significant element if one takes the perspective of Malone & Lepper [32] who clearly recognise fun as a key factor of motivation. However, taking a critical perspective, educators have also been made aware of the careful planning required when bringing games into an educational setting in order to ensure their relevance and effectiveness [20].

The above literature, as a whole, strongly supports the importance of student motivation and the need for an investigation aiming to identify and establish motivation in the high-achieving students. This was the overall intention, as the research subjects were introduced to new, carefully selected maths software with a particular emphasis on digital game-based learning.

3. Background

3.1 School and Participants

This study was conducted in an all boys senior primary school, situated in the southwest area of Dublin. The school enrols 455 boys aged seven – thirteen years (2nd Class to 6th Class). It is well resourced in I.T. infrastructure and holds an open-minded and forward-thinking staff and principal.

Student selection for this research study was based on a combination of teacher recommendations and individual results from a Department of Education & Skills (D.E.S.) approved, standardised numeracy assessment called the Sigma-T. The Sigma-T test is a nationally recognised assessment and is used by the vast majority of Irish primary schools to identify children's strengths and weakness' in relation to numeracy [35]. In general, students who received a percentile score [35] on or over the 90th percentile were considered for the study. Class teachers were then consulted on a student's suitability for the research investigation as their tacit and personal knowledge of the students was seen as invaluable in the selection process. This led to two extra students being added to the sample despite both their scores falling slightly below the 90th percentile. Former class teachers highlighted that the students had a natural ability in mathematics and suggested that the Sigma-T assessment may have not mirrored their true potential in numeracy. It was also important to take a

multi-step approach to student assessment and identification because "to use a single test to make a judgement about a child is a travesty of assessment" ([25, p.27]. In fact "an important basic principle is that no single assessment is a good basis for making an important judgement about a child" [25, p.27].

The 30 high achieving maths students were then divided into two standards, a 5th class (11-12 years old) group who were named *The Newtons* and a 6th class (12-13 years old) group named *The Archimedes*. The students who took part in the study ranged from eleven to thirteen years of age. Both *The Newtons* and *The Archimedes* groups consisted of 15 students each. Both of these groups were subsequently divided into three sub groups of five students. This then left a total of six sub groups with each group receiving one-hour, out-of-class tuition per week as part of this study. During the one-hour session, the researcher assumed the role of a regular class teacher and, as such, the students did not recognise the maths period as anything other than another lesson in their normal school timetable.

3.2 Pedagogy and Software Selection

Both schools and educators worldwide hold a variety of pedagogical stances, which generally derive from their own culture, traditions, values and overall goals. The school in which this research study was carried out promoted behaviourist pedagogy and this in turn proved to be an influential factor that helped shape the investigation. The majority of class teachers within the school employed reward systems in their classrooms. The school also ran a positive behaviour draw once a term in which students needed to collect tickets to win prizes. This approach, as mentioned previously, placed students in an environment, which naturally encouraged extrinsic motivation. As rewarding students for appropriate behaviour was already a central part of the school culture, it was important to choose software that aligned with this pedagogy or style of teaching and learning. An online maths-based software named *Manga High* (http://www.mangahigh.com/) was thus selected as it heavily promoted this important characteristic. The website is designed for ages seven to seventeen and challenges students through a range of competitive games and interactive maths quizzes. *Manga High* also allowed the researchers full control over the content that the young high-achievers were exposed to. This content included various tasks and assignments that ideally aligned with the Irish mathematics curriculum.

Each sub group experienced a one-hour session per week where they were allowed to explore *Manga High*. During a typical weekly session, the students were free to engage with the software and make their own choices on the topics / challenges they wished to pursue. Topics assigned to the students were set at one class level above their current class level e.g. *the Newtons* (5^{th} Class group) were assigned games that were designed and recommend for 6^{th} class students. This was due to the high-achieving ability of the students while also promoting a more challenging element to the students' exploration. Moreover, it was believed that the students would need to display high levels of motivation to persist and succeed at maths concepts that were more challenging to them.

The selection of educational video games available to the high-achieving students covered a variety of maths topics including fractions, algebra, shape and number. Topics selected as part of the study were not completely new to the students with all the high-achievers having some prior knowledge of the concepts from previous schooling. However, the games assigned to the students were designed for a level above the student's current class level. This ensured that new and more complex concepts needed to be mastered by the high-achieving students for them to achieve success. *"Flower Power"* was one such video game that taught and tested knowledge of fractional, decimal

and percentage value. *"Pyramid Panic"* was a survival game that tested student knowledge on the properties of 2D shapes. "*Sigma Prime*" was an interactive game that allowed students break down two and three digit numbers using related prime numbers. *"B.I.D.M.A.S. Blaster"* tested student competency of number rules by focusing on the order of operations using an animated, shooting style interaction. Each game encouraged the students to win a gold medal. To achieve this, the students would be required to display a high degree of mastery and / or a high degree of persistence in a specific maths topic. Games generally began with the more basic concepts of a particular maths topic and would gradually increase in difficulty as time elapsed.

Over the course of any individual data collection session, the students spent the majority of the hour working independently through the various levels of a particular game. Students were permitted to request help with concepts, which they were finding particularly difficult. However, this was only on the condition that the students had utilised the self-help feature within *Manga High,* as the idea of developing independent problem-solvers was desired throughout the school

Manga High also led the students through an interactive online maths environment underpinned by a strong behaviorist pedagogy. Medals and points were awarded as incentives to encourage the students to engage more enthusiastically with the software. Incentives also provided students with a sense of achievement therefore further strengthening this behaviourist ethos. Due to this software trait, the occurrence of motivation was more easily identifiable, as students were already familiar with an incentivised learning approach from their everyday classroom experiences.

Manga High therefore played an influential role due to its pedagogical foundations. Others reasons for its selection are further outlined:

- The children required an alternative approach to mathematics that would differ from a teacher-centred, textbook-led pedagogy. Research [56] has shown that a common trait of students in schools is boredom and thus this alternative approach was deemed necessary.
- There was clearly a need for further stimulation to more actively engage these students [40]. Through the use of visuals, text aids and competitive games, it was hoped that *Manga High* would provide this desired stimulation.
- The benefits of game-based learning has been clearly depicted in various research studies [36, 51, 1, 28] and are described previously in the paper. It was hoped that similar positive effects would apply to the young high achievers.
- A medium was required that would provide an asynchronous environment for the students. This was vital as the students had only one-hour face-to-face teacher time per week. An added bonus to the asynchronous environment was that it took central focus off the teacher, allowing him to be a "guide on the side" rather than "a sage on the stage" [27, p.30].
- The design features of the software were extremely child friendly; encouraging participation with the availability of custom-made avatars, modern animations and vivid colours. The importance of the latter is highlighted in a study by Gaines and Curry [18] who found that even colour has the ability to impact student attention, behaviour, and achievement.

3.3 Ethical Considerations

3.3.1 Informed Consent

Informed consent means that research subjects have "the right to know that they are being researched, the right to be informed about the nature of the research and the right to withdraw at any time" [44, p.231]. Written permission was sought from the parents of students who took part in the research. They were made fully aware of the nature of the research being conducted. It was made clear to all that participation was *voluntary*, an idea which is "at the heart" of informed consent [31 p.40].

3.3.2 Privacy and Confidentiality

Privacy within a research project involving such young students was vital [42]. Though the research subjects' youth and innocence delivered great insight and honesty, it could also have revealed unexpected, sensitive information. Therefore, this research study was obliged to protect the participants of the research process by guaranteeing anonymity and ensuring they came to "no harm" [44 p. 233].

Denzin and Lincoln [15] explain that codes of ethics are necessary to protect people's identities and those of the research locations. The central researchers of this study endeavoured to uphold these ethical principles throughout the investigation.

4. Methodology

A qualitative approach was used in this research study. Qualitative research employs a naturalistic perspective in understanding human experiences [15]. This characteristic of qualitative research made it ideal for this particular study as the opinions, attitudes and experiences of the students were at its very core. The rationale for employing a qualitative methodology is also based upon the fact that the research study is essentially attempting to identify something complex [13]; in this case the motivation of young high-achieving students. Qualitative research is more effective and better able to tolerate ambiguities and contradictions [14] which, was believed, would be prevalent in the opinions of the young students.

Finally, it is important to note that the process of qualitative research is also interpretative as the researchers are "the main instrument of research" [37 p.14]. This identified a need for consistently neutral, trustworthy researchers who display honesty and truth in any related findings. The presence of these traits helped provide validity and reliability to findings made during the study.

4.1 Data Collection Method: Teacher Prompted, Open-Ended Questions

The primary data collection method used throughout this research study was that of teacher-prompted, open-ended questions. Open-ended questions can gather information that is more likely to reflect the full richness and complexity of the views held by the respondent [14]. Therefore, after seven weeks, it was decided to investigate the attitudes and opinions of the students by posing two open-ended questions to each sub-group through a live messaging system on *Manga High*:

Q1. *What do you think of Manga High so far? Do you like it or not? Give reasons for your answer.*

Q2. *What do you think the difference is between Manga High and doing maths in class?*

Another important aspect of the open-ended question process was that students could answer the questions asynchronously. An asynchronous delivery allowed students to be more flexible and reflective in their responses [26]. This feature would allow students to answer within their own time constraints, eliminating the possibility of rushed or forced answers. Furthermore, it was felt that there was a higher possibility that student responses would be more thought-out and insightful.

4.2 Data Collection Period

To give the high-achieving maths students time to become acquainted with the new *Manga High* technology, a grace period of two weeks was allocated prior to data collection. This grace period helped students familiarise themselves with the new online environment. Data collection commenced on the first week of October 2013, allowing students open access to the software. This permitted students to log into their personal accounts both at home and during allocated school time. Students were monitored over an eight-week period between the months of October and November, 2013. By selecting this period of time, the students would have their weeklong midterm break, exactly four weeks into the cycle. It was planned to use this particular week to identify whether the students had been intrinsically or extrinsically motivated. This could be accomplished, because the students were not confined to schoolwork or provided with specific incentives or instructions over this holiday period, yet an opportunity to engage with the content still presented itself.

4.3 Considering the Novelty Factor

As the data collection period for this study was particularly short, the concept of student novelty had to be taken into account and considered before and after data analysis. Due to the young age of the students partaking in this research study and the very alternative approach to mathematics they were about to engage in, any major findings needed to consider a novelty phenomenon. There was a strong possibility that the digital GBL exploration might have even felt like a treat for the high-achievers as they were being allowed to play computer games in school. The probability of the students experiencing a novelty phase was very important to recognise. Citing a study by Burke and James [8, p. 290], students experiencing a novelty phase could, over time, become “less curious and interested”, “pay less attention” and even “spend less time pondering the richness” of the new math software. To form accurate, honest and reliable findings and conclusions, the occurrence of a novelty phenomenon was taken into account during the study.

5. Results and Findings

5.1 Results

Results from the open-ended questions came in the form of text, and were fully collected and analysed after an 8-week period. This raw data was cross-examined and communicated in terms of percentages.

5.1.1 Open-Ended Questions Results

Students replied to the teacher-prompted, open-ended questions through a messaging system provided by Manga High. It was important to let students familiarise themselves with both the online environment and messaging system prior to direct questioning. The students were encouraged to send messages through the system if they were having a particular difficulty with a specific maths problem. By creating situations where students could contact the tutor using the messaging service, student familiarity with the technology was being strengthened.

A high level of responses was collected from the high-achieving students with 83% of students replying to the open-ended questions directly. Responses were also rich and honest in nature, though exhibiting expected spelling and grammatical errors. Nevertheless, the messages being conveyed were easily comprehensible.

Overall results indicated that the students had very positive attitudes towards the software. From a total of 30 high-achievers who took part in the study, 83% submitted positive responses with 17% not responding at all to either of the teacher prompted open-ended questions. In fact all the participants who responded to the open-ended questions did so positively when writing about their experiences on *Manga High*. Out of all 25 responses submitted, 8% contained comments that revealed negative attitudes towards the software. These students identified a lack of face-to-face assistance and the difficulty of the content being of particular concern to them. Through analysis of the responses, six keywords were found to be most prominent. The following percentages represent the number of responses that contained these words over the total number of responses submitted. The most common keywords identified throughout all the responses were 'fun' (72%), 'challenge' (40%), 'games' (28%), 'medals/points' (20%), 'different' (12%), 'friends' (12%). As is clear from these figures, the most consistent keywords and concepts to reoccur were that of *fun and challenge*.

Over the midterm holiday period, data collection continued to identify if the students were actively using *Manga High* during this out of school time. The mid term break lasted a total of ten days and as mentioned previously, all assignments, tasks and incentives were held in abeyance during this period. Over the course of the ten days, 67% of the high-achieving students logged into *Manga* High software outside of school thus leaving 33% of participants not actively engaging over the same period.

5.2 Findings

This section of the paper will discuss the key findings and discoveries that arose from analysis of the responses from the open-ended questions. Critical thinking and alternative perspectives of the results will also be teased out toward the end to signify the open-minded nature of this research.

5.2.1 Fun = Motivation

Through data analysis, evidence arose that suggested the students were motivated when interacting with the software. Students' responses to the open-ended questions tended to be extremely positive toward Manga High with a majority (72%) stating *fun* as their main reason for enjoyment:

*"I think it's a great way of learning maths because people have **fun** doing it and sometime when you are playing a game you forget you are learning."*
(posted by Student 25, 14/11/13)

*"manga high is brilliant **fun** i play after school and it is sooo (sic) much **fun**. I really like it it is harder than the maths in school but i lkike (sic) that it improves my maths and makes me better at school"*
(posted by Student 9, 15/11/13)

*"my opinion of manga high is that it is the most **fun** maths game ever made and i really enjoy playing when i mostly can when i am bored i really love the way i can go on manga high and play my maths challenges and hopefully succeed by getting gold and that's what i think of manga high my rate would be 10/10"*

(posted by Student 20, 19/11/13)

"*manga high is better **fun** and a lot easier than normal maths In the future I hope mangahigh is used to instead of copies and writing*"
(posted by Student 24, 19/11/13)

The above evidence strongly supports the argument that both school and learning must be fun for students irrespective of their ability. Even though these students have an exceptional ability in mathematics, they still crave fun in their learning. This necessity for fun is even more plausible if you consider it as one of the five basic human needs [21]. In fact, when an element of fun was present, these high-achievers blossomed into highly motivated learners. The below comment from an eager 5th class student epitomises this:

"sir I am doing really well with mith (sic) my fractions and decimals and addition subtraction. I have gone from 6 golds to 15 golds and gone from 1 bronze to 3 bronze and got 1 silver. i have been doing really well in the last 2 days. When I got my internet back i was craving to get on mangahigh!!!!!!!!!!!!!! wow!!!!!!!!!!!!!!!!
(posted by Student 1, 13/10/13)

The work of Malone and Lepper clearly identifies fun as a key factor of motivation [32]. In fact, they delve further into this notion by highlighting elements such as competition, challenge, fantasy and control as integral in sustaining motivation in the use of computer games. For the high-achieving students, *Manga High* created situations, which allowed these key elements to occur, thus enabling motivation to flourish.

The students also displayed high levels of motivation by interacting with the game-based software over weekends and the midterm break. Activity over the midterm break was extremely positive with 67% of participants using the software during a period when neither teacher challenges or incentives were assigned. This is highly consistent with research conducted by the Federation of American Scientists cited by Annetta [1, p.230]: "Video games are the next great discovery, as they offer a way to captivate students to the point that they will spend hours learning on their own time."

Furthermore, when engaging with the software over the holiday period, children were no longer learning for prizes or incentives as all teacher-set challenges had expired. This may indicate that intrinsic motivation was at the core of this learning activity. This has been identified as an affluent level of student motivation that can lead to such benefits as "higher levels of sustained interest" and "better learning of the instructional content" [32 p. 229]. At this level, learning could even be occurring subconsciously, in a manner best described as stealth learning [41]. As a result, it is clear that although extrinsic motivation had been at the forefront of much of the high-achieving activity on *Manga High*, the students have displayed traits of intrinsically motivated learners by using the software at home, outside of school hours and of their own accord.

5.2.2 The Importance of Challenge

Analysis of the raw data collected also found another common pattern with 40% of students directly using the word 'challenge' when speaking positively about the software. As these high-achievers had a particular strength in maths and were somewhat ahead of their classroom peers, it is highly probable that they found *Manga High* much more challenging than their everyday school maths tasks. The

students not only had content which was set at a higher level but also had the challenge of orientating and exploring a new virtual environment, which, from a teaching and learning viewpoint was completely foreign to them. Comments made by some of the high-achievers suggested that they enjoyed the pace of learning on *Manga High* while others indicated the benefits of not having to wait for a challenge, which differed immensely from some of their classroom experiences.

*"I prefer playing on manga high because it is a bit more **challenging** and better education".*
(Posted by Student 3, 26/11/13)

*"Manga is fun educational and **challenging** the first day I started it I thought it was easy but now its more **challenging**. I love manga high even though I don't do it at home."*
(Posted by Student 27, 21/11/13)

"I think the difference is in class that maybe other boys could be stuck on something the whole class have to sit there and listen even though you know what the answer is. Where on Manga High you can just plough ahead."
(Posted by Student 25, 21/11/13)

5.2.3 Von Restorff Effect

It could be further argued that the students may be experiencing, to a certain degree, what is known as the *Von Restorff Effect* [23] which stems from the field of psychology. Though this effect lends itself primarily to the area of memory recall, its foundations are underpinned by the idea that something different will hold a person's attention longer. Therefore, it could be argued that the students are interacting so intensely with the software because it is such a different approach to learning from what they are used to in their everyday classroom. This attraction to what is different may have been at the core of the students' *Manga High* fascination. Analysis of the submitted student responses highlighted that 12% of the high-achievers directly used the keyword 'different' when they described their positive experiences of Manga High.

However, whether or not the students are experiencing an alternate form of the Von Restorff Effect, by conducting this study over a longer period of time, further clarity would be gained. Therefore, by conducting this research over a longer time scale, reliability and accuracy in any of the above findings and suggested claims would be increased.

The researchers' opinions are that *Manga High* is a very effective piece of game-based software especially given that children's attention spans are shorter and motivation levels harder to maintain than ever before [33]. To maintain such high levels of motivation and positivity in high-achieving students, even over a two-month period, is a fantastic achievement in itself.

6. Conclusion

In conclusion, this study investigated the effects that a digital game-based exploration had on thirty primary high-achievers. To determine these effects, the study examined and analysed the views and opinions of these students who interacted with the software over a two-month period. Theoretical and

related backgrounds were presented to the reader to add context and greater understanding of the main concepts of the research. The rationale behind the qualitative research methodology and the primary data collection method employed were also discussed.

Results and findings suggested that the high-achieving maths students had positive experiences with the maths software during the study. Findings also indicate that the students did display signs of motivation as they explored the game-based software. In fact, the students engaged with *Manga High* with enthusiasm not only during school time but also during their free time at home and even more importantly without incentives. This paper has even gone further by not only identifying the types of motivation that were present during the students' exploration but also pinpointing 'fun' as the main reason behind this motivation. A majority of student's responses directly stated 'fun' as a determining factor for their positive engagement with *Manga High*. Another key factor, which arose from this study, is the need for high-achieving students to be challenged during video game-based learning. Analysis of the data identified challenge as a factor that many of the students referred to when revealing their positive experiences with *Manga High*.

The contribution of this study can be summarised from two key aspects. Firstly, interactive video game-based learning, although often seen as a resource to aid and support students with learning difficulties can in fact play an important role in the motivation of high-achieving students. When pitched at the right level, this approach to learning can encourage extrinsic and intrinsic motivation in the 21st century learner.

Secondly, this study has also reinforced the work carried out by maths educators who align their pedagogical approaches with technology. Educators who are confronted with misconceptions that digital games and computers are a waste of time and harmful to the development of high-achievers can identify and use this study as a solid source of evidence that depicts the opposite. Primary educators can use interactive learning games to motivate their high-achieving students, especially when factors such as fun and challenge are considered as the findings of this research study suggests.

Although this study has clearly displayed the positive effects interactive game-based software can have on primary high-achievers, it does however, possess some limitations. Primarily, this study only used one maths-based, interactive game-based software to stimulate the students. To ensure further reliability in the findings of the study, a wider range of maths software would need to be incorporated in a future research investigation. As mentioned previously, the longevity of this research may also come into question and as a result another cycle of data collection may be required over a longer period of time to help identify the occurrence of a novelty effect on the young high-achievers. Thirdly, although motivation was clearly identified, neither the learning attainment levels nor the cognitive levels reached by the high-achieving maths students were measured during this research. As a result, there is a strong rationale to conduct a future research dealing with digital GBL and high-achieving students' actual learning advancement.

Overall, however, it is clear from the foregoing that interactive game-based software can influence student motivation and the conclusion reached in this paper strongly supports the view of Cheng and Chen [11] that: "Games can be used for improving learning motivation and effectiveness".

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